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Crop Profile for Greenhouse Cucumber in Canada, 2011

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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.

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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 long as 3000 years ago. In 2030 BC, cucumbers were imported to the Tigris Valley and eaten as pickles. 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 there is now significant production of mini- or gherkin-type cucumbers. All greenhouse cucumbers are sold for the fresh market. They are sweet, seedless and eaten unpeeled, either alone, or in salads, sandwiches or as a garnish. Cucumbers are a good source of potassium, calcium, folic acid and vitamin C.

Crop Production

Industry Overview

Table 1: National greenhouse cucumber production statistics

Canadian production (2011)[1]	43,865,470 dozen 309 hectares
Farm gate value (2011)[1]	$ 279 million
Domestic consumption (2011)[2]	3.94 kg/person (fresh)
Exports (cucumbers and gherkins) (2011)[2,3]	$125 million
	82,368 tonnes
Imports (2011)[2,3]	$59 million
	51,667 tonnes

[1]Source: Statistics Canada. Table 001-0006 - production and value of greenhouse vegetables, annual CANSIM (database) (www.statcan.gc.ca) (accessed 2012-11-27).

[2]Source: Agriculture and Agri-Food Canada. Statistical Overview of Horticulture 2010-2011.Catalogue no. A71-23/2011E-PDF, AAFC No. 11899E. Available at www.agr.gc.ca/horticulture_e

[3]Includes field and greenhouse cucumbers; includes cucumbers provisionally preserved.

Production Regions

Greenhouse cucumbers are grown in Canada in regions where milder temperatures reduce energy costs and that are close to major markets to minimize transportation costs. In 2011, the major production areas for greenhouse cucumbers were Ontario (232 hectares or 75% of the national acreage), British Columbia (39.5 hectares or 13%) and Alberta (28.2 hectares or 9%) (table 2).

Table 2: Distribution of greenhouse cucumber production in Canada in 2011[1]

Production Regions	Harvested area (hectares)	Percent national production
British Columbia	39.5	13%
Alberta	28.2	9%
Saskatchewan	0.4	0.1%
Manitoba	0.07	<1%
Ontario	232	75%
Quebec	7.4	2%
Atlantic Provinces	1.3	<1%
New Brunswick	n/a	n/a
Nova Scotia	1.28	<1%
Prince Edward Island	n/a	n/a
Newfoundland and Labrador	0.03	<1%
Canada	309	100%

[1]Source: Statistics Canada. Table 001-0006 - production and value of greenhouse vegetables, annual CANSIM (database) (www.statcan.gc.ca) (accessed 2012-11-27).

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 transplanted into rockwool blocks, after emergence in propagation houses. The root zone temperature is maintained at 21-25^{o}C and moisture and light intensity and CO_2 levels are carefully monitored. Each seedling is staked to prevent damage and make stringing-up easier. When 3-5 leaves have developed, the rockwool-block seedlings are transplanted into final growing bags containing rockwool, sawdust or coir soaked with nutrient

solution and strung up. Plants are generally grown in twin rows with a walkway between each row. 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 and 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/fall or late fall) and pruning systems vary depending on the growing and training system. Growing conditions (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 2-3 weeks after transplanting and will continue to produce fruit for approximately 60-150 days. Cucumbers are parthenocarpic so pollination is not required for fruit set. The time from flowering to harvest is about 10-14 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 to avoid desiccation.

At least a dozen varieties of long English cucumber are grown across Canada. Varieties tolerant to powdery mildew (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 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 4-crop system to produce a crop 50 weeks per year and reduce insect and disease problems. Some smaller growers still use a 2-crop system. Mini-cucumbers are still a small portion of the total crop, and production of these has been expanding recently in Ontario and British Columbia. In Alberta, there is significant production in winter under supplemental light and intercropping is practiced.

Production Issues

Greenhouse cucumber production is affected by many abiotic factors and biotic pests. Proper management of environmental factors, such as temperature, light, moisture and CO_2 is critical. Good crop management including proper plant training, fruit pruning and nutrition are essential. Poor hygiene or plant management may allow the introduction of insects and/or diseases. Pathogens such as pythium, fusarium and other root-rotting organisms can spread quickly in re-circulating water and botrytis and other pathogens can infect poorly cut fruit stems and plant wounds. Whiteflies, cabbage loopers, thrips, spider mites and fungus gnats are the most damaging insect and mite pests. Monitoring and biological pest controls are widely used in an Integrated Pest Management (IPM) program to combat these pests, with minimal use of chemical insecticides. Some growers market cucumbers under the NutriClean® plan under which no pesticide residues are permitted on the fruit.

