



# Crop Profile for Greenhouse Cucumber in Canada, 2017

Prepared by:  
Pest Management Program  
Agriculture and Agri-Food Canada



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# Preface

National crop profiles are developed by the [Pest Management Program](#) of [Agriculture and Agri-Food Canada](#) (AAFC). The national crop profiles provide baseline information on crop production and pest management practices and document the pest management needs and issues faced by growers. This information is developed through extensive consultation with stakeholders.

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

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

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

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**For inquiries regarding the contents of the profile, please contact:**

Crop Profiles Coordinator  
Pest Management Centre  
Agriculture and Agri-Food Canada  
Building 57, 960 Carling Ave  
Ottawa, ON, Canada K1A 0C6

[aafc.pmcinfo-clainfo.aac@canada.ca](mailto:aafc.pmcinfo-clainfo.aac@canada.ca)

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# Crop Profile for Greenhouse Cucumber in Canada

The cucumber plant (*Cucumis sativus* var. *sativus*) is believed to have originated in India. Cucumbers were consumed in Western Asia, Greece and ancient Egypt as much as 3000 years ago. It is known that cucumbers were imported to the Tigris Valley and eaten as pickles in 2030 BC, and they are mentioned at least twice in the Old Testament. Cucumbers were introduced to the New World by Christopher Columbus. The pickled cucumber was of great importance to early North American pioneers, as it was the only zesty, green vegetable available for many months of the year. Today, cucumbers are produced both in the field and greenhouse. This crop profile covers greenhouse-grown cucumbers only.

In addition to the long English cucumber grown in greenhouses, there is significant production of mini- or gherkin-type cucumbers in protected environments. The mini cucumbers have become popular with consumers as their convenient small size requires minimal preparation. All greenhouse-grown cucumbers are sold for the fresh market. They are sweet, seedless and eaten unpeeled, either alone, or in salads, sandwiches or used as a garnish. Cucumbers are a good source of potassium, calcium, folic acid and vitamin C.

## Crop Production

### ***Industry Overview***

Tomatoes, cucumbers and peppers account for the majority of greenhouse vegetable crops produced in Canada.

In 2017, the farm gate value of greenhouse vegetable production totalled over \$1.4 billion, an increase of 7.1% from 2016, largely due to an increase in the value of cucumbers and tomatoes.

Greenhouse cucumbers and mini-cucumbers were the third largest greenhouse vegetable produced in Canada in 2017 with a farm gate value of \$396 million or 28% of the total, after greenhouse tomatoes and peppers (Table 1). Fresh and chilled cucumber exports (both field and greenhouse) amounted to \$241 million, and imports \$89 million, mostly from Mexico.

**Table 1. General production information for greenhouse cucumber, 2017**

<b>Canadian production<sup>1</sup></b>	206,227 metric tonnes 432 ha
<b>Total farm gate value<sup>1</sup></b>	\$395.8 million
<b>Food available<sup>2</sup></b>	3.18 kg/ person
<b>Exports<sup>3,4</sup></b>	\$241.4 million
	104,038 metric tonnes
<b>Imports<sup>3,4</sup></b>	\$45.1 million
	23,473 metric tonnes

<sup>1</sup> Source: Statistics Canada. Table 32-10-0456-01 (formerly CANSIM 001-0006) - Production and value of greenhouse vegetables (database accessed: 2019-08-14).

<sup>2</sup> Source: Statistics Canada. Table 32-10-0054-01 (formerly CANSIM 002-0011) - Food available in Canada (database accessed: 2019-08-14).

<sup>3</sup> Source: Agriculture and Agri-Food Canada. Statistical Overview of the Canadian Greenhouse Vegetable Industry, 2017. (Accessed 2019-08-14).

<sup>4</sup> Includes cucumbers and gherkins.

## ***Production Regions***

Greenhouse cucumbers / gherkins are generally grown in Canada in regions with milder temperatures that are close to major markets.

In 2017, 322 hectares or 75% of the national greenhouse area planted to greenhouse cucumber was in Ontario, 14% in British Columbia (44 ha), 12% in Alberta (39 ha) and 7% in Quebec (24 ha). Accordingly, the farm gate value of greenhouse cucumber was highest in Ontario with \$273.5 million, equivalent to 69% of the total value for Canada (Table 2).

**Table 2. Distribution of greenhouse cucumber production in Canada, 2017<sup>1</sup>**

<b>Production Regions</b>	<b>Harvested area<sup>1</sup> (hectares) (percent national area)</b>	<b>Production<sup>1</sup> (metric tonnes) (percent national production)</b>	<b>Farm gate value<sup>1</sup> (dollars) (percent national value)</b>
<b>British Columbia</b>	44 ha (10%)	26,315 m. t. (13%)	\$45.7 million (12%)

...continued

**Table 2. Distribution of greenhouse cucumber production in Canada, 2017<sup>1</sup> (continued)**

<b>Production Regions</b>	<b>Harvested area<sup>1</sup> (hectares) (percent national area)</b>	<b>Production<sup>1</sup> (metric tonnes) (percent national production)</b>	<b>Farm gate value<sup>1</sup> (dollars) (percent national value)</b>
<b>Alberta</b>	39 ha (9%)	20,459 m. t. (10%)	\$44.2 million (11%)
<b>Ontario</b>	322 ha (75%)	149,137 m. t. (72%)	\$273.5 million (69%)
<b>Quebec</b>	24 ha (5%)	9,026 m. t. (4%)	\$28.6 million (7%)
<b>Nova Scotia</b>	3 ha (1%)	1,135 m. t. (1%)	\$3.0 million (1%)
<b>Canada</b>	432 ha (100%)	206,227 m. t.	\$395.8 million

<sup>1</sup> Source: Statistics Canada. Table 32-10-0456-01 (formerly CANSIM 001-0006) - Production and value of greenhouse vegetables (database accessed 2019-08-14).

## ***Cultural Practices***

Greenhouse long English cucumbers are grown hydroponically, generally in Rockwool blocks placed on slabs containing Rockwool, coir (coconut fibre) or sawdust. Seeds are sown directly into the blocks or into flats containing vermiculite and then transplanted into the blocks after emergence in propagation houses. Planting density depends on growing method, variety and harvesting method. Generally, a plant density of 1.4 to 1.8 plants per m<sup>2</sup> is used for hand-harvested long English cucumbers grown on trellises. However, many growers buy three-week-old seedlings from commercial propagators. When three to five leaves have developed, the seedlings are transplanted into final growing bags (slabs) soaked with nutrient solution and strung-up. The plant is trained along horizontal wires to the next plant or up to the wire with lateral shoots trained in umbrella fashion. The high wire system is becoming popular in newly constructed high gutter greenhouses. In this system, a single stem or two stems per plant are trained along the strings with all side shoots pruned off. Plants are generally grown in paired rows with a walkway between each pair. Heating pipes are located in the walkway or within the rows. Plant spacing varies depending on the production system.

Throughout the growing season, growing points and older leaves are pruned off to allow lateral stems to grow downward and along the wires. This allows good light penetration that ensures optimum fruit development and colour. In high wire production systems, all side shoots are removed and fruit develops on a single stem. Cucumber fruit is also pruned to ensure a proper balance between foliage and fruit load. Fruit load varies with time of planting (winter, spring or fall or late fall). Pruning programs vary depending on the growing and training system used. Growing conditions (i.e. the number of irrigation cycles, pH of the nutrient solution, CO<sub>2</sub>



levels, media and greenhouse temperature, light intensity, aeration of re-circulating nutrient solution, etc.) are optimized to ensure strong growth and plant vigour which aids in disease resistance. Drip fertigation supplies nutrients and water to plants. Computer control systems continually monitor and regulate temperature, light, humidity, irrigation and nutrient solutions in the greenhouse. The electrical conductivity (EC) and pH of nutrient solutions is monitored continually during the crop growth cycles and nutrient levels are adjusted accordingly.

A cucumber plant can produce mature fruit two to three weeks after transplanting and will continue to produce fruit for approximately 60 to 150 days. Cucumbers are parthenocarpic, as they do not require pollination for fruit set. The time from flowering to harvest is about 10 to 14 days. At harvest, the fruit stalk is cut cleanly to promote rapid healing of the wound and minimize disease development. Fruit is harvested daily or every other day depending on production and the time of year. Fruit is stored at 13°C, in an area free from drafts and sources of ethylene, which can cause the fruit to yellow. The fruit is shrink-wrapped, often on-site, to avoid desiccation.

At least a dozen varieties of long English cucumber are grown across Canada. Varieties which are powdery mildew tolerant ('PMT' varieties) have been available for a few years, but these generally produce a lower yield. As a result, growers often grow standard varieties early in the year then switch to PMT varieties later in the season when light conditions are more favourable for these cultivars. However, some growers use PMT varieties year-round due to mildew pressure and the greater tolerance of these varieties to low light levels during the winter months.

Most growers produce three crops of long English cucumbers per year, although a few larger growers now use a four-crop system to produce a crop 50 weeks per year. Some smaller growers use a two-crop system. In Alberta, cucumber production is most significant in winter under supplemental light.

Mini-cucumbers or gherkins make up a small portion of the total crop, however production of these is expanding in Ontario and British Columbia.

**Table 3. Greenhouse cucumber production and pest management schedule in Canada**

PRODUCTION STAGE	ACTIVITY	ACTION
Seeding	Greenhouse and Media Care	Preparation of the propagation house to ensure it is clean and free of pests and crop debris; setting of appropriate temperature for seed germination
	Disease Management	Sowing of fungicide-treated seed; maintenance of appropriate temperature and moisture levels to promote germination and to prevent disease development
	Insect Management	Monitoring and control of fungus gnats
Plant Raising	Plant Care	Maintenance of appropriate temperature and wetness of the Rockwool blocks; use of supplemental lighting as needed; spacing and staking of plants
	Disease Management	Application of seedling fungicide drenches to control damping-off; control of fungus gnats that can spread root rot organisms with biological control agents or other methods
	Insect Management	Monitoring and control of fungus gnats, thrips, whiteflies, loopers and lygus bugs as needed; maintaining beneficial insect populations and application of insecticides as needed
	Weed Management	Maintaining a three-metre wide vegetation-free zone around the greenhouse
Production and Harvest	Plant Care	Fruit pruning, lateral pruning and training throughout the harvest period as appropriate to the time of year and variety; monitoring of nutrient solution EC and pH; removal of two to three lower leaves every 10 to 14 days; maintaining appropriate environmental controls: temperature, light intensity, CO <sub>2</sub> , humidity, etc.
	Disease Management	Use of disease preventative approaches when harvesting: clean, sharp knives and tools disinfected periodically; harvesting into disinfected bins and promptly storing; monitoring for diseases and applying fungicides as needed; maintaining adequate greenhouse environment (temperature, humidity, light, etc.) to prevent condensation on the plants; application of proper irrigation to avoid excessive or inadequate moisture in the slabs and to ensure adequate nutrient levels
	Insect Management	Maintenance of the greenhouse to keep insect pests out: repair of cracks, use of screens, etc.; weekly monitoring for insect and mite pests using sticky cards and plant inspection; use of beneficial predators and parasites as appropriate and judicious application of insecticides, if necessary
	Weed Management	Maintaining a three-metre wide vegetation-free zone around the greenhouse
Post-Harvest	Fruit Care	Storing and shipping at appropriate temperature (13°C), away from drafts or sources of ethylene; shrink-wrapping fruit to reduce moisture loss
	Greenhouse Care	Thorough cleaning between crops; removal and proper disposal of plant debris; disinfection of greenhouse at the end of the year

## ***Abiotic Factors Limiting Production***

### **Temperature**

Greenhouse cucumbers are highly sensitive to temperature extremes and sudden changes in temperature. Temperature affects the rate of plant development, fruit length, colour and the balance between vegetative growth and fruit development. Low temperatures may harm greenhouse cucumber fruit on the vine or in post-harvest storage. The optimum temperature for seed germination is 26 to 28°C; subsequently, temperature is maintained at an average of 21°C in the production house for an optimum balance between vegetative and fruit growth. Day temperatures are manipulated by venting. Lowering the day or night temperature too quickly or below the recommended minimum can result in chilling injury. Symptoms are more severe on certain cultivars and under low light conditions. Preventing cold drafts and avoiding the use of cold water when spraying the plants with pesticides lessens the risk of chilling injury.

