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Crop Profile for Greenhouse Cucumber in Canada, 2014

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Canada

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Preface

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

Information on pest management practices and pesticides is provided for information purposes only. No endorsement of any 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 cucumber, 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.

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

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Contents

List of Tables

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 far back 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. Until recently, only the long English cucumber was grown in greenhouses but today there is significant production of mini- or gherkin-type cucumbers in protected environments. 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

Table 1. General production information

Canadian production (2014)[1]	180,294.2 tonnes 364.6 hectares
Farm gate value (2014)[1]	$326 million
Food available in Canada (2014)[2]	3.61 kg/ person (fresh cucumbers)
Exports (2014)[3]	112,790 tonnes (fresh cucumbers)
Imports (2014)[3]	54,790 tonnes (fresh cucumbers)

[1]Source: Statistics Canada. Table 001-0006 - Production and value of greenhouse vegetables, annual CANSIM (database) (www.statcan.gc.ca) (accessed 2016-02-22).

[2]Source: Statistics Canada. Table 002-0011 - Food available in Canada, annual CANSIM (database) (accessed 2016-02-22).

[3]Source: Statistics Canada. Table 002-0010 - Supply and disposition of food in Canada, annual (tonnes), CANSIM (database) (accessed 2016-02-22).

Production Regions

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

In 2014, the major production areas for greenhouse cucumbers were Ontario (276.6 hectares or 76% of the national acreage), British Columbia (42.4 hectares or 12%) and Alberta (31 hectares or 9%) (Table 2).

Table 2. Distribution of greenhouse cucumber production in Canada (2014)[1]

Production Regions	Harvested area (hectares)	Percent national production
British Columbia	42.4	12%
Alberta	31	9%
Saskatchewan	0.3	< 1%
Manitoba	0.8E	0.2%
Ontario	276.6	76%
Quebec	11.9	3%
New Brunswick	F	F
Nova Scotia	2.1	1%
Prince Edward Island	0	0%
Newfoundland and Labrador	0.1	< 1%
Canada	364.6	100%

[1]Source: Statistics Canada. Table 001-0006 - Production and value of greenhouse vegetables, annual CANSIM (database) (www.statcan.gc.ca) (accessed 2016-02-22).

E - Use with caution.

F- Too unreliable to be published.

Cultural Practices

Greenhouse cucumbers are grown hydroponically, generally in rockwool blocks placed on slabs containing rockwool, coir (coconut fibre) or sawdust. The crop is trained along wires or up to a high wire with lateral shoots trained in umbrella fashion. Drip fertigation supplies nutrients and water to each plant. Computer systems continually monitor and regulate temperature, light, humidity, irrigation and nutrient levels. Cucumber seeds are sown directly into rockwool cubes or into flats containing vermiculite and then transplanted into rockwool blocks after emergence in propagation houses. When three to five leaves have developed, the rockwool-block seedlings are transplanted into final growing bags (slabs) soaked with nutrient solution and strung up. Plants are generally grown in paired rows with a walkway between each pair. Heating pipes are located on the walkway or within the rows. Plant spacing varies depending on the production system.

Throughout the growing season, growing points and leaves are pinched off to allow lateral stems to grow downward and along the wires to ensure good light penetration for optimum fruit development and colour. Cucumber fruit is pruned to ensure a proper balance between foliage and fruit set. Fruit load varies with time of planting (winter, spring and fall or late fall) and pruning systems vary depending on the growing and training system. Growing conditions (i.e. the number of irrigation cycles, pH of the nutrient solution, CO_2 levels, media and greenhouse temperature, light intensity, aeration of re-circulating nutrient solution, etc.) are optimized to ensure the plant has strong growth and vigour which aids in disease resistance.

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, meaning pollination is not required for fruit set. The time from flowering to harvest is about 10 to14 days. At harvest, the fruit stalk is cut cleanly so the wound heals rapidly to avoid disease development. Fruit is harvested daily or every other day depending on production and the time of year. Fruit is stored at 13^{o}C, in an area free of 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 a PMT variety later in the season when light conditions are more favourable for these cultivars. However, some growers are using PMT varieties year round due to mildew pressure and their greater tolerance to low light levels during the winter months.

New production systems and new varieties continue to improve yield, disease resistance and fruit quality. 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. Mini-cucumbers are a small portion of the total crop, although production of these is expanding in Ontario and British Columbia. In Alberta, there is significant production in winter under supplemental light.

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

TIME OF YEAR	ACTIVITY	ACTION
Seeding	Greenhouse and Media Care	Preparation of the propagation house to ensure cleanliness and lack of pests and crop debris; implement proper temperature for seed germination.
	Disease Management	Sowing of fungicide treated seed; maintenance of proper seed germination temperature and moisture levels.
	Insect Management	Monitoring and controlling 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. Maintenance of populations of beneficial insects and application of insecticides as needed.
	Weed Management	Maintenance of a three-metre wide vegetation-free zone around the greenhouse.
Production and Harvest	Plant Care	Fruit pruning, lateral pinching and training throughout the harvest period as appropriate to the time of year and variety; monitoring of nutrient solution salt levels and pH; maintenance of appropriate environmental controls: temperature, light intensity, CO_2, 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; monitor for diseases and apply fungicides as needed; maintenance of greenhouse environment to prevent condensation on the plants; application of proper irrigation to avoid excessive or inadequate moisture in the slabs and ensure adequate nutrient levels.
	Insect Management	Maintenance of greenhouse to keep insect pests out: repair of cracks, use of screens, etc.; weekly monitoring for insect and mite pests using sticky cards and leaf inspection; use of beneficial predators and parasites as appropriate and application of insecticides only if necessary.
	Weed Management	Maintenance of a three-metre wide vegetation-free zone around the greenhouse.
Post-Harvest	Fruit Care	Store and ship at appropriate temperature (13^oC), away from drafts or sources of ethylene. Shrink-wrap fruit to reduce moisture loss.
	Greenhouse Care	Clean as thoroughly as possible between crops. Remove and properly dispose of plant debris and disinfect 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^{o}C; subsequently, temperature is maintained at an average of 21^{o}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 will favour the development of both 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, etc.