Table 3: Canadian greenhouse cucumber production and pest management schedule

TIME OF YEAR	ACTIVITY	ACTION
Seeding	Greenhouse and Media Care	Ensure the propagation house is clean and free of pests and crop debris. Use clean trays and propagation media. Ensure proper temperature for seed germination.
	Disease Management	Obtain seed treated with a seed-protectant fungicide for sowing. Ensure proper seed germination temperature and don't over-water.
	Insect Management	Monitor and control fungus gnats.
Plant Raising	Plant Care	Maintain appropriate temperature and wetness of the rockwool blocks and use supplemental lighting as needed. Space and stake plants.
	Disease Management	Drench seedlings with registered fungicides to control damping-off. Note: young cucumber seedlings can be sensitive to some fungicides. Several microbial fungicides are also available for suppression of root diseases. Control fungus gnats that can spread pythium and other root rot organisms. Biological control agents can also be released at the seedling stage to assist in suppression of fungus gnats.
	Insect Management	Monitor and control fungus gnats, thrips, whiteflies, loopers and lygus bugs as needed. Maintain populations of beneficial insects and apply insecticides if needed.
	Weed Management	Maintain a 3-metre wide vegetation-free zone around the greenhouse.
Production and Harvest	Plant Care	Practice appropriate fruit pruning and lateral pinching and training throughout the harvest period depending on the time of year and variety. Monitor nutrient solution EC and pH and irrigate as needed. Maintain appropriate environmental controls: temperature, light intensity, CO_2, humidity, etc. Avoid drafts and chilling injury.
	Disease Management	Use clean, sharp knives when harvesting fruit and disinfect tools periodically during harvest. Place in clean, disinfected harvest bins and store promptly. Monitor for diseases and apply registered fungicides as needed. Use powdery mildew-tolerant (PMT) cultivars when feasible or desirable. Pay particular attention to environment management, the objective being to keep the plants dry and avoid condensation on the plants. Proper irrigation to avoid excessive or inadequate moisture in the slabs and adequate EC levels are also important in disease management.
	Insect Management	Keep cracks sealed and doorways closed. Screen vents if possible. Monitor weekly for insect and mite pests using sticky cards and leaf inspection. Release beneficial predators and parasites and apply registered insecticides only if necessary.
	Weed Management	Maintain a 3-metre wide vegetation-free zone around the greenhouse.
Post-Harvest	Fruit Care	Store and ship at appropriate temperature (13^{o}C) 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. The optimum temperature for seed germination is 26-28^{o}C. Seedlings are kept at 25^{o}C until roots are established. Subsequently the temperature is lowered to 21^{o}C at night and 23-25^{o}C during the day, depending on the light intensity. Rockwool block temperature is maintained at 21-23^{o}C for optimum root growth. In the production house, it is important to maintain an average 24 hour temperature of 21^{o}C for an optimum balance between vegetative and fruit growth. Initially, the difference between day and night temperatures is kept small to ensure rapid development of a plant with a long, thin stem and small leaves. Once the plants reach the overhead wire, the night temperature is lowered to produce a plant with a thicker stem and leaves or raised to produce a thinner plant. To avoid condensation on the leaves which can lead to disease development, the temperature is raised gradually by 1^{o}C per hour at the end of the night so that the day temperature is reached 1-2 hours before sunrise to give the plants time to warm up to that temperature. Day temperatures are manipulated by venting. Low temperatures may harm greenhouse cucumber fruit on the vine or in post-harvest storage. 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. Plants may develop slowly with excessively large leaves, flowering delayed and fruit may curl or abort. Preventing cold drafts and avoiding the use of cold water when spraying the plants with pesticides lessen the risk of chilling injury.