### **Other environmental factors**

Humidity is closely monitored and controlled for greenhouse cucumber crops. Humidity that is too high or that fluctuates significantly will favour the development of diseases such as powdery mildew and gummy stem blight. Sudden changes in temperature that could lead to condensation on the leaves favour the development of diseases including botrytis grey mould, downy mildew, gummy stem blight, fusarium diseases and others.

The levels of CO<sub>2</sub> are also monitored and modified according to the stage of plant development and cultivar. Temperature, humidity and CO<sub>2</sub> levels are adjusted for light conditions. Low light intensity or fluctuations in light intensity can cause curled or pale fruit.

### **Media and nutrient solution quality**

Nutrients and water are provided to greenhouse cucumber plants through a recirculating (hydroponic) water system with drippers delivering the nutrient solution to each plant. The salt concentration or electrical conductivity (EC), and the pH of the nutrient solution are tested frequently. The concentration of fertilizer and amount of water applied varies depending on the time of year, the size of the plant and the environmental conditions in the greenhouse. Cucumbers are susceptible to drought stress and up to 30 irrigation cycles may be applied per day in hot, sunny conditions. However, over-saturation of the media and the subsequent lack of oxygen in the root zone favours the development of Pythium root rot. During fruiting, a higher EC solution may be applied to increase fruit quality and shelf life. Calcium deficiency is the most common nutritional problem and results in light green or yellowish areas on mid-section leaves. Calcium deficiency can occur in the younger, rapid plant growth stage. When this occurs, upper leaves become rounded and cupped downward and may have yellow to brown edges. Excesses of major or minor nutrients can result in toxicity symptoms on the plants.

### **Premature fruit yellowing**

Premature fruit yellowing or light-coloured fruit is associated with low nitrogen (low EC), high temperatures, over-maturity, low light levels and high humidity. The following measures may reduce fruit yellowing: increasing the amount of light reaching the fruit; reducing the number of fruits per plant; and increasing the concentration of fertilizer in the nutrient solution.

### **Root death**

Stresses such as temperature extremes, high EC levels, poor oxygenation of the nutrient solution or too heavy a fruit load can cause sudden root death. Plants wilt abruptly and die within five to eight hours. Once sudden root death occurs, it is irreversible.

### **Other physiological disorders**

Soft neck, which occurs when the stem shrivels and loses water just after harvest, is associated with low relative humidity, the harvesting of immature fruit and a large fruit load.

Black, discoloured fruit is associated with lack of plant vigour, water (drought) stress, high EC and sudden cloudy / sunny transitional weather.

Aborted fruit is associated with high fruit load, low light levels, a poor root system and high temperatures during periods of low light. This can also be caused by thrips feeding activity and diseases such as gummy stem blight.

Fruit curling is associated with fluctuations in light intensity and moisture, mechanical injury, chilling injury and other factors such as thrips feeding injury.

## ***Diseases***

### ***Key issues***

- The registration of new classes of reduced risk fungicides including biofungicides is needed for the management of a number of diseases in greenhouse cucumber and for resistance management. It is important that new disease control products have short pre-harvest intervals and short re-entry times to facilitate frequent plant care activities and harvesting of the crop.
- The development of resistant cultivars or root grafting stock is required for the management of a number of diseases of greenhouse cucumber.
- Diseases such as black rot, fusarium rot and Pythium root rot diseases cause severe problems in organic production systems where cucumbers are often grown in soil. There is a need for the development of cultural approaches, biopesticides and other control products that can be used in organic production systems.
- There is a need for the development of new cultivars resistant to powdery mildew.

**Table 4. Occurrence of diseases in greenhouse cucumber production in Canada<sup>1,2</sup>**

Disease	British Columbia	Alberta	Ontario
Damping-off			
Downy mildew			
Black rot			
Botrytis grey mould			
Gummy stem blight			
Powdery mildew			
White mould			
Pythium crown rot and root rot			
Crazy root (root mat disorder)			
<b>Viral diseases</b>			
Beet pseudo-yellows			
Cucumber green mottle mosaic virus			
Cucumber mosaic virus			
Widespread yearly occurrence with high pest pressure.			
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.			
Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pest pressure.			
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.			
Pest is present and of concern, however little is known of its distribution, frequency and pressure.			
Pest not present.			
Data not reported.			

<sup>1</sup>Source: Greenhouse cucumber stakeholders in reporting provinces (British Columbia, Alberta and Ontario); the data reflect the 2017, 2016 and 2015 production years.

<sup>2</sup>Refer to Appendix 1 for a detailed explanation of colour coding of occurrence data.

**Table 5. Adoption of disease management practices in greenhouse cucumber production in Canada<sup>1</sup>**

Practice / Pest		Grey mould	Downy mildew	Fusarium wilt	Gummy stem blight	Powdery mildew	Pythium crown and root rot
Avoidance	Rotation with non-host crops						
	Optimizing fertilization for balanced growth and to minimize stress						
	Minimizing wounding and insect damage to limit infection sites						
	Control of disease vector						
	Varietal selection / use of resistant or tolerant varieties						
Prevention	Equipment sanitation						
	End of season disinfection of structure						
	Use of sterile growing medium						
	Optimize ventilation and air circulation in crop						
	Maintain optimum temperature and humidity conditions						
	Modification of plant density (row or plant spacing; seeding rate)						
	Water / irrigation management						
	Culling and proper disposal of infected plants and plant parts						
	Isolation of infected areas and working in these sections last						
	Restriction of movement of workers and visitors to greenhouse to minimize / prevent disease introduction and spread						

... continued

**Table 5. Adoption of disease management practices in greenhouse cucumber production in Canada<sup>1</sup> (continued)**

Practice / Pest		Grey mould	Downy mildew	Fusarium wilt	Gummy stem blight	Powdery mildew	Pythium crown and root rot
Monitoring	Regular monitoring throughout the crop cycle						
	Maintaining records to track diseases						
	Use of indicator plants						
Decision making tools	Economic threshold						
	Weather conditions						
	Crop specialist recommendation or advisory bulletin						
	Decision to treat based on observed disease symptoms						
	Decision to treat based on stage of crop development						
Suppression	Use of biopesticides (microbial and non-conventional pesticides)						
	Use of diverse product modes of action for resistance management						
	Spot (targeted) application of biopesticides and pesticides						
	Use of biopesticides and pesticides that are compatible with beneficial organisms						
	Use of novel biopesticides and pesticide application techniques						
	Follow sanitation practices						

... continued



**Table 5. Adoption of disease management practices in greenhouse cucumber production in Canada<sup>1</sup> (continued)**

Practice / Pest		Grey mould	Downy mildew	Fusarium wilt	Gummy stem blight	Powdery mildew	Pythium crown and root rot
<b>Crop specific practices</b>	Management of greenhouse environment to prevent condensation on foliage						
<b>New practices (by province)</b>	Use of vertical fans for air movement (Alberta)						
	Use of vapour pressure deficit (VPD) for climate control (Alberta)						
This practice is used to manage this pest by at least some growers.							
This practice is not used by growers to manage this pest.							
This practice is not applicable for the management of this pest.							
Information regarding the practice for this pest is unknown.							

<sup>1</sup>Source: Greenhouse cucumber stakeholders in reporting provinces (British Columbia, Alberta and Ontario); the data reflect the 2017, 2016 and 2015 production years.

## **Seedling Damping-off (*Pythium* spp., *Fusarium* spp., *Rhizoctonia* spp. and other fungi)**

### ***Pest Information***

*Damage:* Seedlings are susceptible to damping-off before or after emergence. Symptoms of infection include pale-brown and water-soaked stem tissue, which usually collapses and causes the seedling to wilt and fall over.

*Life Cycle:* Damping-off pathogens are common in various non-sterilized growing media. Optimum temperatures vary for different species of *Pythium* and other fungi associated with damping-off. Infection is favoured by high moisture in the growing medium. The pathogens can be spread in irrigation water. Fungus gnats spread *Pythium* sporangia (spore producing structures). Their feeding wounds on roots create entry points for damping-off organisms.

### ***Pest Management***

*Cultural Controls:* Sowing seeds in sterile propagation media and minimizing the overcrowding of seedlings will help reduce disease. Strict water regulation and avoiding seedling stress will reduce disease development. Good water management is key to minimizing *Pythium* rot problems. Avoiding well water or stream water may prevent the spread of disease as these may carry *Pythium*.

*Resistant Cultivars:* None available.

### ***Issues for Damping-off***

None identified.

## **Downy Mildew (*Pseudoperonospora cubensis*)**

### ***Pest Information***

*Damage:* This disease is common in fall crops or where ventilation is inadequate and humidity is high. Symptoms appear as angular, light-green patches between the veins of leaves. Leaves may shrivel-up and turn brown if severely infected. Although downy mildew usually does not directly affect the fruit, the fruit may be undersized and of poor quality due to the loss of leaves.

*Life Cycle:* The downy mildew pathogen is an obligate parasite that overwinters in areas without killing frosts. However, it can overwinter on living cucurbit plant material growing in greenhouses. Sporangia typically are carried into Canada from the US by wind and get into the greenhouse in the summer months. Spores may also spread by water, and on clothing and tools. To germinate and cause infection, sporangia require a film of water on the leaf. After landing on a leaf, sporangia release zoospores, which can swim in the film of water and enter the plant through the leaf breathing pores or stomata. Optimum infection occurs at temperatures ranging from 16 to 22°C. About four to five days after infection, new spores are produced and released into the air and spread the disease to other plants.

### ***Pest Management***

*Cultural Controls:* Preventing condensation on the leaves by controlling the night temperature and ensuring adequate ventilation so leaves dry quickly will result in conditions less favourable for disease development. Segregating new crops and older ones and practicing good sanitation including the removal of old crop debris promptly from the greenhouse will minimize disease spread. Additional management practices for downy mildew are listed in *Table 5. Adoption of disease management practices in greenhouse cucumber production in Canada.*

*Resistant Cultivars:* None available.

### ***Issues for Downy Mildew***

1. There is a need for the registration of new reduced risk products for the control of downy mildew.

## **Botrytis Grey Mould (*Botrytis cinerea*)**

### ***Pest Information***

*Damage:* *Botrytis cinerea* may infect the stem, petiole, base of the leaf, fruit stem or flowers.

The initial symptoms of grey mould are often seen on fruit peduncles at the top of the plant in summer, when fluctuating day and night temperatures result in morning condensation on the plants. Other symptoms include basal stem cankers or rotted tissue and grey-green shriveled leaves. Severe infection results in the girdling of the stem or petiole and can result in death of lateral branches, fruit stems and entire plants.