The levels of CO_2 are also monitored and modified according to the stage of development and cultivar type. Temperature, humidity and CO_2 levels are adjusted for light conditions. Low light intensity or fluctuations in light intensity can cause curled or pale fruit. Large humidity fluctuations will increase the incidence and severity of some diseases such as powdery mildew.

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 electrolyte concentration (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 fruit per plant and increasing the concentration of fertilizer in the nutrient solution.

Root Death

Abrupt plant wilting accompanied by root necrosis, disintegration and death that develops within five to eight hours, is often associated with plant stress, such as temperature extremes, EC levels that are too high, poor oxygenation of the nutrient solution, or too heavy a fruit load. 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 injury 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.
- There is a requirement for grower education on the use of integrated approaches, including the use of climate control, sanitation and proper pruning practices for the management of a number of diseases of greenhouse cucumber.
- Diseases such as black rot, fusarium rot and pythium root 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 and biological and other control products that are amenable to use in organic production systems.

Table 4. Occurrence of diseases in greenhouse cucumber production in Canada[1,2]

Disease	British Columbia	Alberta	Ontario
Damping-off			
Downy mildew			
Powdery mildew			
Grey mould			
Gummy stem blight			
Pythium crown rot and root rot			
Virus diseases			
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 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 not present.

Data not reported.

[1]Source: Stakeholders in greenhouse cucumber producing provinces.

[2]Please refer to Appendix 1, for a detailed description of colour coding of occurrence data.

Table 5. Adoption of disease management practices in greenhouse cucumber production in Canada[1]

Practice / Pest		Grey mould	Downy mildew	Fusarium wilt	Gummy stem blight	Powdery mildew	Pythium crown rot and root rot
Avoidance	Crop rotation						
	Optimizing fertilization						
	Reducing mechanical damage or insect damage						
	Control of disease vector						
	Resistant varieties						
Prevention	Equipment sanitation						
	End of season disinfection of structure						
	Use of a 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 of the greenhouse and working in these sections last						
	Allocation of sections of the crop to specific workers to prevent disease spread						
Monitoring	Regular monitoring throughout crop cycle						
	Records to track diseases						
	Use of indicator plants						

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

Practice / Pest		Grey mould	Downy mildew	Fusarium wilt	Gummy stem blight	Powdery mildew	Pythium crown rot and root rot
Decision-making tools	Economic threshold						
	Weather conditions						
	Recommendation from crop specialist or consultant						
	First appearance of pest or pest life stage						
	Observed crop damage						
	Crop stage						
	Calendar spray						
Suppression	Biopesticides						
	Pesticide rotation for resistance management						
	Spot application of pesticides						
	Use of pesticides which are compatible with beneficials						
	Novel pesticide application techniques						
	Follow sanitation practices						
New practices (by province)	Preventing condensation in the greenhouse (Alberta)						
	Changing greenhouse temperature gradually (Alberta)						

This practice is used to manage this pest by growers in at least one reporting province.

This practice is not used to manage this pest in reporting provinces.

This practice is not applicable for this pest

Information regarding the practice for this pest is unknown.

[1]Source: Stakeholders in provinces producing greenhouse cucumbers (British Columbia, Alberta and Ontario).

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

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Bacillus amyloliquefaciens strain D747	microbial: *Bacillus* spp. and the fungicidal lipopeptides they produce	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	44	R	powdery mildew, phytophthora blight (partial suppression)
Bacillus subtilis strain QST 713	microbial: *Bacillus* spp. and the fungicidal lipopeptides they produce	F3: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	44	R	gummy stem blight, cercospora leaf spot, downy mildew, powdery mildew
Bacillus subtilis strain MBI 600	microbial: *Bacillus* spp. and the fungicidal lipopeptides they produce	F3: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	44	R	damping off and root disease caused by *Fusarium* spp., *Rhizoctonia solani* and *Pythium* sp. (suppression)
boscalid + pyraclostrobin	pyridine-carboxamide + methoxy-carbamate	C2: respiration + C3: respiration	complex II: succinate-dehydrogenase + complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	7 + 11	R + R	powdery mildew (suppression), gummy stem blight (suppression)
citric acid + lactic acid	not classified	unknown	unknown	N/A	R	powdery mildew (suppression), downy mildew (suppression)
copper octanoate	inorganic	multi-site contact activity	multi-site contact activity	M1	R	powdery mildew, downy mildew, alternaria leaf blight, anthracnose, angular leaf spot, bacterial wilt, septoria leaf spot

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

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
cyprodinil + difenoconazole	anilino-pyrimidine + triazole	D1: amino acids and protein synthesis + G1:sterol biosynthesis in membranes	methionine biosynthesis (proposed) (cgs gene) + C14-demethylase in sterol biosynthesis (erg11/cyp51)	9 + 3	RE + RE	gummy stem blight (suppression)
cyprodinil + fludioxonil	anilino-pyrimidine + phenylpyrrole	D1: amino acids and protein synthesis + E2: signal transduction	methionine biosynthesis (proposed) (cgs gene) + MAP/histidine-kinase in osmotic signal transduction (os-2, HoG1)	9 + 12	RE + RE	powdery mildew (suppression)
fenhexamid	hydroxyanilide	G3: sterol biosynthsis in membranes	3-keto reductase, C4-demethylation (erg27)	17	RE	grey mould
ferbam	dithiocarbamate and relatives	multi-site contact activity	multi-site contact activity	M3	RE	grey mould
garlic powder	biological	unknown	unknown	N/A	R	powdery mildew (suppression), downy mildew (may inhibit symptoms), seed rot, damping-off and root rot (partial suppression)