Other environmental factors

Humidity is closely monitored and controlled for greenhouse cucumber crops. Too high humidity will favour the development of both powdery mildew and gummy stem blight and sudden changes of temperature that lead to condensation on the leaves, favours 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

Greenhouse cucumbers are grown in soilless media, such as rockwool, sawdust or coir. Nutrients and water are provided to plants through a recirculating (hydroponic) water system with drippers delivering the nutrient solution to each plant. The EC (salt concentration) 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 subsequent lack of oxygen in the root zone favours the development of pythium root rot. The amount of water is critical also for development of healthy seedling roots. 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. Upper leaves are rounded and cupped downward and may have yellow to brown edges. Iron, phosphorus and manganese deficiencies are less common. 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 (low vapour pressure deficit). 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, may help reduce the incidence of fruit yellowing.

Root Death

Abrupt plant wilting accompanied by root necrosis, disintegration and death, that develops within 5-8 hours, is often associated with plant stress, such as too low or too high temperature, too high EC levels, 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, in which the stem shrivels and loses water just after harvest is associated with low relative humidity, harvesting immature fruit, a large fruit load and harvesting in the afternoon.

Black fruit, in which the fruit develops a black discolouration, 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, although it should be noted that 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

- There are few fungicides registered for control of the major diseases of greenhouse cucumber including pythium crown rot, fusarium root and stem rot, gummy stem blight, powdery mildew, downy mildew and botrytis grey mould. There is a need for the registration of new, reduced risk fungicides especially those with a shorter pre-harvest interval (PHI) for the management of these diseases.
- The development of resistant cultivars to diseases such as fusarium stem and root rot, fusarium wilt and gummy stem blight, is needed. There is a need for the continued development of powdery mildew tolerant cultivars that yield well.
- There is a need to prepare and update information for growers on the use of climate controls for the management of diseases such as gummy stem blight and grey mould.
- There is a need for the development of biological controls for the management of black root rot suitable for use in organic greenhouses.
- There is a need for the registration of pesticides to control the cucumber beetle which is the vector of bacterial wilt.

Table 4: Occurrence of diseases in greenhouse cucumber production in Canada by province[1,2]

Disease	British Columbia	Alberta	Ontario
Angular leaf spot			
Bacterial wilt			
Damping-off			
Downy mildew			
Fusarium wilt			
Grey mould			
Gummy stem blight			
Penicillium stem rot			
Powdery mildew			
Pythium crown rot and root rot			
Verticillium wilt			
Virus diseases			
Cucumber mosaic			
Zucchini yellow mosaic			

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 is present and of concern, however little is known of its distribution, frequency and importance.

Pest not present.

Data not reported.

[1]Source: greenhouse cucumber stakeholders in reporting provinces.

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

Table 5: Adoption of disease management approaches in greenhouse cucumber production in Canada[1]

Practice / Pest		Grey mould	Damping-off	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 sterilized 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							
Monitor-ing	regular monitoring throughout crop cycle							
	records to track diseases							
	use of indicator plants							

Practice / Pest		Grey mould	Damping-off	Downy mildew	Fusarium wilt	Gummy stem blight	Powdery mildew	Pythium crown 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							

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: Greenhouse cucumber stakeholders in producing provinces (British Columbia and Ontario).

Table 6: Fungicides and bactericides registered for disease management in greenhouse cucumber in Canada

Active Ingredient[1,2]	Classification[3]	Mode of Action[3]	Target Site[3]	Resistance Group[3]	Re-evaluation Status[4]	Targeted Pests[1,5]
bacillus-subtilis strain QST 713	*Bacillus subtilis* and the fungicidal lipopeptides produced	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	44	R	suppresses damping-off and root diseases caused by *Fusarium* spp., *Rhizoctonia solani* and *Pythium* spp.
boscalid + pyraclostrobin	pyridine carboxamide + methoxy carbamate	C2. respiration + C3. respiration	complex II: succinate-dehydro-genase + complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	7 + 11	R + R	powdery mildew (*Sphaerotheca fuliginea*) suppression, gummy stem blight (*Didymella bryoniae*)-suppression
cyprodinil + fludioxonil	anilino-pyrimidine + phenlypyrrole	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	R + R	suppression of powdery mildew (*Podosphaera xanthii*)
fenhexamid	hydroxyanilide	G3: sterol biosynthesis in membranes	3-keto reduc-tase, C4-de-methylation (erg27)	17	R	grey mould (*Botrytis cinerea*)
ferbam	dithio-carbamates and relatives	Multi-site contact activity	Multi-site contact activity	M3	RE	grey mould (*Botrytis cinerea*)