*Life Cycle:* Grey spore masses are produced by the fungus under humid conditions on infected plant parts and are the main cause of new infections. Spores can become air-borne and will spread quickly in the greenhouse. The fungus overwinters as black sclerotia in soil, on perennial plants and on plant debris.

### ***Pest Management***

*Cultural Controls:* Preventing condensation on the leaves by controlling ventilation and raising temperatures gradually prior to sunrise will make conditions less hospitable for the pathogen. As wounds provide an entry route for this disease, it is important to minimize wounding of the plants. Good sanitation between crops and when handling the plants, as well as the use of sharp, clean knives for harvesting fruit, will reduce disease. Harvesting in the morning when fruit and foliage are dry will also reduce disease development. The prompt removal of crop residue from the greenhouse will help eliminate sources of inoculum. Pruning and avoiding excessive nitrogen, to maintain a proper balance between foliage and fruit load, is also helpful since lush growth is more susceptible to infection and a heavy canopy will slow the drying of leaves. Additional management practices for botrytis grey mould are listed in *Table 5.*

*Adoption of disease management practices in greenhouse cucumber production in Canada.*

*Resistant Cultivars:* None available.

### ***Issues for Botrytis Grey Mould***

1. The registration of new, reduced-risk fungicides, including those suitable for use in organic production systems, is needed for the control of botrytis grey mould on greenhouse cucumber and to reduce the development of resistance in the pathogen population.
2. There is a need for further development of climate control strategies and other cultural practices for the management of botrytis grey mould in the greenhouse.

### **Gummy Stem Blight (*Didymella bryoniae*, syn. *Mycosphaerella melonis*, syn. *M. citrullina*)**

#### ***Pest Information***

**Damage:** Gummy stem blight can affect stems foliage and fruit. The first sign of gummy stem blight is an amber-red gummy exudate on the stem tissue where the fungal infection occurred. The associated lesions grow, girdle and eventually the plant tissue above the lesion dies. Infected fruit becomes shriveled at the flower-end. Traces of brown rotting tissue may also occur internally in diseased fruit. This disease may cause post-harvest problems because healthy-looking fruit that is infected by gummy stem blight may spoil before it reaches the market. This disease renders plants more susceptible to other diseases, such as botrytis grey mould and powdery mildew and also makes them more attractive to aphids.

**Life Cycle:** The gummy stem blight pathogen may stay dormant for up to two years as mycelium in undecomposed plant debris. It produces two types of spores, one that can be spread by splashing water (conidia) and the other that can be spread by air currents (ascospores). Spores can also be spread by physical contact of workers, on clothing and on tools. Moisture on leaves makes the cucumber plant susceptible to infection by this fungus. Secondary spores may be produced on diseased plants in as little as four days after initial infection and these can then infect flowers and wounded tissue.

#### ***Pest Management***

**Cultural Controls:** The removal of all crop debris from the greenhouse at the end of each crop cycle and the placement of cull piles away and downwind of the greenhouse, will help to reduce sources of infection. The cleaning and disinfection of pruning shears and other tools and equipment in contact with cucumber plants will also help minimize spread of the disease. Other practices which help reduce disease development include: preventing condensation on the plants by providing good ventilation and raising temperatures gradually prior to sunrise; harvesting fruit in the morning when it is cool and dry; and harvesting frequently to avoid over ripening of fruit. Ultraviolet (UV)-absorbing plastic films may help reduce the incidence of gummy stem blight as UV light is required for *D. bryoniae* spore production. Additional management practices for gummy stem blight are listed in *Table 5. Adoption of disease management practices in greenhouse cucumber production in Canada*.

**Resistant Cultivars:** None available.

### ***Issues for Gummy Stem Blight***

1. The registration of biopesticides and other reduced-risk fungicides in new classes is required for the control of gummy stem blight and for resistance management. As cucumbers are harvested daily, it is important that newly registered materials have short re-entry intervals and short pre-harvest intervals.
2. The development of cultivars resistant to gummy stem blight is required.
3. There is a need for further development of climate control strategies and other cultural practices for the management of gummy stem blight in the greenhouse.

### **Powdery Mildew [*Podosphaera xanthii* (*Sphaerotheca fuliginea*) and *Erysiphe cichoracearum*]**

#### ***Pest Information***

**Damage:** Powdery mildew causes round, white patches of fungal mycelium and spores on the upper surface of older leaves. These patches enlarge and can eventually cover the entire surface of the leaf. Occasionally the disease appears on petioles and stems as well. The fungus absorbs nutrients from the leaf cells. Diseased leaves eventually dry up and die. Plants infected early, during fruit development have a lower fruit count and produce smaller fruits.

**Life Cycle:** Powdery mildew spores can germinate under conditions of low relative humidity (20%), however, infection rates are higher with higher humidity levels. Spores are usually present in mid-summer when temperatures range between 20 and 26°C. Spores may survive for as long as 10 days in the greenhouse. Secondary spores are produced in lesions five to seven days after the initial infection of the leaf surface. They spread easily with air currents in the greenhouse. The disease often appears first in corners near vents or doorways, where humidity and temperature are less well-controlled. Spores may survive outdoors on cull piles and crop debris or on field cucurbit crops.

#### ***Pest Management***

**Cultural Controls:** Sanitation practices to reduce disease sources include: removal and destruction of infected leaves when the disease is first seen; good sanitation between crops; and the prompt removal and destruction of cull piles and old crop debris. Maintaining a uniform relative humidity of 70 to 80% will reduce disease development. Spraying the plants every two to three days with water may reduce spore buildup, but may also predispose plants to other diseases such as gummy stem blight and botrytis grey mould. Additional management practices for powdery mildew are listed in *Table 5. Adoption of disease management practices in greenhouse cucumber production in Canada*.

**Resistant Cultivars:** Powdery mildew tolerant (PMT) cultivars, such as *Enigma* and *Flamingo*, are available, but these do not yield as well as standard cultivars. As such, they are generally planted for late spring or early summer crops when conditions are most favourable for disease development.

### ***Issues for Powdery Mildew***

1. The registration of new, reduced-risk fungicides is needed for the management of powdery mildew and to facilitate fungicide rotation to minimize the risk of resistance development.
2. There is a need for the development of powdery mildew resistant or tolerant cultivars that provide good yield.
3. There is a need for the further development of cultural and environmental controls for powdery mildew.

### **White Mould (*Sclerotinia sclerotiorum*)**

#### ***Pest information***

*Damage:* White mould infects the stem and the fruit of cucumber through senescent tissues.

Infected tissues appear water-soaked and wilted. White mould is not common in greenhouse cucumber production under artificial media.

*Life Cycle:* *Sclerotinia sclerotiorum* forms hard black bodies (sclerotia) in the pith of the stem and on the surface of the fruit. Sclerotia produce apothecia which release ascospores.

Ascospores can be blown by the wind from outside the greenhouse to the aerial portions of greenhouse plants.

#### ***Pest Management***

*Cultural Controls:* This disease can be reduced by good sanitation practices inside and outside the greenhouse. Steam sterilization will kill sclerotia in soil media used in organic greenhouse production. Preventing condensation on plants, especially at flowering, will help reduce the development of disease. Good weed control around the greenhouse will eliminate potential hosts of the pathogen. Regular elimination and destruction of plant debris from the greenhouse will eliminate a potential source of the pathogen.

*Resistant Cultivars:* None available.

### ***Issues for White Mould***

None identified.

### **Pythium Crown Rot and Root Rot (*Pythium aphanidermatum* and other spp.)**

#### ***Pest Information***

*Damage:* Pythium crown rot affects plants primarily in the spring at early fruit set or later in the season (summer crops). Infected crowns become orange-brown with a soft, dry rot. When only tiny feeder roots are infected, they appear soft and water-soaked and the plants wilt, although the crown may remain white and healthy. Pythium is a water mould and can cause

severe problems in crops produced with re-circulating irrigation systems. Other *Pythium* species, such as *P. irregulare* and *P. ultimum* are also known to cause damage in greenhouse cucumber. *Pythium* outbreaks can lead to significant yield loss.

**Life Cycle:** *Pythium* species survive in soil, root debris, propagation mixes, plug transplants, and untreated water. Sporangia spread in recirculating water and germinate to produce tiny zoospores that infect root tips or wounds on the root. Fungus gnats (*Bradysia impatiens*) and shore flies (*Scatella stagnalis*) can also spread *Pythium*. Their root feeding wounds provide points of entry for the pathogen.

### ***Pest Management***

**Cultural Controls:** Disinfection of irrigation troughs, tanks and supply lines for water between crops will prevent the carry-over of *Pythium* to the next crop. Reducing water and temperature stress on the plants and ensuring good aeration of recirculating water also helps to reduce *Pythium* infection. Regular monitoring for slightly wilting plants and checking cucumber stem bases for discoloration can be helpful to diagnose the disease. A strict greenhouse sanitation program during the year, followed by a full year-end clean up will eliminate sources of disease in the greenhouse. Additional management practices for *Pythium* crown rot and root rot are listed in Table 5. *Adoption of disease management practices in greenhouse cucumber production in Canada.*

**Resistant Cultivars:** None identified.

### ***Issues for Pythium Crown Rot and Root Rot***

1. New reduced risk products, especially those with short pre-harvest intervals and biopesticides are required for the management of *Pythium* diseases.
2. Cultural and biological approaches are required for the management of *Pythium* in soil, particularly for use in organic production systems.

## ***Crazy Root or Root Mat (*Rhizobium rhizogenes*)***

### ***Pest information***

**Damage:** Crazy root disease or root mat is a bacterial disease affecting both greenhouse cucumbers and tomatoes. The disease promotes excessive root growth. In greenhouse production, roots invade the growing substrate and can block the drip irrigation system.

**Life Cycle:** The primary source of infection has not been established. The bacterium is assumed to survive in soil media and could be transmitted from transplant plugs. Disease development seems to be linked to a change in the plant hormonal system. The pathogen introduces a pRi plasmid into plant tissue which induces a genetic change in the plant.

### ***Pest Management***

**Cultural Controls:** Using disease-free plug transplants and following a strict sanitation program, including disinfection of tools and disinfection of the drip irrigation system and gutters between crops will help reduce the spread of the disease. Sterilizing the nutrient solution and

avoiding contact between roots and drip irrigation outlets will also minimize development of the disease.

*Resistant Cultivars:* None available.

#### ***Issues for Crazy Root***

None identified.

### **Fusarium Root and Stem Rot (*Fusarium oxysporum* f. sp. *radicis-cucumerinum*)**

#### ***Pest Information***

*Damage:* Symptoms of Fusarium root and stem rot include wilting of the upper leaves and declining plant vigour. The stem develops tan-pink coloured streaks extending up to 30 cm from the base and stems may become girdled. Underlying tissue becomes soft and may emit a slight odour. Roots develop a brown-black necrosis, starting from the tips. Infection will cause most damage in the first four weeks after planting.

*Life Cycle:* The fungus can grow on Rockwool blocks and in sawdust bags. Infection is favoured by high moisture in the growing media. Spores are mostly spread by water and by handling. Because the spores are contained within a slimy material, they are not easily dispersed by air. Fungus gnats and shore flies may spread spores and their feeding wounds on roots can create entry points for infection. The disease can also be carried on infected seed.