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

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
iprodione	dicarboximide	E3: signal transduction	MAP/ histidine-kinase in osmotic signal transduction (os-1, Daf1)	2	RE	gummy stem blight, grey mould
mancozeb	dithiocarbamate and relatives	multi-site contact activity	multi-site contact activity	M3	RE	gummy stem blight, powdery mildew
mandipropamid	mandelic acid amide	H5: cell wall biosynthesis	cellulose synthase	40	R	downy mildew (suppression)
metalaxyl-m	acylalanine	A1: nucleic acids synthesis	RNA polymerase I	4	R	*Pythium* spp.
myclobutanil	triazole	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	3	R	powdery mildew, gummy stem blight
oxathiapiprolin	piperidinyl-thiazole-isoxazoline	unknown	oxysterol binding protein (OSBP) inhibition (proposed)	U15	R	downy mildew, phytophthora blight
penthiopyrad	pyrazole-4-carboxamide	C2: respiration	complex II: succinate-dehydro-genase	7	R	grey mould, powdery mildew

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

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
phosphorous acid (mono and di-potassium salts of phosphorous acid	phosphonate	unknown	unknown	33	R	phytopthora foliar blight (suppression), downy mildew (suppression)
potassium bicarbonate	not classified	diverse	unknown	N/A	R	powdery mildew
propamocarb hydrochloride	carbamate	F4: lipid synthesis and membrane integrity	cell membrane permeability, fatty acids (proposed)	28	RE	pythium root rot and damping-off, downy mildew (suppression)
Reynoutria sachalinensis (extract)	complex mixture, ethanol extract	P5: host plant defence induction	P5	P5	R	powdery mildew (suppression), downy mildew (suppression)
Streptomyces griseoviridis strain K61	biological	unknown	unknown	N/A	R	damping-off, root and crown rot and wilt caused by fusarium (suppression), damping off and root and crown rot caused by pythium (suppression)
Streptomyces griseoviridis strain WYEC 108	biological	unknown	unknown	N/A	R	powdery mildew (suppression), seed rot, damping off and root rot caused by pythium (suppression)

…. continued

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

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
sulphur	inorganic	multi-site contact activity	multi-site contact activity	M2	R	powdery mildew
tea tree oil (*Melaleuca alternifolia)*	terpene hydrocarbons and terpene alcohols	F7: lipid synthesis and membrane integrity	cell membrane disruption (proposed)	46	R	powdery mildew, downy mildew (suppression)
Trichoderma harzanium Rifai strain KRL-AG2	biological	unknown	unknown	N/A	RE	root rot (pythium, rhizoctonia, fusarium) (suppression), botrytis blight (suppression)
Trichoderma harzianum Rifai strain T-22	biological	unknown	unknown	N/A	RE	damping-off (suppression)

[1]Source: Pest Management Regulatory Agency label database (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 March 10, 2016. The product label is the final authority on pesticide use and should be consulted for application information. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

[2]Source: Fungicide Resistance Action Committee. *FRAC Code List 2016: Fungicides sorted by mode of action (including FRAC code numbering)* (www.frac.info/) (accessed March 4, 2016).

[3]PMRA re-evaluation status: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review, as published in PMRA *Re-evaluation Note REV2016-07, Pest Management Regulatory Agency Re-evaluation and Special Review Workplan 2015-2020*, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA as of October 30, 2015.

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) and 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.

Resistant Cultivars: None available.

Chemical Controls: Fungicides and biofungicides registered for the control of seedling damping-off are listed in *Table 6. Fungicides and biofungicides registered for disease management in greenhouse cucumber in Canada.*

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. It rarely causes severe losses in greenhouse cucumbers if the crop is well-managed. Symptoms are angular, light-green patches on leaf blades between the veins. 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: Spores of downy mildew are produced in a purplish mass on the underside of infected leaves. They are spread by moist air, water, and on clothing and tools. Spores require a film of water on the leaf to germinate and cause infection.

Pest Management

Cultural Controls: Preventing condensation on the leaves by controlling the night temperature and ensuring adequate ventilation so leaves will dry quickly will result in conditions less favourable for disease development. Avoiding planting new crops near older ones and practicing good sanitation including the removal of old crop debris promptly from the greenhouse will minimize disease spread.

Resistant Cultivars: None available.

Chemical Controls: Fungicides and biofungicides registered for the control of downy mildew are listed in *Table 6. Fungicides and biofungicides registered for disease management in greenhouse cucumber in Canada.*

Issues for downy mildew

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

Powdery mildew (*Podosphaera xanthii, Erysiphe cichoracearum,*)

Pest Information

Damage: Powdery mildew causes the development of round, white spots on the upper surface of older leaves. These spots enlarge and can eventually cover the entire surface of the leaf. Occasionally the disease appears on petioles and stems as well. White powdery spores develop on the leaf surface. The fungus absorbs nutrients from the leaf cells and diseased leaves eventually dry up and die. Yield can be severely reduced.

Life Cycle: Powdery mildew spores germinate at a relative humidity of 80% or higher and at temperatures between 22 and 31°C. Spores may survive 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 on air currents in the greenhouse and occasionally on thrips and other insects. 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.

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

Chemical Controls: Fungicides registered for the control of powdery mildew are listed in *Table 6. Fungicides and biofungicides registered for disease management in greenhouse cucumber in Canada*.

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 yield well.
3. There is a need for the further development of cultural and environmental controls for powdery mildew.

Botrytis grey mould *(Botrytis cinerea)*

Pest Information

Damage: Botrytis causes some crop loss each year and in some years, the losses can be quite significant. The initial symptoms 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: Botrytis cinerea may infect the stem, petiole, base of the leaf, fruit stem or flowers. Grey spore masses are produced by the fungus under humid conditions on infected plant parts and are the main source of new infections. Spores can become air-borne and will spread quickly in the greenhouse. The fungus overwinters in soil, on perennial plants and on plant debris as black sclerotia.

Pest Management

Cultural Controls: As wounds provide an entry route for this disease, it is important to avoid wounding the plants. Good sanitation between crops and when handling the plants and 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 eliminate a source of the disease. Preventing condensation on the leaves by controlling ventilation and raising temperatures gradually prior to sunrise, will make conditions less hospitable for botrytis. 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 botrytis infection and a heavy canopy will slow the drying of leaves.