Active Ingredient[1,2]	Classification[3]	Mode of Action[3]	Target Site[3]	Resistance Group[3]	Re-evaluation Status[4]	Targeted Pests[1,5]
fludioxonil + cyprodinil	phenylpyrrole + anilo-pyrimidine	E2: signal transduction + D1: amino acids and protein synthesis	MAP/Histidine-Kinase in osmotic signal transduction (os-2, HOG1) + methionine biosynthesis (proposed) (cgs gene)	12 + 9	R + R	suppression of powdery mildew (*Podosphaera xanthii*)
Gliocladium catenulatum	biological	unknown	unknown	N/A	R	suppression of damping off caused by *Pythium* spp. and *Rhizoctonia solani*; suppression of crown and root rot caused by *Pythium* spp.; suppression of stem wilt disease caused by *Fusarium oxysporum*
iprodione	dicarboximides	E3: signal transduction	MAP/Histidine-Kinase in osmotic signal transduction (os-1, Daf1)	2	RE	botrytis grey mould, gummy stem blight
mancozeb	dithio-carbamates and relatives	Multi-site contact activity	Multi-site contact activity	M3	RE	gummy stem blight, powdery mildew
metalaxyl-M	acylalanines	A1: nucleic acids synthesis	RNA polymerase I	4	R	*Pythium* spp.
potassium bicarbonate	not classified	diverse	unknown	NC	R	powdery mildew (*Podosphaera xanthii*)

Active Ingredient[1,2]	Classification[3]	Mode of Action[3]	Target Site[3]	Resistance Group[3]	Re-evaluation Status[4]	Targeted Pests[1,5]
propamocarb	carbamate	F4: lipid synthesis and membrane integrity	cell membrane permeability, fatty acids (proposed)	28	R	root rot and damping off caused by pythium, downy mildew (*Pseudoperonospora cubensis*)
pyraclostrobin + boscalid	methoxy-carbamate + pyridine carboximide	C3. respiration + C2 respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene) + complex II: succinate-dehydrogenase	11 + 7	R + R	powdery mildew (*Sphaerotheca fuliginea*) suppression, gummy stem blight (*Didymella bryoniae*)-suppression
Streptomyces-k61 (streptomyces-griseoviridis)*	biological	unknown	unknown	N/A	R	suppression of fusarium and pythium
Streptomyces-k61	biological	unknown	unknown	N/A	R	suppression of damping -off, root and crown rot and wilt caused by fusarium; suppression of damping off and root and crown rot caused by pythium
Streptomyces lydicus	biological	unknown	unknown	N/A	R	suppression of powdery mildew (*Podosphaera xanthii*)
sulphur	inorganic	Multi-site contact activity	Multi-site contact activity	M2	R	powdery mildew

Active Ingredient[1,2]	Classification[3]	Mode of Action[3]	Target Site[3]	Resistance Group[3]	Re-evaluation Status[4]	Targeted Pests[1,5]
Trichoderma harzianum rifai	biological	unknown	unknown	N/A	R	suppression of root diseases caused by pythium, rhizoctonia and fusarium

[1]Registrations confirmed on the PMRA Registered Products Database (www.hc-sc.gc.ca/cps-spc/pest/index-eng.php) November 7, 2012.

[2] Not all end use products containing this active ingredient may be registered for use on this crop. The information in these tables should not be relied upon for pesticide application decisions. Individual product labels must be consulted for up to date, accurate information concerning the use of these pesticides and specific registration details.

[3]Source: FRAC Code List: Fungicides sorted by mode of action (including FRAC code numbering) published by the Fungicide Resistance Action Committee (March 2012) (www.frac.info/frac/index.htm).

[4]PMRA re-evaluation status as of **October 31, 2012**: R – full registration, RE (yellow) – under re-evaluation, DI (red) – discontinued by registrant, PO (red) – being phased out as a result of re-evaluation.