#### ***Pest Management***

*Cultural Controls:* Good sanitation practices are important in minimizing the impact of this disease. The control of fungus gnats and shore flies and disinfection of greenhouse structures, reservoirs and irrigation lines thoroughly between crops will reduce the spread of the pathogen. Other sanitation practices including the frequent disinfection of pruning shears and harvest knives when working in infected areas and the prompt removal and destruction of plant debris, will also help reduce disease spread.

*Resistant Cultivars:* None available.

#### ***Issues for Fusarium Root and Stem Rot***

1. New reduced risk products, including biopesticides suitable for use in organic systems, are required for the management of fusarium root and stem rot.
2. The development of cultivars or root grafting stock resistant to fusarium root and stem rot, would provide a useful tool for the management of this disease.
3. There is a need for further development of climate control strategies and other cultural practices for the management of fusarium root and stem rot.



## Beet Pseudo-Yellows Virus

### ***Pest Information***

*Damage:* Beet pseudo-yellows virus causes yellowing and yellow spotting between the veins of older and intermediate-aged leaves. Diseased plants are less productive.

*Life Cycle:* The virus is spread by the greenhouse whitefly and can be easily transmitted through plant to plant contact.

### ***Pest Management***

*Cultural Controls:* To minimise infections, the greenhouse whitefly must be controlled. See whitefly management description below.

*Resistant Cultivars:* None available.

### ***Issues for Pseudo-Yellows Virus***

None identified.

## Cucumber Green Mottle Mosaic Virus (CGMMV)

### ***Pest Information***

*Damage:* Cucumber Green Mottle Mosaic Virus (CGMMV) causes leaf mottling, blistering and deformities. Plant growth may be stunted. Symptoms vary depending on the strain of the virus. Damage from this disease can be extensive and can result in substantial yield loss.

*Life Cycle:* The virus is seed-borne, and can be easily transmitted through plant to plant contact, through recirculation of nutrient solutions and by handling of plants. For greenhouse grafted cucumber plants, both the scion (the fruit-producing shoot) and the rootstock may harbor the virus.

### ***Pest Management***

*Cultural Controls:* When planting a new crop, using seeds and seedlings free of CGMMV will help prevent the introduction of the disease into the crop. Close observation in the first two to three weeks after planting for the presence of virus, will allow early intervention measures to be implemented, such as removal of virus-infected seedlings, in order to restrict the spread of the virus. Avoiding the recirculation of the nutrient solution during this two- to three-week period is also helpful to prevent the spread of the virus. Strict sanitation between crops will prevent virus carry-over to the new crop.

*Resistant Cultivars:* None available.

### ***Issues for Cucumber Green Mottle Mosaic Virus***

1. Disinfection protocols and other management practices are required to help growers prevent the spread of CGMMV.
2. The development of cultivars resistant or tolerant to CGMMV is required for the management of this disease.

## **Cucumber Mosaic Virus (CMV)**

### ***Pest Information***

*Damage:* Plants infected at an early stage with CMV turn yellow, become stunted and may be killed by this virus. Newly infected leaves become wrinkled and mottled and show slight downward curling of the edges. Small, greenish translucent lesions may also appear on young leaves. Plants that become infected at a later stage set few fruits. Cucumber fruits that do develop have a yellow-green mottle over the surface, often interspersed with dark green, raised areas.

*Life Cycle:* Cucumber mosaic virus has a wide range of hosts including more than 40 angiosperm (flowering plant) families. It typically overwinters in perennial weeds. The virus is spread by aphids and in some cases by tools such as pruning knives and handling.

### ***Pest Management***

*Cultural Controls:* The spread of the disease may be restricted by controlling aphid vectors within the crop and screening greenhouse vents to prevent the entry of aphids. Working first in areas of the greenhouse with healthy plants, and finishing in diseased areas will reduce the potential of transferring the disease to healthy plants.

*Resistant Cultivars:* None available.

### ***Issues for Cucumber Mosaic Virus***

None identified.

## ***Fungicides, bactericides and biofungicides registered for disease management in greenhouse cucumber production in Canada***

Active ingredients registered for the management of diseases in greenhouse cucumbers are listed below in Table 6. *Fungicides, bactericides and biofungicides registered for disease management in greenhouse cucumber production in Canada*. This table also provides registration numbers for products registered on greenhouse cucumber as of January 15, 2020 for each active ingredient, in addition to information about chemical family and re-evaluation status. For guidance about active ingredients registered for specific diseases, the reader is referred to individual product labels available on the PMRA pesticide label database <https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management.html> and to provincial crop production guides.

**Table 6. Fungicides, bactericides and biofungicides registered for disease management in greenhouse cucumber in Canada**

Active Ingredient <sup>1</sup>	Product Registration Numbers <sup>1</sup>	Chemical Group <sup>2</sup>	Resistance Group <sup>2</sup>	Mode of Action <sup>2</sup>	Site of Action <sup>2</sup>	Re-evaluation Status (Re-evaluation Decision Document) <sup>3</sup>
<i>Aureobasidium pullulans</i> DSM 14940 and DSM 14941	31248	biological	N/A	unknown	unknown	R
<i>Bacillus amyloliquefaciens</i> strain D747 (synonym to <i>B.subtilis</i> )	31887, 31888	microbial: <i>Bacillus</i> spp. and the fungicidal lipopeptides they produce	44	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	R
<i>Bacillus subtilis</i> , strain MBI 600	28705, 28706, 28707, 28708, 30054	microbial: <i>Bacillus</i> spp. and the fungicidal lipopeptides they produce	44	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	R
<i>Bacillus subtilis</i> strain QST 713	28627, 30522	microbial: <i>Bacillus</i> spp. and the fungicidal lipopeptides they produce	44	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	R
<i>Gliocladium catenulatum</i> , strain J1446	28820, 32404	biological	N/A	unknown	unknown	R
<i>Streptomyces lydicus</i> , strain WYEC 108	28672	biological	N/A	unknown	unknown	R
<i>Streptomyces (Griseoviridis)</i> Strain K61	26265	biological	N/A	unknown	unknown	RE
<i>Trichoderma harzanium</i> Rifai strain KRL-AG2	27115, 27116, 29890, 30539, 31103, 31104, 31503, 31989	biological	N/A	unknown	unknown	R (RVD2018-19)
<i>Trichoderma harzanium</i> strain T-22	31502, 31503	biological	N/A	unknown	unknown	R (RD 2018-14)

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**Table 6. Fungicides, bactericides and biofungicides registered for disease management in greenhouse cucumber in Canada (continued)**

Active Ingredient <sup>1</sup>	Product Registration Numbers <sup>1</sup>	Chemical Group <sup>2</sup>	Resistance Group <sup>2</sup>	Mode of Action <sup>2</sup>	Site of Action <sup>2</sup>	Re-evaluation Status (Re-evaluation Decision Document) <sup>3</sup>
<i>Trichoderma virens</i> strain G-41	31989	biological	N/A	unknown	unknown	R (RD 2018-14)
<i>Trichoderma harzanium</i> Rifai strain KRL-AG2 + <i>Trichoderma virens</i> , strain G-41	30539, 31989	biological	N/A	unknown	unknown	R (RVD2018-19) + R (RD 2018-14)
ametoctradin + dimethomorph	30321	triazolo-pyrimidylamine + cinnamic acid amide	45 + 40	C8: respiration + H5: cell wall biosynthesis	complex III: cytochrome bc1 (ubiquinone reductase) at Qo site, stigmatellin binding sub-site + cellulose synthase	R + RE (PRVD2019-03)
boscalid + pyraclostrobin	27985	pyridine-carboxamide + methoxy-carbamate	7 + 11	C2: respiration + C3: respiration	complex II: succinate-dehydrogenase + complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	R + R
captan	9582, 23691, 24613, 26408, 31949	phthalimide (electrophile)	M04	multi-site contact activity	multi-site contact activity	R (RVD2018-12)
citric acid + lactic acid	30110, 30459	not classified	N/A	unknown	unknown	R
copper octanoate	31825	inorganic (electrophile)	M01	multi-site contact activity	multi-site contact activity	R

... continued

**Table 6. Fungicides, bactericides and biofungicides registered for disease management in greenhouse cucumber in Canada (continued)**

Active Ingredient <sup>1</sup>	Product Registration Numbers <sup>1</sup>	Chemical Group <sup>2</sup>	Resistance Group <sup>2</sup>	Mode of Action <sup>2</sup>	Site of Action <sup>2</sup>	Re-evaluation Status (Re-evaluation Decision Document) <sup>3</sup>
copper (present as cupric ammonium formate and tannate complex)	33376	inorganic (electrophile)	M01	multi-site contact activity	multi-site contact activity	R
cyazofamid	27984, 30392	cyano-imidazole	21	C4: respiration	complex III: cytochrome bc1 (ubiquinone reductase) at Qi site	R
cyprodinil	30185	anilino-pyrimidine	9	D1: amino acids and protein synthesis	methionine biosynthesis (proposed) (cgs gene)	R
cyprodinil + difenoconazole	30827	anilino-pyrimidine + triazole	9 + 3	D1: amino acids and protein synthesis + G1:sterol biosynthesis in membranes	methionine biosynthesis (proposed) (cgs gene) + C14-demethylase in sterol biosynthesis (erg11/cyp51)	R + R
cyprodinil + fludioxonil	30185, 30763	anilino-pyrimidine + phenylpyrrole	9 + 12	D1: amino acids and protein synthesis + E2: signal transduction	methionine biosynthesis (proposed) (cgs gene) + MAP/histidine-kinase in osmotic signal transduction (os-2, HoG1)	R + R (RVD2018-04)

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**Table 6. Fungicides, bactericides and biofungicides registered for disease management in greenhouse cucumber in Canada (continued)**

Active Ingredient <sup>1</sup>	Product Registration Numbers <sup>1</sup>	Chemical Group <sup>2</sup>	Resistance Group <sup>2</sup>	Mode of Action <sup>2</sup>	Site of Action <sup>2</sup>	Re-evaluation Status (Re-evaluation Decision Document) <sup>3</sup>
dazomet (soil fumigant)		methyl isothiocyanate generator	8F <sup>4</sup>	miscellaneous non-specific (multi-site) inhibitor	miscellaneous non-specific (multi-site) inhibitor <sup>4</sup>	R (RVD2018-34)
fenhexamid	26132	hydroxyanilide	17	G3: sterol biosynthesis in membranes	3-keto reductase, C4-demethylation (erg27)	RE (PRVD2020-01)
ferbam	20136, 20536	dithiocarbamate and relatives (electrophile)	M03	multi-site contact activity	multi-site contact activity	R (RVD2018-37)
fludioxonil	31528	phenylpyrrole	12	E2: signal transduction	MAP/histidine- kinase in osmotic signal transduction (os-2, HOG1)	R (RVD2018-04)
fluopyram	32208	pyridinyl-ethyl-benzamide	7	C2: respiration	complex II: succinate-dehydrogenase	R
garlic powder	29667, 30692	biological	N/A	unknown	unknown	R
<i>Gliocladium catenulatum</i> , strain J1446	32404, 28820	biological	N/A	unknown	unknown	R
hydrogen peroxide + peroxyacetic acid	32907	inorganic	N/A	unknown	unknown	R (RVD2018-09, RVD 2018-10)
iprodione	n/a	dicarboximide	2	E3: signal transduction	MAP/ histidine-kinase in osmotic signal transduction (os-1, Daf1)	PO (RVD2018-16)