Resistant Cultivars: None available.

Chemical Controls: Fungicides registered for the control of grey mould are listed in *Table 6. Fungicides and biofungicides registered for disease management in greenhouse cucumber in Canada.*

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 control of botrytis on greenhouse cucumber and to reduce the development of resistance within the pathogen population.
2. There is a need for grower education on the use of climate control strategies and other cultural practices for the management of botrytis in the greenhouse.

Gummy stem blight (*Didymella bryoniae, syn. Mycosphaerella melonis, syn. M. citrullina*)

Pest Information

Damage: 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 kill the plant above the lesion. Infected fruit becomes shriveled at the flower-end. Traces of brown rotting tissue may also occur internally on 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 and powdery mildew and also makes them more attractive to aphids.

Life Cycle: Moisture on leaves makes the cucumber 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. Inoculum is spread primarily on tools and by crop handling. The fungal mycelium can survive for up to two years on intact plant debris.

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.

Resistant Cultivars: None available.

Chemical Controls: Fungicides registered for the control of gummy stem blight are listed in *Table 6. Fungicides and biofungicides registered for disease management in greenhouse cucumber in Canada*.

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 new registered materials have short re-entry intervals and short pre-harvest intervals.
2. The development of resistant cultivars is required.
3. Education on the management of gummy stem blight through the effective use of climate control in the greenhouse would be helpful for growers.

Pythium crown rot and root rot (*Pythium aphanidermatum* and other *Pythium* spp).

Pest Information

Damage: Pythium crown rot affects plants primarily in the spring at early fruit set, or late in the season (summer crops). Infected crowns become orange-brown with a soft, dry rot. There are also few lateral roots at the crown and the plants lift easily out of the growing medium. 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.

Life Cycle: Pythium species survive in soil, root debris, propagation mixes and untreated water. Spores (sporangia) spread in recirculating water and germinate to produce tiny zoospores that infect root tips or wounds on the root. Fungus gnats and shore flies spread pythium spores and their root feeding wounds allow points of entry for the pathogen. Pythium diseases are favoured by low oxygen in the root zone.

Pest Management

Cultural Controls: Irrigation troughs, tanks and supply lines for water should be cleaned and disinfected thoroughly between crops. Reducing water and temperature stress on the plants and ensuring good aeration of recirculating water also helps to reduce disease.

Resistant Cultivars: None identified.

Chemical Controls: Fungicides registered for use against pythium diseases on greenhouse cucumber are listed in *Table 6. Fungicides and biofungicides registered for disease management in greenhouse cucumber in Canada.*

Issues for crown and root rot

1. New reduced risk products, especially those with short pre-harvest intervals (PHI's) 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.

Fusarium root and stem rot (*Fusarium oxysporum* f. sp. *radicis-cucumerinum)*

Pest Information

Damage: The strain of *Fusarium oxysporum* that causes this disease is genetically different from the strain that causes fusarium wilt disease. Symptoms 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 is soft and may emit a slight odour. Roots develop a brown-black necrosis, starting from the tips.

Life Cycle: The fungus may grow on rockwool blocks and in sawdust bags. Infection is favoured by high moisture in the growing media. Spores are spread in water and by handling. Fungus gnats and shore flies may spread spores and their feeding wounds on roots create entry points for infection.

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 fusarium. 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 spread of the disease.

Resistant Cultivars: None available.

Chemical Controls: Refer to *Table 6. Fungicides and biofungicides registered for disease management in greenhouse cucumber in Canada,* for biofungicides registered for the control of fusarium root and stem rot.

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. Grower education is required on cultural approaches such as sanitation and climate control in the greenhouse for the management of fusarium root and stem rot.

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 strain of virus.

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.

Pest Management

Cultural Controls: When planting a new crop, it is important to use seeds and seedlings free of CGMMV. Close observation in the first two to three weeks after planting will enable a grower to detect the presence of virus and implement measures to restrict its spread. It is important to avoid recirculation of the nutrient solution during this two to three week period until all virus-infected seedlings have been removed. Strict sanitation between crops will prevent virus carry-over to the new crop.

Resistant Cultivars: None available.

Chemical Controls: None available.

Issues for cucumber green mottled 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 turn yellow, become stunted and may be killed by this virus. Newly infected leaves are 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 fruit. Fruit that does develop has a yellow-green mottle over the surface, often interspersed with dark green, raised areas.

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

Pest Management

Cultural Controls: The spread of the disease may be restricted by controlling aphid vectors and screening greenhouse vents to prevent the entry of aphids. Areas of the greenhouse with diseased plants can be worked in last to avoid transferring the disease to healthy plants.

Resistant Cultivars: Most long English cucumber cultivars have little to no resistance.

Chemical Controls: None available.

Issues for Cucumber mosaic virus

None identified.

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 control of common pests and for resistance management.

Table 7. Occurrence of insect and mite pests in Canadian greenhouse cucumber production[1,2]

Insect	British Columbia	Alberta	Ontario
Aphids			
Melon / cotton aphid			
Mites			
Carmine mite			
Two-spotted spider mite			
Broad mite			
Thrips			
Western flower thrips			
Whiteflies			
Greenhouse whitefly			
Cucumber beetles			
Spotted cucumber beetle			
Striped cucumber beetle			
Caterpillars (various species)			
Cabbage looper			
Fungus gnats and shore flies			

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 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 not present.

Data not reported.

[1]Source: Stakeholders in greenhouse cucumber stakeholders producing provinces.

[2]Please refer to Appendix 1, for a detailed description of colour coding of occurrence data.