[5] Please consult the pesticide label for a detailed listing of pests controlled by products containing each active ingredient. Information on registered pesticide uses is also available from the PMRA Registered Products Database (www.hc-sc.gc.ca/cps-spc/pest/index-eng.php).

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: Different temperatures are optimal for different species of pythium and the other fungi associated with damping-off. Infection is favoured by high moisture in the growing media. The pathogens can be spread in irrigation water. Fungus gnats spread pythium sporangia 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 will reduce disease development as will maintaining a minimum temperature of 20°C at the root zone and avoiding seedling stress.

Biological Controls: Bacillus subtilis, Gliocladium catenulatum, Streptomyces griseoviridis and Trichoderma harzianum are microbial fungicides registered for the suppression of damping off.

Resistant Cultivars: None available.

Chemical Controls: Fungicides registered for the control of seedling damping-off are listed in table 6.

Issues for damping-off

None identified.

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-season (summer crops). Plants wilt suddenly in hot, sunny weather. Infected crowns are orange-brown with a soft, dry rot. There are few lateral roots at the crown and the plants lift easily out of the growing medium. When tiny feeder roots alone are infected, these appear soft and water-soaked and the plants wilt although the crown may remain white and healthy.

Life Cycle: Pythium species are oomycetes (protists). They 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. *Pythium aphanidermatum* is one of the most common species, but other *Pythium* spp. can cause symptoms also. Fungus gnats and shoreflies 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.

Biological Controls: Bacillus subtilis, Gliocladium catenulatum, Streptomyces griseoviridis and *Trichoderma harzianum* are microbiological fungicides that are registered for suppression of pythium.

Resistant Cultivars: None identified.

Chemical Controls: Fungicides registered for use against pythium diseases on greenhouse cucumber are listed in table 6.

Issues for crown and root rot

1. There is a need for the registration of new reduced risk products, especially those with a shorter pre-harvest interval (PHI) for application, ie 1-2 weeks for inter-planted crops and biological controls, for the management of pythium diseases.
2. With the re-circulation of the nutrient solution, growers may face an increased incidence of root diseases.

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 are wilting of the upper leaves and declining plant vigour. The base of 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. Fungus gnats and shore flies should be controlled and greenhouse structures, reservoirs and irrigation lines cleaned and disinfected thoroughly between crops. The movement of workers from diseased to healthy crop areas should be restricted. Pruning shears and harvest knives should be disinfected frequently when working in infected areas and plant debris should be removed and destroyed promptly.

Biological Controls: Bacillus subtilis, Streptomyces griseoviridis, Trichoderma harzianum rifai are registered for the suppression of fusarium diseases.

Resistant Cultivars: None available.

Chemical Controls: None available.

Issues for fusarium root and stem rot

1. There is a need for the registration of new products, including reduced risk pesticides and biological controls for the management of fusarium root and stem rot.
2. Research to develop resistant cultivars or root grafting stock is needed.

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

Pest Information

Damage: The first symptom of this disease is an amber-red gummy exudate on the stem tissue where the fungal infection has 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 also makes plants more susceptible to other diseases, such as botrytis and powdery mildew and 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 infect flowers and wounded tissue. Inoculum is spread primarily by tools and crop handling. The fungal mycelium can survive for up to two years on un-decomposed plant debris.

Pest Management

Cultural Controls: The removal of all crop debris from the greenhouse at the end of each crop cycle and the destruction of cull piles or the placement of cull piles away and downwind of the greenhouse, will help to reduce sources of infestation. The cleaning and disinfection of pruning shears and other tools and equipment in contact with cucumber plants will also help to minimize spread of the disease. Other practices which help to 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.

Biological Controls: None available.

Resistant Cultivars: None available.

Chemical Controls: Fungicides registered for the control of gummy stem blight are listed in table 6.

Issues for gummy stem blight

1. The registration of effective, new, reduced-risk fungicides with short pre-harvest intervals (PHI) is needed for the control of gummy stem blight. Resistance to currently registered pesticides is present in the pathogen population.
2. The development of resistant cultivars is required.
3. There is a need to prepare and update information on managing this disease through the effective use of climate controls.