...continued

**Table 6. Fungicides, bactericides and biofungicides registered for disease management in greenhouse cucumber in Canada (continued)**

Active Ingredient <sup>1</sup>	Product Registration Numbers <sup>1</sup>	Chemical Group <sup>2</sup>	Resistance Group <sup>2</sup>	Mode of Action <sup>2</sup>	Site of Action <sup>2</sup>	Re-evaluation Status (Re-evaluation Decision Document) <sup>3</sup>
mancozeb	10526	dithiocarbamate and relatives (electrophile)	M03	multi-site contact activity	multi-site contact activity	R (RVD2018-21)
mandipropamid	29074, 30759	mandelic acid amide	40	H5: cell wall biosynthesis	cellulose synthase	R
mandipropamide + oxathiapiproline	32805	mandelic acid amide + piperidiny-thiazole isoxazoline	40 + 49	H5: cell wall biosynthesis + F9: lipid synthesis or transport / membrane integrity or function	cellulose synthase + lipid homeostasis and transfer / storage	R + R
metalaxyl-M and S-isomer	25384, 28474	acylalanine	4	A1: nucleic acids synthesis	RNA polymerase I	R
mineral oil	27666	not classified	N/A	unknown	unknown	R
myclobutanil	22399	triazole	3	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	R
oxathiapiprolin	32101, 32103, 32146	piperidiny-thiazole isoxazoline	49	F9: lipid synthesis or transport / membrane integrity or function	lipid homeostasis and transfer / storage	R
penthiopyrad	30331	pyrazole-4-carboxamide	7	C2: respiration	complex II: succinate-dehydrogenase	R

...continued

**Table 6. Fungicides, bactericides and biofungicides registered for disease management in greenhouse cucumber in Canada (continued)**

Active Ingredient <sup>1</sup>	Product Registration Numbers <sup>1</sup>	Chemical Group <sup>2</sup>	Resistance Group <sup>2</sup>	Mode of Action <sup>2</sup>	Site of Action <sup>2</sup>	Re-evaluation Status (Re-evaluation Decision Document) <sup>3</sup>
phosphites (mono and dibasic sodium, potassium and ammonium phosphite)	30449, 30648	not classified	N/A	unknown	unknown	R
phosphorous acid (mono and di-potassium salts of phosphorous acid)	30648, 30649, 30654	ethyl phosphonate	P07	P7: host plant defence induction	phosphonates	R
polyoxin D zinc salt	32688, 32918	polyoxin	19	H4: cell wall biosynthesis	H4: chitin synthase	R
potassium bicarbonate	28095, 31091	diverse	N/A	not classified	unknown	R
propamocarb hydrochloride	26288	carbamate	28	F4: lipid synthesis and membrane integrity	cell membrane permeability, fatty acids (proposed)	R
pydiflumetofen	33019	N-methoxy-(phenyl-ethyl)-pyrazole-carboxamide	7	C2: respiration	complex II: succinate dehydrogenase	R
pyrimethanil	29975	anilino-pyrimidine	9	D1: amino acids and protein synthesis	methionine biosynthesis (proposed) (cgs gene)	R
<i>Reynoutria sachalinensis</i> (extract)	30199	complex mixture, ethanol extract (anthraquinones resveratrol)	P05	P5: host plant defence induction	anthraquinone elicitors	R

...continued



**Table 6. Fungicides, bactericides and biofungicides registered for disease management in greenhouse cucumber in Canada (continued)**

Active Ingredient <sup>1</sup>	Product Registration Numbers <sup>1</sup>	Chemical Group <sup>2</sup>	Resistance Group <sup>2</sup>	Mode of Action <sup>2</sup>	Site of Action <sup>2</sup>	Re-evaluation Status (Re-evaluation Decision Document) <sup>3</sup>
sulphur	14653, 18836, 29487, 31869	inorganic (electrophiles)	M02	multi-site contact activity	multi-site contact activity	R
tea tree oil ( <i>Melaleuca alternifolia</i> )	30910	terpene hydrocarbons and terpene alcohols	46	F7: lipid synthesis and membrane integrity	cell membrane disruption (proposed)	R
<b>Greenhouse Treatment</b>						
potassium peroxymonosulfate (disinfectant)	24210	Potassium peroxymonosulfate Sulfate	N/A	unknown	diverse	R

<sup>1</sup>Source: Pest Management Regulatory Agency label database ([www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php](http://www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php)). The list includes all active ingredients registered as of January 15, 2020. While every effort has been made to ensure all fungicides, bactericides and biofungicides registered in Canada on greenhouse cucumber have been included in this list, some active ingredients or products may have been inadvertently omitted. 'Numerous products' is entered where there are more than ten products for an active ingredient. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The product label is the final authority on pesticide use and should be consulted for application information. The information in this table should not be relied upon for pesticide application decisions and use.

<sup>2</sup>Source: Fungicide Resistance Action Committee. *FRAC Code List 2019: Fungicides sorted by mode of action (including FRAC code numbering)*. February 2019. ([www.frac.info/](http://www.frac.info/)) (accessed September 17, 2019).

<sup>3</sup>PMRA re-evaluation status as published in Re-evaluation Note REV2019-05, Pest Management Regulatory Agency Re-evaluation and Special Review Work Plan 2019-2024 and other re-evaluation documents: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES\* (yellow) - under re-evaluation and special review. Other codes include: DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

<sup>4</sup>Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (Version 9.3; June 2019)* (excluding pheromones) ([www.irac-online.org](http://www.irac-online.org)) (accessed September 17, 2019).

## ***Insects and Mites***

### ***Key issues***

- Many greenhouse pests have resistance to a number of commonly used greenhouse pesticides. The registration of new, reduced risk insecticides and miticides that are safe for beneficial insects is required for the control of common pests and for resistance management.

**Table 7. Occurrence of insect and mite pests in greenhouse cucumber production in Canada<sup>1,2</sup>**

Insect and mite	British Columbia	Alberta	Ontario
<b>Aphids</b>			
Melon (cotton) aphid			
<b>Cucumber beetles</b>			
Spotted cucumber beetle			
Striped cucumber beetle			
Fungus gnats and shore flies			
<b>Caterpillars (various species)</b>			
Cabbage looper			
Lygus bugs			
Tarnished plant bug			
<b>Mites</b>			
Two-spotted spider mite			
Broad mite			
<b>Thrips</b>			
Onion thrips			
Western flower thrips			
Eastern flower thrips			
European flower thrips			
<b>Whiteflies</b>			
Greenhouse whitefly			
Sweet potato whitefly			
Widespread yearly occurrence with high pest pressure.			
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.			
Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pest pressure.			
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.			
Pest is present and of concern, however little is known of its distribution, frequency and pressure.			
Pest not present.			
Data not reported.			

<sup>1</sup>Source: Greenhouse cucumber stakeholders in reporting provinces (British Columbia, Alberta and Ontario); the data reflect the 2017, 2016 and 2015 production years.

<sup>2</sup>Refer to Appendix 1 for a detailed explanation of colour coding of occurrence data.

**Table 8. Adoption of insect and mite pest management practices in greenhouse cucumber production in Canada<sup>1</sup>**

Practice / Pest		Aphids	Fungus gnats and shore flies	Caterpillars (various species)	Two-spotted spider mite	Thrips	Whiteflies
Avoidance	Rotation with non-host crops						
	Optimizing fertilization for balanced growth						
	Minimizing wounding to reduce attractiveness to pests						
	Use of trap crops						
	Use of physical barriers to prevent pest entry into greenhouses						
Prevention	Equipment sanitation						
	End of season crop residue removal and clean-up						
	Pruning out / removal of infested material throughout the cropping season						
Monitoring	Regular monitoring throughout crop cycle						
	Maintaining records to track pests						
	Use of indicator plants						
Decision making tools	Economic threshold						
	Weather conditions						
	Crop specialist recommendation or advisory bulletin						
	Decision to treat based on observed presence of pest at susceptible stage of life cycle						
	Decision to treat based on observed crop damage						
	Decision to treat based on crop stage						

... continued

**Table 8. Adoption of insect and mite pest management practices in greenhouse cucumber production in Canada<sup>1</sup> (continued)**

Practice / Pest		Aphids	Fungus gnats and shore flies	Caterpillars (various species)	Two-spotted spider mite	Thrips	Whiteflies
Suppression	Use of biopesticides (microbial and non-conventional pesticides)						
	Release of arthropod biological control agents						
	Use of banker plants as reservoirs or refuges for beneficial insects and mites						
	Trapping						
	Use of diverse pesticide modes of action for resistance management						
	Spot (targeted) application of pesticides						
	Use of pesticides that are compatible with beneficial organisms						
	Use of novel pesticide application techniques (e.g. use of pollinating insects to carry biopesticides)						
	Follow sanitation practices						
New Practices (by province)	Algae control (Alberta)						
This practice is used to manage this pest by at least some growers.							
This practice is not used by growers to manage this pest.							
This practice is not applicable for the management of this pest.							
Information regarding the practice for this pest is unknown.							

<sup>1</sup>Source: Greenhouse cucumber stakeholders in reporting provinces (British Columbia, Alberta and Ontario); the data reflect the 2017, 2016 and 2015 production years.

**Table 9. Biological control agents commercially available for the management of insect and mite pests in greenhouse vegetable crops in Canada<sup>1,2</sup>**

<b>Pest</b>	<b>Biological Control Agent<sup>1</sup></b>	<b>Description</b>
Aphids	<i>Aphelinus abdominalis</i> <i>Aphidius colemani</i> <i>Aphidius ervi</i> <i>Aphidius matricariae</i>	Parasitic wasp
	<i>Aphidoletes aphidimyza</i>	Predatory midge
	<i>Adalia bipunctata</i> <i>Hippodamia convergens</i> <i>Cryptolaemus montrouzieri</i>	Predatory lady beetle
	<i>Chrysoperla</i> (= <i>Crysopa</i> ) <i>carnea</i> <i>Chrysoperla rufilabris</i>	Predatory lacewing
Caterpillars	<i>Trichogramma spp.</i> <i>Chrysoperla rufilabris</i>	Parasitic wasp Predatory lacewing
Fungus gnats	<i>Steinernema feltiae</i>	Predatory nematode
	<i>Dalotia</i> (= <i>Atheta</i> ) <i>coriaria</i>	Predatory beetle
	<i>Gaeolaelaps gillespiei</i> <i>Stratiolaelaps scimitus</i> (= <i>Hypoaspis miles</i> )	Predatory mite
Leafminers	<i>Dacnusa siberica</i> <i>Diglyphus isaea</i>	Parasitic wasp
Mites (two-spotted spider mite)	<i>Amblyseius andersoni</i> <i>Neoseiulus</i> (= <i>Amblyseius</i> ) <i>californicus</i> <i>Neoseiulus</i> (= <i>Amblyseius</i> ) <i>fallacis</i> <i>Phytoseiulus persimilis</i>	Predatory mite
	<i>Feltiella acarisuga</i>	Predatory midge
	<i>Stethorus punctillum</i>	Predatory beetle
	<i>Chrysoperla rufilabris</i>	Predatory lacewing

... continued

**Table 9. Biological control agents commercially available for the management of insect and mite pests in greenhouse vegetable crops in Canada<sup>1,2</sup> (continued)**