Table 8. Adoption of insect and mite pest management practices in greenhouse cucumber production in Canada[1]

Practice / Pest		Aphids	Fungus gnats and shore flies	Caterpillars (various species)	Two-spotted spider mite	Thrips	Whiteflies
Avoidance	Crop rotation						
	Optimizing fertilization						
	Reducing mechanical damage						
	Trap crops						
	Physical barriers to prevent insect entry into greenhouses						
Prevention	Equipment sanitation						
	End of season crop residue removal and clean-up						
	Pruning out / removal of infested material throughout cropping season						
Monitoring	Regular monitoring throughout crop cycle						
	Records to track pests						
	Use of indicator plants						
Decision-making tools	Economic threshold						
	Weather conditions						
	Recommendation from crop specialist or consultant						
	First appearance of pest or pest life stage						
	Observed crop damage						
	Crop stage						
	Calendar spray						

…. continued

Table 8. Adoption of insect and mite pest management practices in greenhouse cucumber production in Canada[1] (continued)

Practice / Pest		Aphids	Fungus gnats and shore flies	Caterpillars (various species)	Two-spotted spider mite	Thrips	Whiteflies
Suppression	Biopesticides						
	Arthropod biological control agents						
	Use of banker plants as reservoirs or refuges for beneficial insects						
	Trapping						
	Pesticide rotation for resistance management						
	Spot application of pesticides						
	Use of pesticides which are compatible with beneficials						
	Novel pesticide application techniques (eg. use of pollinating insects to carry bio-pesticides)						
	Follow sanitation practices						
Crop specific practices	Screening of greenhouse vents and use of dormant oil						
New practices (by province)	Mass trapping of insects (Alberta)						

This practice is used to manage this pest by growers in at least one reporting province.

This practice is not used to manage this pest in reporting provinces.

This practice is not applicable for this pest.

Information regarding the practice for this pest is unknown.

[1]Source: Stakeholders in provinces producing greenhouse cucumbers (British Columbia, Alberta and Ontario).

Table 9. Arthropod biological control agents available for the management of insect and mite pests in greenhouse vegetable crops in Canada

Pest	Biological Control Agent[1]	Description
Aphids	*Aphidius* spp. *Aphelinus abdominalis*	parasitic wasp
	Aphidoletes aphidimyza	predatory midge
	Hippodamia spp.	predatory lady beetle
	Lacewings	predator
Fungus gnats	*Dalotia(=Atheta) coriaria*	predatory rove beetle
	Hypoaspis aculeifer *Hypoaspis miles* *Gaelaelaps gillespiei* *Stratiolaelaps scimtus*	predatory mite
Leafminers	*Dacnusa sibirica* *Diglyphus isaea*	parasitic wasp
Lepidopteran pests (cabbage looper, European corn borer)	*Coetesia marginiventris* *Trichogramma brassicae*	parasitic wasp
Mites	*Amblyseius andersoni* *Amblyseius californicus* *Amblyseius fallacis* *Phytoseiulus persimilis*	predatory mite
	Feltiella acarisuga	predatory midge
	Stethorus punctillum	predatory lady beetle
Thrips	*Amblydromalus limonicus* *Amblyseius swirskii* *Iphesius (=Amblyseius) desgenerans* *Neoseiulus (=Amblyseius) cucumeris* *Gaeolaelaps (=Hypoaspis) aculeifer* *Gaeolaelaps gillespiei* *Stratiolaelaps scimtus* (*= Hypoaspis miles*)	predatory mite
	Dalotia(=Atheta) coriaria	predatory beetle
	Orius insidiosus	predatory bug

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Table 9. Arthropod biological control agents available for the management of insect and mite pests in greenhouse vegetable crops in Canada (continued)

Pest	Biological Control Agent[1]	Description
Whiteflies	*Delphastus catalinae* *Delphastus pusillus*	predatory lady beetle
	Dicyphus hesperus	predatory bug
	Encarsia formosa *Eretmocerus eremicus* *Eretmocerus mundus*	parasitic wasp

[1]References:

Alberta Agriculture. *Pests of Greenhouse Sweet Peppers and their Biological Control.* (Web published July 2, 2002; revised Dec. 16, 2015) (www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/opp4527) (accessed March 8, 2016).

Ontario Ministry of Agriculture, Food and Rural Affairs. *Thrips in Greenhouse Crops - Biology, Damage and Management.* (Order no. 14-001; Publication date 01/14; Agdex 290/621) (www.omafra.gov.on.ca/english/crops/facts/14-001.htm) (accessed March 8, 2016).

Ontario Ministry of Agriculture, Food and Rural Affairs. *Whitelflies in Greenhouse Crops - Biology, Damage and Managemen*t . (Order no. 14-031; Publication date July 2014; Agdex 290/620) (www.omafra.gov.on.ca/english/crops/facts/14-031.htm) (accessed March 8, 2016).

Ontario Ministry of Agriculture, Food and Rural Affairs. *Mite Pests in Greenhouse Crops: Description, Biology and Management.* (Order no. 14-013; Publication date May 2014; Agdex 290/621) (www.omafra.gov.on.ca/english/crops/facts/14-013.htm) (accessed March 8, 2016).

Ontario Ministry of Agriculture, Food and Rural Affairs. *Publication 836 Crop Protection Guide for Greenhouse Vegetables 2014-2015.* (Order Number: 109062; Agdex 290) (www.omafra.gov.on.ca/english/crops/hort/greenhouse.html) (accessed March 8, 2016).