Penicillium stem rot (*Penicillium oxalicum)*

Pest Information

Damage: This disease has occasionally caused severe losses in some greenhouses. Symptoms are similar to gummy stem blight and grey mould except the fungus produces a blue-grey mass of spores in the lesions. Lesions can occur anywhere on the stems or petioles but are most common at the base of the plant at a pruned leaf node. The internal stem tissue rots at the point of infection and the plant dies back above the lesion.

Life Cycle: Penicillium spores are air-borne and spread by handling and splashing water. This pathogen is a wound-invader. Infection is favoured by low light, high humidity (low vapour pressure deficit) or condensation on the plants and a low EC in the nutrient solution.

Pest Management

Cultural Controls: The removal of infected stems to allow a new sucker to develop, avoiding wounding of the stem and pruning with sharp knives that are disinfected frequently between cuts will reduce disease development. Preventing condensation on the leaves by raising the night temperature slowly before sunrise and ensuring adequate ventilation so leaves will dry quickly will reduce the chances of infection. Good sanitation practices including the removal of old crop debris promptly from the greenhouse will reduced sources of disease.

Biological Controls: None available.

Resistant Cultivars: None available.

Chemical Controls: None available.

Issues for penicillium stem rot

None identified.

Fusarium wilt *(Fusarium oxysporum* f. sp*. cucurbitacearum,* syn. *F. oxysporum* f. sp. *cucumerinum)*

Pest Information

Damage: Infected plants typically wilt slowly, with progressive yellowing of the leaves. Symptomless plants may suddenly wilt in hot, sunny weather. A yellow discolouration can usually be seen in the stems, often at leaf nodes. There are often no visible root or crown rot symptoms. The *Fusarium oxysporum* strain that causes wilt disease is different from the strain that has caused a more serious disease, fusarium root and stem rot.

Life Cycle: Fusarium wilt is carried on seeds and is spread by spores. The spores infect roots and progress upward in the xylem tissue, blocking water uptake. This disease is favoured by a hot, dry climate. Fungus gnats and other insects may also spread fusarium spores. The fungus survives in soil or on crop debris.

Pest Management

Cultural Controls: Cultural controls include the removal and destruction of diseased plants; the cleaning and disinfection of growing media, the greenhouse and all tools and equipment and other sanitation practices. Seeds can be disinfected by heating them to 75°C for 3 days or 80°C for 2 days. Fungus gnat populations should be controlled to reduce the spread of fusarium spores.

Biological Controls: Gliocladium catenulatum is registered for the suppression of fusarium wilt on greenhouse cucumber.
Resistant Cultivars: None available.
Chemical Controls: None available.

Issues for Fusarium wilt

1. Research is required for the development of fusarium resistant cultivars and rootstocks.
2. There are no fungicides currently registered for the control of this disease in Canada; there is a need for the registration of new products, including reduced risk pesticides and bio-pesticides, for the control of fusarium wilt.

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

Pest Information

Damage: These soil-borne pathogens rarely infect greenhouse crops grown in soilless media. Plants wilt and cease to be productive. Leaf blades often develop a yellow, V-shaped lesion at the tips. Yellow to brown discolouration (streaks) can often be seen in the stem vascular tissue, particularly at nodes. There is no root rot.
Life Cycle: Both fungi have a wide host range. *V. dahliae* survives as small, dark microsclerotia and can persist for several years in soil. *V. albo-atrum* is more short-lived. Water-borne spores enter roots and move up in the vascular system of the plant, blocking water uptake.

Pest Management

Cultural Controls: Good sanitation practices such as the prompt removal and destruction of infected plants, disinfection of the greenhouse thoroughly between crops and the destruction of crop debris and culls will help to minimize disease development.
Biological Controls: None available.
Resistant Cultivars: None available.
Chemical Controls: None available.

Issues for Verticillium wilt

None identified.

Bacterial wilt *(Erwinia tracheiphila)*

Pest Information

Damage: This disease is occasionally a problem in greenhouse cucumber. Leaves may yellow or become necrotic. Plants wilt and stems exude a stringy, bacterial ooze when cut open.
Life Cycle: Bacterial wilt is transmitted by cucumber beetles. The bacteria overwinter in the gut of adult beetles and are transmitted to the plant through feeding or by contaminated insect frass coming in contact with a small wound on the host plant. There is no evidence that this disease is spread by seed.