<b>Pest</b>	<b>Biological Control Agent<sup>1</sup></b>	<b>Description</b>
Mealybug	<i>Cryptolaemus montrouzieri</i>	Predatory lady beetle
	<i>Chrysoperla</i> (= <i>Chrysopa</i> ) <i>carnea</i> <i>Chrysoperla rufilabris</i> <i>Micromus variegatus</i>	Predatory lacewing
Thrips (western flower thrip)	<i>Steinernema feltiae</i>	Predatory nematode
	<i>Amblydromalus limonicus</i> <i>Amblyseius swirskii</i> <i>Iphesius</i> (= <i>Amblyseius</i> ) <i>degenerans</i> <i>Neoseiulus</i> (= <i>Amblyseius</i> ) <i>cucumeris</i> <i>Gaeolaelaps gillespiei</i> <i>Stratiolaelaps scimitus</i> (= <i>Hypoaspis miles</i> )	Predatory mite
	<i>Dalotia</i> (= <i>Atheta</i> ) <i>coriaria</i>	Predatory beetle
	<i>Orius insidiosus</i>	Predatory bug
Whiteflies: Greenhouse whitefly and/or silverleaf whitefly, sweet potato whitefly	<i>Chrysoperla</i> (= <i>Chrysopa</i> ) <i>carnea</i> <i>Chrysoperla rufilabris</i> <i>Micromus variegatus</i>	Predatory lacewing
	<i>Amblydromalus limonicus</i> <i>Amblyseius swirskii</i>	Predatory mite
	<i>Delphastus catalinae</i>	Predatory beetle
	<i>Dicyphus hesperus</i>	Predatory bug
	<i>Encarsia formosa</i> <i>Eretmocerus eremicus</i>	Parasitic wasp

<sup>1</sup>Source: R. Buitenhuis, Research Scientist Biological Control. Vineland Research and Innovation Centre, Vineland Station, ON, Canada

<sup>2</sup>For information on biological agent sources, see Beneficial Insects and Mites Suppliers, OMAFRA. ([www.omafr.gov.on.ca/english/crops/resource/beneficial.htm](http://www.omafr.gov.on.ca/english/crops/resource/beneficial.htm)) (accessed online December 31, 2019)

## Melon (Cotton) Aphid (*Aphis gossypii*)

### *Pest Information*

**Damage:** The melon aphid feeds on a variety of plants, including several vegetable crops. Heavy feeding causes leaves to wilt and collapse. Younger leaves may become dark green and stunted. Aphids secrete honeydew that supports the growth of black sooty mould, reducing fruit quality. Aphids may also transmit cucumber mosaic virus. Aphid populations can increase very quickly, especially under warm, humid conditions, and an unchecked infestation may result in severe yield reduction and possibly crop failure. Even in small numbers, aphids may make a crop unmarketable due to their presence.

**Life Cycle:** Melon aphids are adapted to high temperatures. Under ideal conditions, populations can increase by as much as 10 to 12-fold per week on cucumber. Adults produce on average 40 nymphs in seven days. Once a colony becomes crowded, winged adults migrate to neighboring plants. Winged adults are usually the source of primary infestations, often moving into greenhouses from the outdoors.

### *Pest Management*

**Cultural Controls:** Screening vents and maintaining a weed-free zone around the greenhouse will help to prevent aphids from entering the greenhouse. Avoiding the growing of ornamental plants and other vegetable crops in the greenhouse will also eliminate sources of aphids.

Additional management practices for aphids are listed in *Table 8. Adoption of insect and mite pest management practices in greenhouse cucumber production in Canada.*

**Biological Controls:** Biological control agents commercially available for the management of aphids in the greenhouse are listed in Table 9.

**Resistant Cultivars:** None available.

### *Issues for Melon (Cotton) Aphid*

1. There is a need for the registration of new, reduced-risk pesticides that are not harmful to biological control agents, to permit the rotation of chemicals, for resistance management.

## Striped Cucumber Beetle (*Acalymma vittatum*) and Spotted Cucumber Beetle or Southern Corn Rootworm (*Diabrotica undecimpunctata*)

### *Pest Information*

**Damage:** Early beetle populations are generally the most damaging; however late-season feeding on the fruit may reduce marketable yields. Adults feed on the leaves, resulting in a “shot-hole” appearance. They also feed on stems and flowers, which reduces yield and may result in broken stems. Larvae feed on plant roots and tunnel into them causing wilting in some cases. Damage is generally minimal on older, established plants. Adult cucumber beetles are vectors of bacterial wilt and cucumber mosaic virus.



*Life Cycle:* Adult beetles overwinter in weeds and crop debris and become active in early spring. They typically do not enter greenhouses until mid-summer. Outdoors, adults feed on pollen, petals and leaves of various plants, and mate and lay eggs in the ground near host plants. The larvae hatch in about ten days and feed on the roots of the plants for about one month. Larvae pupate in the soil and adults emerge after two weeks. There is typically only one generation per year.

#### ***Pest Management***

*Cultural Controls:* Screening vents and other openings of the greenhouse, maintaining a weed free border around the greenhouse and eliminating crop debris, will minimize beetle entry into the greenhouse.

*Biological Controls:* None available.

*Resistant Cultivars:* None available.

#### ***Issues for Cucumber Beetles***

1. There is a need for the registration of reduced risk insecticides for the control of cucumber beetle in greenhouse cucumber crops.

### **Fungus Gnats (*Sciaridae: Bradysia* and *Corynoptera* spp.) and Shore Flies (*Ephydriidae* spp.)**

#### ***Pest Information***

*Damage:* Adults of these species are occasionally a nuisance through their sheer numbers. Larvae are found in growing media where they feed on decaying organic matter, fungi and algae. They may also feed on roots and root hairs of young seedlings which can become stunted. Feeding wounds provide entry sites for fungal pathogens such as pythium, phytophthora, fusarium and rhizoctonia. Fungus gnats have been shown to transmit Pythium diseases.

*Life Cycle:* Mature female fungus gnats lay eggs in moist soils, potting mixes and hydroponic media. The eggs hatch in two to four days. Larvae feed for about two weeks before pupating and maturing into an adult. The life cycle of shore flies is similar to that of fungus gnats.

#### ***Pest Management***

*Cultural Controls:* Screening vents and keeping doorways and other openings to the greenhouse closed will minimize entry by adult insects. Other cultural controls include avoiding overwatering, removing waste plant material and practicing good sanitation. Adult flies can be monitored with the use of yellow sticky traps. Additional management practices for fungus gnats and shore flies are listed in *Table 8. Adoption of insect and mite pest management practices in greenhouse cucumber production in Canada.*

*Biological Controls:* Refer to Biological control agents commercially available for the management of fungus gnats and shore flies in the greenhouse are listed in *Table 9.*

*Resistant Cultivars:* None available.

### ***Issues for Fungus Gnats and Shore Flies***

1. The registration of new, reduced-risk products is required for the management of fungus gnats and shore flies.

### **Cabbage Looper (*Trichoplusia ni*) and other caterpillars (Order Lepidoptera)**

#### ***Pest Information***

*Damage:* Caterpillars chew holes in leaves and fruit. Cabbage looper larvae can cause significant damage by feeding on leaf tissue. Damage to leaves reduces yield and may also provide entry sites for secondary disease organisms.

*Life Cycle:* Adult moths enter the greenhouse from outside and lay eggs on the leaves of cucumber. Eggs hatch and larvae develop through a number of instars (stages) before pupating and eventually emerging as adults. Several generations may occur in the greenhouse compared with only one or two generations per year in the field. The cabbage looper does not typically overwinter in Canada. It generally moves north from the south as an adult moth in July and August. However, it has been known to overwinter in greenhouses. In greenhouses, as many as three generations per year are possible. Adult moths lay eggs near the edge or underside of a leaf. Larvae hatch in three to four days and develop through five instars (stages) over the next two to three weeks. The insects pupate within a loose cocoon for about two weeks, and then emerge as mature moths.

#### ***Pest Management***

*Cultural Controls:* The screening of vents, doorways and other openings to the greenhouse especially at night will minimize the entry of adult moths. Additional management practices for caterpillars are listed in *Table 8. Adoption of insect and mite pest management practices in greenhouse cucumber production in Canada.*

*Biological Controls:* Biological control agents commercially available for the management of caterpillars in the greenhouse are listed in *Table 9.*

*Resistant Cultivars:* None available.

### ***Issues for Cabbage Looper***

1. The registration of new, reduced-risk products, including biopesticides, is needed for the management of cabbage looper and for resistance management.

### **Lygus Bugs: Tarnished Plant Bug (*Lygus lineolaris*)**

#### ***Pest Information***

*Damage:* Lygus bugs are found on a wide range of wild plants and crops, including vegetables, fruits, fibre and forage crops. The tarnished plant bug commonly infests greenhouse pepper and, to a lesser extent, greenhouse cucumbers. Damage to cucumbers may include destruction

of the growing point of young seedlings and "ragging" of leaves, which appear crinkled and may have several perforations.

*Life Cycle:* Lygus bugs overwinter as adults in sheltered areas between leaves of plants and long dry grasses outside the greenhouse. They usually begin emerging from these sites in April and early May at temperatures as low as 8°C, and start to feed, mate and lay eggs in young plant tissue. Eggs incubate for about 7 to 12 days, depending on temperature. Females live for about 50 days at 20°C, and 37 days at 28°C. The larvae develop through five nymphal stages, and new generation adults appear after 30 to 45 days.

### ***Pest Management***

*Cultural Controls:* The presence of lygus bugs on greenhouse crops occurs each spring. Weed suppression in the immediate vicinity of the greenhouse will prevent the development of large populations during the fall and will discourage overwintering in these areas. Monitoring the upper canopy of the crop is essential for early detection. Yellow sticky cards used for monitoring other pests in greenhouse crops also attract lygus bugs. Regular examination of young flowers and leaves of cucumbers also helps to detect their presence and provides an indication of the population level in the crop.

*Biological Controls:* There are no commercially available biological control agents that target lygus bugs.

*Resistant Cultivars:* None available.

### ***Issues for Lygus bugs***

None identified.

## **Two-spotted Spider Mite (*Tetranychus urticae*)**

### ***Pest Information***

*Damage:* Infestations of spider mites can result in significant and sometimes total loss of the crop.

Mites feed on the plant by puncturing the surface, causing in small, yellow or white speckled feeding lesions which lead to leaf necrosis and death. Mites appear first on the underside of leaves. Fine webbing may be present and damaged leaf surfaces have a silver sheen.

*Life Cycle:* Although spider mites have a broad host range, greenhouse cucumber is a preferred host. Spider mites go through five developmental stages: egg, larva, protonymph, deutonymph and adult. The cycle may be completed in as little as three to four days at 32°C, but typically takes two weeks to complete when temperatures are lower. Adult females lay approximately 100 eggs on the lower leaf surface (five to eight eggs per day). The two-spotted spider mite spreads by hanging from the plant by silken strands that easily attach to people and equipment. The female mite overwinters in dark crevices in the greenhouse and does not feed during this time.

### ***Pest Management***

*Cultural Controls:* Monitoring for spider mite infestations is done by routine examination of the lower surface of the leaves. Good sanitation, including the removal of weeds, especially chickweed, from around the perimeter of the greenhouse and the maintenance of a three-metre-wide weed-free zone will help to minimize mite populations. Restricting the movement of people, equipment and plants from infested to non-infested plant areas is also beneficial. Mite problems at the end of the growing season are often controlled by fumigation followed by the removal and destruction of all plant material. Misting plants and raising the humidity will help suppress spider mite populations. Additional management practices for two-spotted spider mite are listed in Table 8. *Adoption of insect and mite pest management practices in greenhouse cucumber production in Canada.*

*Biological Controls:* Biological control agents commercially available for the management of two-spotted spider mites in the greenhouse are listed in Table 9.