Table 10. Pesticides and biopesticides registered for insect and mite management in greenhouse cucumber production in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
abamectin	avermectin, milbemycin	glutamate-gated chloride channel (GLUCL) allosteric modulator	6	RE	leafminer, two spotted spider mite
acequinocyl	acequinocyl	mitochondrial complex III electron transport inhibitor	20B	R	two spotted spider mite
Autographa californica Nucleopolyhedrosis virus, FV11	biological	unknown	N/A	R	cabbage looper
Bacillus thuringiensis ssp. *aizawai* strain ABTS-1857	*Bacillus thuringiensis* and the insecticidal proteins they produce	microbial disruptors of insect midgut membranes	11A	R	beet armyworm, cabbage looper, corn earworm, tomato looper
Bacillus thuringiensis subsp. *kurstaki* strain ABTS-351	*Bacillus thuringiensis* and the insecticidal proteins they produce	microbial disruptor of insect midgut membranes	11A	R	European pepper moth (*Duponchelia fovealis*), loopers
Bacillus thuringiensis subsp. *kurstaki* strain EVB113-19	*Bacillus thuringiensis* and the insecticidal proteins they produce	microbial disruptor of insect midgut membranes	11A	R	European pepper moth (*Duponchelia fovealis*), banana moth (*Opongona sacchari*)

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Table 10. Pesticides and biopesticides registered for insect and mite management in greenhouse cucumber production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Beauvaria bassiana strain ANT-03	biological	unknown	N/A	R	whiteflies, aphids, thrips
bifenazate	bifenazate	mitochondrial complex III electron transport inhibitor	20D	R	two spotted spider mite
chlorantraniliprole	diamide	ryanodine receptor modulator	28	R	cabbage looper
dichlorvos	organophosphate	acetylcholinesterase (AChE) inhibitor	1B	RES*	aphids, whiteflies
fenbutatin oxide	organotin miticide	inhibitor of mitochondrial ATP synthase	12B	R	two spotted spider mite
flonicamid	flonicamid	chlordotonal organ modulator - undefined target site	29	R	thrips, aphids, lygus bugs, whiteflies(suppression only for foliar application)
imidacloprid	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	RES*	aphids, whiteflies
permethrin	pyrethroid, pyrethrin	sodium channel modulator	3A	RE	greenhouse whitefly

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Table 10. Pesticides and biopesticides registered for insect and mite management in greenhouse cucumber production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
potassium salts of fatty acids	not classified	unknown	N/A	R	aphids, mites, whiteflies
pymetrozine	pyridine azomethine derivative	chlordotonal organ TRPV channel modulators	9B	RES	green peach aphid, melon aphid
pyridaben	METI acaricide and insecticide	mitochondrial complex I electron transport inhibitor	21A	RE	two spotted spider mite
pyriproxyfen	pyriproxyfen	juvenile hormone mimic	7C	RE	silverleaf whitefly, sweet potato whitefly, greenhouse whitefly
pyrethrin	pyrethroid, pyrethrin	sodium channel modulator	3A	RE	spider mites, whitefly
spinetoram	spinosyn	nicotinic acetylcholine receptor (nAChR) allosteric modulator	5	R	cabbage looper, European corn borer, exposed western flower thrips (suppression)
spinosad	spinosyn	nicotinic acetylcholine receptor (nAChR) allosteric modulator	5	R	cabbage looper, European corn borer, exposed western flower thrips (suppression)

…. continued

Table 10. Pesticides and biopesticides registered for insect and mite management in greenhouse cucumber production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
spiromesifin	tetronic and tetramic acid derivative	inhibitor of acetyl CoA carboxylase	23	R	two spotted spider mite, sweet potato whitefly, silverleaf whitefly, greenhouse whitefly
spirotetramat	tetronic and tetramic acid derivative	inhibitor of acetyl CoA carboxylase	23	R	aphids, whiteflies

[1]Source: Pest Management Regulatory Agency label database (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 March 9, 2016. The product label is the final authority on pesticide use and should be consulted for application information. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

[2]Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (Version 8.0; December 2015)* (www.irac-online.org) (accessed February 15, 2016).

[3]PMRA re-evaluation status: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review, as published in PMRA *Re-evaluation Note REV2016-07, Pest Management Regulatory Agency Re-evaluation and Special Review Workplan 2015-2020*, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA as of October 30, 2015.

Melon (cotton) aphid *(Aphis gossypii)*

Pest Information

Damage: The melon aphid feeds on a variety of plants, including several vegetable crops. Heavily infested leaves wilt and collapse. Younger leaves may become dark green and stunted. Plants become covered in aphid secretions (honeydew) and cast aphid skins. Black sooty mould develops on the honeydew, reducing fruit quality. Aphids may also transmit cucumber mosaic virus. Because aphid populations can increase very quickly, especially under warm, humid conditions, 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 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 a source of aphids.

Biological Controls: Arthropod biological control agents available for the management of aphids in greenhouse cucumber are listed in *Table 9. Arthropod biological control agents available for the management of insect and mite pests in greenhouse vegetable crops in Canada*.

Resistant Cultivars: None available.

Chemical Controls: Pesticides and biopesticides registered for aphid control are listed in *Table 10. Pesticides and biopesticides registered for insect and mite management in greenhouse cucumber production in Canada*.

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.

Mites: Two-spotted spider mite *(Tetranychus urticae)* and carmine mite (*T. cinnabarinus)*

Pest Information

Damage: Infestations of the two-spotted spider mite can result in significant and sometimes total loss of the crop. Mites feed on the plant by puncturing the surface, resulting 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: The two-spotted spider mite has a broad host range, but greenhouse cucumber is a preferred host. The five developmental stages of spider mites are egg, larva, protonymph, deutonymph and adult. Adult females lay approximately 100 eggs on the lower leaf surface (five to eight eggs per day). The cycle may be completed in as little as three to four days at 32ºC, but typically takes two weeks to complete when temperatures are lower. 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 controlled by fumigation followed by the removal and destruction of all plant material.

Biological Controls: Arthropod biological control agents available for the management of mites in greenhouse cucumber are listed in *Table 9. Arthropod biological control agents available for the management of insect and mite pests in greenhouse vegetable crops in Canada.*

Resistant Cultivars: None available.

Chemical Controls: Miticides registered for the control of spider mites are listed in *Table 10. Pesticides and biopesticides registered for insect and mite management in greenhouse cucumber production in Canada.*

Issues for two spotted spider mites and carmine 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 not harmful to biological control agents and will contribute to resistance management.

Western flower thrips (*Frankliniella occidentalis*)

Pest information

Damage: The western flower thrips has a very broad host range. Nymphs and adults of the western flower thrips 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.

Life Cycle: Adult female thrips insert eggs individually into the plants leaves, stems and flowers. Eggs hatch after three to six days and nymphs feed on leaves and flowers. After six to nine days, the nymphs move into the soil and enter the non-feeding pre-pupal and pupal stages. Adults emerge after five to seven days, fly to a host, mate and lay eggs. The life cycle can be completed in about 15 days at 25ºC.

Pest Management

Cultural Controls: Monitoring and trapping of adult thrips is possible using commercially available blue or yellow sticky traps or ribbons. 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 sources of spread. It is important to thoroughly sanitize the greenhouse between crops. At the end of the growing season, infested crops can be fumigated and then removed and destroyed. Heating empty greenhouses to 35ºC for five days or 40ºC for two to three days will starve any emerging adults.

Biological Controls: Arthropod biological control agents available for the management of thrips in greenhouse cucumber are listed in *Table 9. Arthropod biological control agents available for the management of insect and mite pests in greenhouse vegetable crops in Canada*.

Resistant Cultivars: None available.

Chemical Controls: Insecticides registered for the control of thrips are listed in *Table 10. Pesticides and biopesticides registered for insect and mite management in greenhouse cucumber production in Canada.*

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.

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 vector Beet Pseudo Yellows Virus and this virus can persist and be a year-round problem. Adults suck sap from the plant and fruit, reducing plant vigour, and secrete honeydew, a waste product that can coat the plant. Secondary fungi (sooty mould) grow on the honeydew, reducing fruit quality. Feeding injury provides an entry point for diseases.

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 by the use of sticky traps and by 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.

Biological Controls: Arthropod biological control agents available for the management of whiteflies in greenhouse cucumber are listed in *Table 9. Arthropod biological control agents available for the management of insect and mite pests in greenhouse vegetable crops in Canada*.

Resistant Cultivars: None available.

Chemical Controls: Insecticides registered for the control of whiteflies, are listed in *Table 10. Pesticides and biopesticides registered for insect and mite management in greenhouse cucumber production in Canada.*

Issues for whiteflies

1. New, reduced risk insecticides that are not harmful to beneficial organisms and that could be used as resistance management tools are required.

Striped cucumber beetle (*Acalymma vittatum)*

Pest Information

Damage: Adult cucumber beetles are vectors of bacterial wilt and cucumber mosaic virus. The adults feed on the leaves of host plants, resulting in a "shot-hole" appearance. Adult beetles will 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.

Life Cycle: The adult beetles overwinter in weeds and crop debris and become active in early spring. Typically, beetles do not enter greenhouses until mid-summer. 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 10 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: The screening of vents and other openings to the greenhouse, maintaining a weed free border around the greenhouse and the elimination of crop debris, will minimize beetle entry into the greenhouse.

Biological Controls: None available.

Resistant Cultivars: None available.

Chemical Controls: There are no pesticides registered for use in greenhouses against cucumber beetles.

Issues for striped cucumber beetle

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

Caterpillars (various species) (Order: Lepidoptera)

Pest Information

Damage: Caterpillars chew holes in leaves and fruit.

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.

Pest Management

Cultural Controls: Screening of vents and other entry points into the greenhouse will minimize the potential for entry of these pests.

Biological Controls: Arthropod biological control agents available for the management of caterpillars in greenhouse cucumber are listed in *Table 9. Arthropod biological control agents available for the management of insect and mite pests in greenhouse vegetable crops in Canada.*

Resistant Cultivars: None available.

Chemical Controls: Pesticides and biopesticides registered for the control of whiteflies are listed in *Table 10. Pesticides and biopesticides registered for insect and mite management in greenhouse cucumber production in Canada.*

Issues for caterpillars

None identified.

Cabbage looper (*Trichoplusia ni*)

Pest Information

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

Life Cycle: Although the cabbage looper does not typically overwinter in Canada, moving north as an adult moth from the south in July and August, it has been known to overwinter in greenhouses. In greenhouses, as many as three generations 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 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.

Biological Controls: Arthropod biological control agents available for the management of cabbage loopers in greenhouse cucumber are listed in *Table 9. Arthropod biological control agents available for the management of insect and mite pests in greenhouse vegetable crops in Canada.*

Resistant Cultivars: None available.

Chemical Controls: Pesticides and biopesticides registered for the control of cabbage looper are listed in *Table 10. Pesticides and biopesticides registered for insect and mite management in greenhouse cucumber production in Canada.*

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.

Fungus gnats (*Sciaridae: Bradysia* and *Corynoptera spp.*) and shore flies (*Ephydidae*)

Pest Information

Damage: Adults are occasionally a nuisance to workers through 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.

Life Cycle: Mature female fungus gnats lay eggs in moist soils, potting mixes and hydroponic media. The eggs hatch in two to four days and the resulting larvae feed on plant roots, root hairs and fungal mycelium. The 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.

Biological Controls: Arthropod biological control agents available for the management of fungus gnats and shore flies in greenhouse cucumber are listed in *Table 9. Arthropod biological control agents available for the management of insect and mite pests in greenhouse vegetable crops in Canada*.

Resistant Cultivars: None available.

Chemical Controls: 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.

Weeds

Weed management in and around greenhouses is important as weeds can be an alternate host for insects and diseases. Weeds within the greenhouse are eliminated by hand weeding and through the use of ground coverings. Weeds exterior 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 pest and disease problems entering the greenhouse from outside. Herbicides may be used in the vicinity of greenhouses for the control of weeds. When herbicides are used, it is important that measures are taken to reduce the potential of spray drift from entering the greenhouse.

Vertebrate Pests

Rodents: Field mice (voles), house mice and Norway rats

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, piles of sawdust, old planting media, building debris, burlap or styrofoam which are left outdoors or where bags of seed or slug bait are stored.

Pest Management

Cultural Controls: Cultural controls include maintaining a weed-free zone around the perimeter of the greenhouse, installing tight-fitting screens over doors and windows, and placing wire screens over basement windows and vents. 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.

Chemical Controls: Poison bait stations can be used to control both house mice and rats. Bait stations can be placed in areas where rodents or their signs (droppings, chewing, burrows or sounds) have been observed. Bait stations should be covered and secure from access by pets and birds.