*Resistant Cultivars:* None available.

### ***Issues for Mites***

1. Spider mite populations have resistance to a number of registered control products. There is a need for the registration of new reduced-risk miticides for spider mite control that are compatible with biological control agents and will contribute to resistance management.

## ***Broad Mite (*Polyphagotarsonemus latus*)***

### ***Pest Information***

*Damage:* Broad mites attack a variety of greenhouse ornamentals and vegetable crops. They feed on young growing (meristematic) tissues of flower and leaf buds. While feeding, they inject toxins into the tissues that cause thickening and deformities of the new growth. Affected cucumber leaves may show downward curling and affected fruit may be misshapen or cracked.

*Life Cycle:* Broad mites lay eggs on foliage or in the growing points of plants. They develop through five developmental stages: egg, protonymph, two deutonymph stages including a quiescent stage and adult. Development from egg to adult may take less than a week in the summer but up to 18 days in winter. The broad mite can be spread through the greenhouse by plant to plant contact, on air currents, by workers and other insects. Also, female nymphs and adults may be moved to new leaves by male broad mites.

### ***Pest Management***

*Cultural Controls:* Thorough clean-up and sanitation of the greenhouse at the end of a crop will eliminate the carry-over of mites to the next crop. Close monitoring of crops and of new plant material brought into the greenhouse is important for early detection. Restricting the movement of people, equipment and plants from infested to non-infested plant areas is also beneficial.

*Biological Controls:* Biological control agents commercially available for the management of mites in the greenhouse are listed in Table 9.

*Resistant Cultivars:* None available.

### ***Issues for Broad Mites***

None identified.

### **Thrips: Western Flower Thrips (*Frankliniella occidentalis*), Onion Thrips (*Thrips tabaci*), Eastern Flower Thrips (*F. tritici*), and European Flower Thrips (*F. intonsa*)**

#### ***Pest information***

**Damage:** Thrips damage in cucumber is first noticed on the lower leaves. Nymphs and adults feed on the leaves and fruit of the plant by piercing the surface and sucking the contents of the plant cells. This results in the formation of silvery white streaks or spots on the leaf or fruit surface. Insect frass may also be present. Excessive feeding reduces plant yield and can cause severe distortion or curling of cucumber fruit. Western flower thrips is the most important vector of tospoviruses in greenhouse crops.

**Life Cycle:** Thrips go through five developmental stages: egg, larval, pre-pupal, pupal and adult. The life cycle can be completed in about 15 days at 25°C. Eggs are inserted individually into leaves, stems and flowers where they hatch after three to six days. Nymphs will then feed on leaves and flowers. After six to nine days, nymphs move into the soil or growing medium and enter the non-feeding pre-pupal and pupal stages. Adults emerge after five to seven days, mate and lay eggs. The adults are weak fliers, taking short flights from leaf to leaf or plant to plant. Nevertheless, they disperse rapidly throughout the greenhouse.

#### ***Pest Management***

**Cultural Controls:** Monitoring and trapping of adult thrips with blue or yellow sticky traps is an integral practice of greenhouse pest management. The screening of greenhouse vents and other entry points will help prevent thrips from entering the greenhouse. The elimination of weeds and ornamental plants from around the perimeter of the greenhouse and avoiding moving non-crop material into the greenhouse will eliminate insect sources. Effective sanitation can eliminate or significantly reduce thrips in the greenhouse. Maintaining an optimal relative humidity of 80% can slow the development of thrips populations. Heating an empty greenhouse to 35°C for five days or 40°C for two to three days will starve any emerging adults. At the end of the growing season, infested crops can be fumigated and then removed and destroyed to eliminate sources of thrips. Additional management practices for thrips are listed in Table 8. *Adoption of insect and mite pest management practices in greenhouse cucumber production in Canada.*

**Biological Controls:** Biological control agents commercially available for the management of thrips in the greenhouse are listed in Table 9.

**Resistant Cultivars:** None available.

### ***Issues for Thrips***

1. There is a need for the registration of new classes of reduced risk insecticides for thrips control and for resistance management, especially for products which can be used as drench or irrigation treatments.

### **Whiteflies: Greenhouse Whitefly (*Trialeurodes vaporariorum*) and Sweet Potato Whitefly (*Bemisia tabaci*)**

#### ***Pest Information***

*Damage:* Whiteflies can cause severe damage to greenhouse cucumbers by decreasing fruit yield and quality. Adults can vector the persistent beet pseudo-yellows virus, causing year-round problems. Adults suck sap from the plant and fruit, reducing plant vigour. Whiteflies secrete honeydew, a waste product that can coat the plant. Feeding injury provides an entry point for diseases. Secondary fungi (sooty mould) grow on the honeydew, reducing fruit quality.

*Life Cycle:* The adult female whitefly lays eggs on the underside of leaves. Eggs hatch within 10 to 14 days and the first nymphal stage or crawler seeks a suitable feeding site. The second and third nymphal stages are immobile. Nymphs feed for about 14 days and then pupate. The adult emerges about six days later. Adults live for 30 to 40 days, but can lay eggs as early as four days after emergence.

#### ***Pest Management***

*Cultural Controls:* Screening vents and keeping doorways and other openings to the greenhouse closed will minimize entry by adult whiteflies. The crop can be monitored for the presence of whiteflies with the use of sticky traps and by visual plant inspection. Populations of adults can be reduced with the use of yellow sticky traps at a rate of one to two traps per two to five plants. Additional management practices for whiteflies are listed in *Table 8. Adoption of insect and mite pest management practices in greenhouse cucumber production in Canada*.

*Biological Controls:* Biological control agents commercially available for the management of whiteflies in the greenhouse are listed in Table 9.

*Resistant Cultivars:* None available.

### ***Issues for Whiteflies***

1. New, reduced risk insecticides that are compatible with beneficial organisms and that could be used as resistance management tools are required.

## ***Insecticides, miticides and bioinsecticides registered for the management of insect and mite pests in greenhouse cucumber production***

Active ingredients registered for the management of insects and mites in greenhouse cucumbers are listed below in *Table 9. Insecticides, miticides and bioinsecticides registered for the management of insect and mite pests in greenhouse cucumber production in Canada*. This table also provides registration numbers for products registered on greenhouse cucumber as of January 15, 2020 for each active ingredient in addition to information about chemical family and re-evaluation status. For guidance about active ingredients registered for specific insects and mites, the reader is referred to individual product labels on the PMRA pesticide label database <https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management.html> and to provincial crop production guides.

**Table 10. Insecticides, miticides and bioinsecticides registered for insect and mite management in greenhouse cucumber production in Canada**

Active Ingredient <sup>1</sup>	Product Registration Numbers <sup>1</sup>	Chemical Group <sup>2</sup>	Resistance Group <sup>2</sup>	Mode of Action <sup>2</sup>	Re-evaluation Status (re-evaluation decision document) <sup>3</sup>
<i>Autographa californica</i> Nucleopolyhedrosis virus, FV11	31791, 33105	biological	N/A	unknown	R
<i>Bacillus thuringiensis</i> subsp. <i>aizawai</i> , strain ABTS-1857	31557	<i>Bacillus thuringiensis</i> and the insecticidal proteins they produce	11A	microbial disruptor of insect midgut membranes	R
<i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> strain ABTS-351	24978, 26508	<i>Bacillus thuringiensis</i> and the insecticidal proteins they produce	11A	microbial disruptor of insect midgut membranes	R
<i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> strain EVB113-19	26854, 27750	<i>Bacillus thuringiensis</i> and the insecticidal proteins they produce	11A	microbial disruptor of insect midgut membranes	R
<i>Bacillus thuringiensis</i> var. <i>israelensis</i> , strain AM 65-52	19455	<i>Bacillus thuringiensis</i> and the insecticidal proteins they produce	11A	microbial disruptor of insect midgut membranes	R
<i>Beauveria bassiana</i> strain ANT-03	31231, 31232	biological	N/A	UNF fungal agents of unknown or uncertain mode of action	R
<i>Beauveria bassiana</i> strain GHA	29320, 29321	biological	N/A	UNF fungal agents of unknown or uncertain mode of action	R

... continued



**Table 10. Insecticides, miticides and bioinsecticides registered for insect and mite management in greenhouse cucumber production in Canada (continued)**

Active Ingredient <sup>1</sup>	Product Registration Numbers <sup>1</sup>	Chemical Group <sup>2</sup>	Resistance Group <sup>2</sup>	Mode of Action <sup>2</sup>	Re-evaluation Status (re-evaluation decision document) <sup>3</sup>
<i>Beauveria bassiana</i> strain PPRI 5339	32993	biological	N/A	UNF fungal agents of unknown or uncertain mode of action	R
<i>Metarhizium anisopliae</i> , strain F52	30829	biological	N/A	unknown	R
abamectin	24485	avermectin, milbemycin	6	glutamate-gated chloride channel (GluCl) allosteric modulator	R
acequinocyl	28640	acequinocyl	20B	mitochondrial complex III electron transport inhibitor	R
bifenazate	27924	bifenazate	20D	mitochondrial complex III electron transport inhibitor	R
canola oil	32408	not classified	N/A	unknown	R
chlorantraniliprole	28982	diamide	28	ryanodine receptor modulator	R
chlorfenapyr	30666	pyrroles	13	uncouplers of oxidate phosphorylation	R
cyantraniliprole	30895, 32368	diamide	28	ryanodine receptor modulator	R
dichlorvos	23915	organophosphate	1B	acetylcholinesterase (AChE) inhibitor	RES*
fenbutatin oxide	16162, 16309	organotin miticides	12B	inhibitors of mitochondrial ATP Synthase	R

... continued

**Table 10. Insecticides, miticides and bioinsecticides registered for insect and mite management in greenhouse cucumber production in Canada (continued)**

Active Ingredient <sup>1</sup>	Product Registration Numbers <sup>1</sup>	Chemical Group <sup>2</sup>	Resistance Group <sup>2</sup>	Mode of Action <sup>2</sup>	Re-evaluation Status (re-evaluation decision document) <sup>3</sup>
fenpyroximate	32245, 32302	METI acaricide and insecticide	21A	mitochondrial complex I electron transport inhibitor	R
ferric phosphate	27085, 30025	not classified	N/A	unknown	R (RVD2018-23)
ferric sodium ethylenediamine tetra acetic acid (EDTA)	28774	not classified	N/A	unknown	R
flonicamid	29796	flonicamid	29	chlordingonal organ modulator - undefined target site	R
flupyradifurone	33175, 33176	butenolide	4D	nicotinic acetylcholine receptor (nAChR) competitive modulator	R
imidacloprid	25636, 27357	neonicotinoid	4A	nicotinic acetylcholine receptor (nAChR) competitive modulator	RES*
mineral oil	27666	not classified	N/A	unknown	R
naled	7442	organophosphate	1B	acetylcholinesterase (AChE) inhibitor	RES*
permethrin	14976; 16688, 28877	pyrethroid, pyrethrin	3A	sodium channel modulator	R (RVD2019-11)
potassium salts of fatty acids	14669, 27886, 28146, 31433, 31848	not classified	N/A	unknown	R