Issues for Rodents

None identified.

Resources

IPM/ICM resources for production of Greenhouse Cucumber in Canada

British Columbia Ministry of Agriculture and Lands (factsheets)
www.al.gov.bc.ca/ghvegetable/factsheets.htm

Centre de Référence en Agriculture et Agroalimentaire du Québec (CRAAQ). Agri-Réseau.
www.agrireseau.qc.ca/

Howard, R. J., J. Allan Garland, W. Lloyd Seaman (Eds.). *Diseases and Pests of Vegetable Crops in Canada.* (1994). Canadian Phytopathological Society and Entomological Society of Canada, Ottawa. 534 pp.

Ontario Ministry of Agriculture Food and Rural Affairs. (factsheets)
www.omafra.gov.on.ca/english/crops/hort/greenhouse.html

Ontario Ministry of Agriculture, Food and Rural Affairs. Publication 835 Crop Protection Guide for Greenhouse Vegetables 2014-2015
www.omafra.gov.on.ca/english/crops/hort/greenhouse.html

Ontario Ministry of Agriculture Food and Rural Affairs. Publication 836 Growing Greenhouse Vegetables in Ontario www.omafra.gov.on.ca/english/crops/hort/greenhouse.html

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

Provincial Crop Specialists and Provincial Minor Use Coordinators

Province	Ministry	Crop Specialist	Minor Use Coordinator
British Columbia	British Columbia Ministry of Agriculture and Lands www.gov.bc.ca/al	David Woodske david.woodske@gov.bc.ca	Caroline Bédard caroline.bédard@gov.bc.ca
Alberta	Alberta Agriculture and Rural Development www.agric.gov.ab.ca/	Simone Dalpe simone.dalpe@gov.ab.ca	Jim Broatch jim.broatch@gov.ab.ca
Ontario	Ontario Ministry of Agriculture, Food and Rural Affairs www.omafra.gov.on.ca/	Cara McCreary cara.mccreary@ontario.ca Shalin Khosla shalin.khosla@ontario.ca	Jim Chaput jim.chaput@ontario.ca

National and Provincial Greenhouse Grower Organizations

Alberta Greenhouse Growers Association
http://agga.ca/

British Columbia Greenhouse Growers' Association
www.bcgreenhouse.ca

Greenhouse Nova Scotia
http://greenhousenovascotia.com/

Le Syndicat de producteurs en serre du Québec
http://www.spsq.info/

Ontario Greenhouse Vegetable Growers
www.ontariogreenhouse.com/

Saskatchewan Greenhouse Growers Association
www.saskgreenhouses.com

National:

Canadian Horticultural Council
http://www.hortcouncil.ca

Appendix 1

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

Information on the occurrence of disease, insect and mite and weed 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.

<table>
<tr><th>Presence</th><th colspan="4">Occurrence information</th><th>Colour Code</th></tr>
<tr><td rowspan="12">Present</td><td rowspan="10">Data available</td><td>Frequency</td><td>Distribution</td><td>Pressure</td><td></td></tr>
<tr><td rowspan="5">**Yearly** - Pest is present 2 or more years out of 3 in a given region of the province.</td><td rowspan="3">**Widespread** - The pest population is generally distributed throughout crop growing regions of the province. In a given year, outbreaks may occur in any region.</td><td>**High** - If present, potential for spread and crop loss is high and controls must be implemented even for small populations.</td><td>Red</td></tr>
<tr><td>**Moderate** - If present, potential for spread and crop loss is moderate: pest situation must be monitored and controls may be implemented.</td><td>Orange</td></tr>
<tr><td>**Low** - If present, the pest causes low or negligible crop damage and controls need not be implemented.</td><td>Yellow</td></tr>
<tr><td rowspan="3">**Localized** - The pest is established as localized populations and is found only in scattered or limited areas of the province.</td><td>**High** - see above</td><td>Orange</td></tr>
<tr><td>**Moderate** - see above</td><td>White</td></tr>
<tr><td>**Low** - see above</td><td>White</td></tr>
<tr><td rowspan="5">**Sporadic** - Pest is present 1 year out of 3 in a given region of the province.</td><td rowspan="3">**Widespread** - as above</td><td>**High** - see above</td><td>Orange</td></tr>
<tr><td>**Moderate** - see above</td><td>Yellow</td></tr>
<tr><td>**Low** - see above</td><td>White</td></tr>
<tr><td rowspan="3">**Localized** - as above</td><td>**High** - see above</td><td>Yellow</td></tr>
<tr><td>**Moderate** -see above</td><td>White</td></tr>
<tr><td>**Low** - see above</td><td>White</td></tr>
<tr><td rowspan="2">Data **not** available</td><td colspan="3">**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.</td><td>White</td></tr>
<tr><td colspan="3">**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.</td><td></td></tr>
<tr><td>Not present</td><td colspan="4">The pest is not present in commercial crop growing areas of the province, to the best of your knowledge.</td><td>black</td></tr>
<tr><td>Data not reported</td><td colspan="4">Information on the pest in this province is unknown. No data is being reported for this pest.</td><td>grey</td></tr>
</table>

References

Agriculture and Agri-Food Canada. 2013 Statistical Overview of the Canadian Greenhouse Vegetable Industry . Catalogue Number A71-39E-PDF, AAFC No. 12324E. Available at www.publications.gc.ca/site/eng/home.html

Howard, R. J., J. Allan Garland, W. Lloyd Seaman (Eds.). Diseases and Pests of Vegetable Crops in Canada.1994. Canadian Phytopathological Society and Entomological Society of Canada, Ottawa. pp. 534.

Ontario Ministry of Agriculture, Food and Rural Affairs. Publication 836 Crop Protection Guide for Greenhouse Vegetables 2014-2015
www.omafra.gov.on.ca/english/crops/hort/greenhouse.html

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

Statistics Canada. CANSIM
www5.statcan.gc.ca/cansim/home-accueil?lang=eng