... continued

**Table 10. Insecticides, miticides and bioinsecticides registered for insect and mite management in greenhouse cucumber production in Canada (continued)**

Active Ingredient <sup>1</sup>	Product Registration Numbers <sup>1</sup>	Chemical Group <sup>2</sup>	Resistance Group <sup>2</sup>	Mode of Action <sup>2</sup>	Re-evaluation Status (re-evaluation decision document) <sup>3</sup>
potassium salts of fatty acids + pyrethrins	24363	not classified + pyrethroid, pyrethrin	N/A + 3A	unknown + sodium channel modulator	R + R
pymetrozine	27273	pyridine azomethine derivative	9B	chlorodantal organ TRPV channel modulator	RES*
pyrethrins	24363	pyrethroid, pyrethrin	3A	sodium channel modulator	R
pyridaben	25134, 25229, 33434	METI acaricide and insecticide	21A	mitochondrial complex I electron transport inhibitor	RE (PRVD2016-04)
pyriproxyfen	28414	pyriproxyfen	7	juvenile hormone mimic	RE (2019-10)
spinetoram	28778	spinosyn	5	nicotinic acetylcholine receptor (nAChR) allosteric modulator	R
spinosad	26835, 27825, 30382	spinosyn	5	nicotinic acetylcholine receptor (nAChR) allosteric modulator	RE (REV2018-07)
spiromesifen	28590	tetronic and tetramic acid derivative	23	inhibitor of acetyl CoA carboxylase	R
spirotetramat	29567	tetronic and tetramic acid derivative	23	inhibitor of acetyl CoA carboxylase	R
sulphur	14653, 18836, 31869	sulphur	N/A	unknown	R
<b>Greenhouse Treatment</b>					
phosphine (greenhouse fumigant)	27684	phosphine	24A	mitochondrial complex IV electron transport inhibitor	R

... continued

**Table 10. Insecticides, miticides and bioinsecticides registered for insect and mite management in greenhouse cucumber production in Canada (continued)**

Active Ingredient <sup>1</sup>	Product Registration Numbers <sup>1</sup>	Chemical Group <sup>2</sup>	Resistance Group <sup>2</sup>	Mode of Action <sup>2</sup>	Re-evaluation Status (re-evaluation decision document) <sup>3</sup>
<b>Insect Growth Regulator</b>					
buprofezin (IGR)	32341, 32383	buprofezin	16	inhibitor of chitin biosynthesis, type 1	R
novaluron (IGR)	28515, 28881	benzoylurea	15	inhibitor of chitin biosynthesis, type 0	R

<sup>1</sup>Source: Pest Management Regulatory Agency label database ([www.hc-sc.gc.ca/cps-spc/pest/registant-titulaire/tools-outils/label-etiq-eng.php](http://www.hc-sc.gc.ca/cps-spc/pest/registant-titulaire/tools-outils/label-etiq-eng.php)). The list includes all active ingredients registered as of January 15, 2020. While every effort has been made to ensure all insecticides, miticides and biopesticides registered in Canada on greenhouse cucumber have been included in this list, some active ingredients or products may have been inadvertently omitted. 'Numerous products' is entered where there are more than ten products for an active ingredient. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The product label is the final authority on pesticide use and should be consulted for application information. The information in this table should not be relied upon for pesticide application decisions and use.

<sup>2</sup>Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (Version 9.3; June 2019)* (excluding pheromones) ([www.irac-online.org](http://www.irac-online.org)) (accessed September 17, 2019).

<sup>3</sup>PMRA re-evaluation status as published in Re-evaluation Note REV2019-05, Pest Management Regulatory Agency Re-evaluation and Special Review Work Plan 2019-2024 and other re-evaluation documents: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES\* (yellow) - under re-evaluation and special review. Other codes include: DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

## Weeds

Weed management in and around greenhouses is important as weeds can be an alternate host for insects, mites and diseases. Weeds within the greenhouse can be eliminated by hand weeding and through the use of ground coverings. Weeds external to the greenhouse can be reduced by mowing and by maintenance of a 10-metre-wide lawn area. These measures will reduce the chances of pests entering the greenhouse from outside. Herbicides may be used in the vicinity of greenhouses for the control of weeds; however, it is important that measures be taken to reduce the potential of spray drift from entering the greenhouse.

## Vertebrate Pests

**Rodents: Field Mouse (Vole) (*Microtus pennsylvanicus*), House Mouse (*Mus musculus*) and Norway Rat (*Rattus norvegicus*)**

### *Pest Information*

*Damage:* Rodents can chew through plastic ground liners causing drainage problems and contaminating re-circulating water. House mice and Norway rats are also known to chew on young plants or fruit in greenhouses.

*Life Cycle:* These rodents are primarily outdoor pests, but house mice and Norway rats can invade indoor facilities. Field mice prefer weedy, covered areas. These rodents are attracted to sources of food, water and shelter for nesting, such as garbage containers, cull piles, old planting media, building debris, piles of sawdust, burlap or Styrofoam sheets which are left outdoors or where bags of seed or slug bait are stored.

### *Pest Management*

*Cultural Controls:* Maintaining a weed-free zone around the perimeter of the greenhouse and installing tight-fitting screens over doors and windows are practices that will help deter rodents from entering the greenhouse. Sheet-metal plates at the base of wooden doors will prevent rodents from chewing through the doors. Feeding and nesting sites can be eliminated by cleaning up debris and cull piles around the greenhouse and storage buildings. Feed and seed, including slug bait can be stored in metal, rodent-proof containers and all garbage containers provided with tight-fitting lids. Various trapping methods exist but are not consistently effective.

*Resistant Cultivars:* None available.

### *Issues for Rodents*

None identified.

## Resources

### ***Integrated pest management / integrated crop management resources for greenhouse cucumber production in Canada***

British Columbia Ministry of Agriculture and Lands. Greenhouse Vegetables Production. Plant Health. <https://www2.gov.bc.ca/gov/content/industry/agriculture-seafood/animals-and-crops/plant-health>

Centre de Référence en Agriculture et Agroalimentaire du Québec (CRAAQ). Agri-Réseau. Légumes de serre. <https://www.agrireseau.net/legumesdeserre>

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Health Canada. Pest Management Regulatory Agency. <http://www.hc-sc.gc.ca/cps-spc/pest/index-eng.php>

Ontario Ministry of Agriculture, Food and Rural Affairs. (2017). *Publication 835, Crop Protection Guide for Greenhouse Vegetables 2016-2017*. 135 pp. <http://www.omafra.gov.on.ca/english/crops/pub835/p835order.htm>

Ontario Ministry of Agriculture Food and Rural Affairs. (2010). *Publication 836, Growing Greenhouse Vegetables in Ontario*. 146 pp. <http://www.omafra.gov.on.ca/english/crops/pub836/p836order.htm>

## ***Provincial Crop Specialists and Provincial Minor Use Coordinators***

<b>Province</b>	<b>Ministry</b>	<b>Crop Specialist</b>	<b>Minor Use Coordinator</b>
<b>British Columbia</b>	British Columbia Ministry of Agriculture <a href="https://www2.gov.bc.ca/gov/content/home">https://www2.gov.bc.ca/gov/content/home</a>	Maria Jeffries <a href="mailto:Maria.Jeffries@gov.bc.ca">Maria.Jeffries@gov.bc.ca</a>	Caroline Bédard <a href="mailto:caroline.bédard@gov.bc.ca">caroline.bédard@gov.bc.ca</a>
<b>Alberta</b>	Alberta Agriculture and Forestry <a href="https://www.alberta.ca/ministry-agriculture-forestry.aspx">https://www.alberta.ca/ministry-agriculture-forestry.aspx</a>	Simone Dalpé <a href="mailto:simone.dalpe@gov.ab.ca">simone.dalpe@gov.ab.ca</a>	Gayah Sieusahai <a href="mailto:gayah.sieusahai@gov.ab.ca">gayah.sieusahai@gov.ab.ca</a>
<b>Ontario</b>	Ontario Ministry of Agriculture, Food and Rural Affairs <a href="http://www.omafra.gov.on.ca/english">www.omafra.gov.on.ca/english</a>	Cara McCreary <a href="mailto:cara.mccreary@ontario.ca">cara.mccreary@ontario.ca</a>  Shalin Khosla <a href="mailto:shalin.khosla@ontario.ca">shalin.khosla@ontario.ca</a>	Jim Chaput <a href="mailto:jim.chaput@ontario.ca">jim.chaput@ontario.ca</a>

## ***Provincial Greenhouse Grower Organizations***

Alberta Greenhouse Growers Association

<https://agga.ca/>

British Columbia Greenhouse Growers' Association

<https://bcgreenhouse.ca/>

Ontario Greenhouse Vegetable Growers

<http://ogvg.com/>

Ontario Greenhouse Alliance

<https://www.theontariogreenhousealliance.com/>

## ***National Grower Organizations***

Canadian Federation of Agriculture / Fédération canadienne de l'agriculture

<http://www.cfa-fca.ca/>

Canadian Horticultural Council / Conseil canadien de l'horticulture

<https://www.hortcouncil.ca/en/>

Canadian Organic Growers / Cultivons Biologique Canada

<https://www.cog.ca/>



## Appendix 1

### Definition of terms and colour coding for pest occurrence table of the crop profiles.

Information on the occurrence of disease and insect and mite pests in each province is provided in Tables 4 and 7 of the crop profile, respectively. The colour coding of the cells in these tables is based on three pieces of information, namely pest distribution, frequency and pressure in each province as presented in the following chart.

Presence	Occurrence information				Colour Code
Present	Data available	Frequency	Distribution	Pressure	
		Yearly - Pest is present 2 or more years out of 3 in a given region of the province.	Widespread - The pest population is generally distributed throughout crop growing regions of the province. In a given year, outbreaks may occur in any region.	High - If present, potential for spread and crop loss is high and controls must be implemented even for small populations.	Red
				Moderate - If present, potential for spread and crop loss is moderate: pest situation must be monitored and controls may be implemented.	Orange
				Low - If present, the pest causes low or negligible crop damage and controls need not be implemented.	Yellow
			Localized - The pest is established as localized populations and is found only in scattered or limited areas of the province.	High - see above	Orange
				Moderate - see above	White
				Low - see above	White
		Sporadic - Pest is present 1 year out of 3 in a given region of the province.	Widespread - as above	High - see above	Orange
				Moderate - see above	Yellow
				Low - see above	White
			Localized - as above	High - see above	Yellow
				Moderate -see above	White
	Low - see above			White	
	Data not available	Not of concern: The pest is present in commercial crop growing areas of the province but is causing no significant damage. Little is known about its population distribution and frequency in this province; however, it is not of concern.			White
Is of concern: The pest is present in commercial crop growing areas of the province. Little is known about its population distribution and frequency of outbreaks in this province and due to its potential to cause economic damage, is of concern.			Blue		
Not present	The pest is not present in commercial crop growing areas of the province, to the best of your knowledge.				Black
Data not reported	Information on the pest in this province is unknown. No data is being reported for this pest.				Grey

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Ontario Ministry of Agriculture, Food and Rural Affairs. (2014). Factsheet: *Fungus gnats and shore flies in greenhouse crops*. Agdex 290/621; Order #14-003.  
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Ontario Ministry of Agriculture, Food and Rural Affairs. (2012). *Managing the lygus bug in greenhouse crops*. Agdex 290/621; Order #12-015.  
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