Pest Management

Cultural Controls: Placing screens on ventilators and doors to prevent entry of cucumber beetles, the disease vector, will delay the onset of the disease. Diseased plants should be destroyed as soon as possible. Raising the temperature briefly above 30ºC will activate defense mechanisms in the plant and may help to reduce disease symptoms.

Biological Controls: None available.

Resistant Cultivars: There are no resistant cultivars, but late-bloomers tend to be less severely affected.

Chemical Controls: None available.

Issues for Bacterial wilt

1. There is a need for the registration of pesticides to control the cucumber beetle which is the vector of this disease.

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 first small infections 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. Botrytis grey mould is characterized by basal stem cankers or rotted tissue and grey-green shriveled leaves. Severe infection results in the girdling of the stem or petiole. Plants, lateral branches or fruit stems die as a result of lower lesions.

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 and are the main source of new infections. Spores are air-borne and 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 using sharp, clean knives for harvesting fruit will reduce disease as will harvesting in the morning when fruit and foliage are dry. Crop residue should be removed promptly from the greenhouse. Preventing condensation on the leaves by controlling ventilation and raising temperatures gradually prior to sunrise and avoiding excessive nitrogen, will make conditions less hospitable for botrytis. Pruning should be done as needed to maintain a proper balance between foliage and fruit load, since lush growth is more susceptible to botrytis infection and a heavy canopy will slow drying of leaves.

Biological Controls: None available.

Resistant Cultivars: None available.

Chemical Controls: Fungicides registered for the control of grey mold are listed in table 6.

Issues for botrytis grey mould

1. The registration of new, reduced-risk fungicides 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 the development of educational material on the use of climate control strategies.

Powdery mildew (*Erysiphe cichoracearum, Sphaerotheca fuliginea)*

Pest Information

Damage: Powdery mildew is one of the most damaging diseases of greenhouse cucumber. Round, white spots on the upper surface of older leaves are the initial symptoms of this disease. These spots enlarge and often cover the entire surface of the leaf. Occasionally the disease appears on petioles and stems as well. White powdery spores develop over 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 mildews are obligate parasites. Spores germinate at a relative humidity of 80% or higher and at temperatures between 22-31°C. In the greenhouse, spores may survive as long as 10 days. Secondary spores are produced in lesions 5-7 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 or near vents and doorways, where humidity and temperature is less well controlled. Spores may survive outdoors on cull piles and crop debris or field cucurbit crops.

Pest Management

Cultural Controls: Sanitation practices such as the 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 will help to reduce sources of the disease. Maintaining a uniform, relative humidity of 70-80% will reduce disease development. Spraying the plants every 2-3 days with water may reduce spore buildup, but may also predispose plants to other diseases, such as gummy stem blight and botrytis grey mould.

Biological Controls: None available.

Resistant Cultivars: 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.

Issues for powdery mildew

1. The registration of new, reduced-risk fungicides is needed to control the disease and reduce the risk of resistance development.
2. There is a need for continued development of powdery mildew tolerant cultivars that yield well.
3. There is a need for the development of cultural and environmental controls for powdery mildew.

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.

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.

Biological Controls: None available.

Resistant Cultivars: None available.

Chemical Controls: None available.

Issues for downy mildew

1. This disease is a serious threat to the greenhouse cucumber industry. There is a need for the registration of new reduced risk products for the control of this disease.

Angular leaf spot *(Pseudomonas syringae* pv*. lachrymans,* syn. *P. lachrymans)*

Pest Information

Damage: This disease is rare in greenhouse cucumbers and is only occasionally a problem in poorly-ventilated greenhouses with overhead irrigation or excessive condensation on the crop. Symptoms can appear at any stage of plant growth and development and include small, round, or somewhat irregular, water-soaked spots on the leaf or cotyledon surface. As the disease progresses, the spots dry and turn yellow-brown. The centre of the spot may fall out, leaving an angular shot-hole. Stems, petioles and fruit are also affected with a whitish crust in the dry lesions. Disease results in reduced yield as infected fruit is not marketable.

Life Cycle: This bacterial disease is spread through seed contamination and water. Bacterial ooze released from the leaf spots is readily dispersed by water, machinery and workers. The bacteria may survive in the soil in association with host roots. Insects may also vector this disease.

Pest Management

Cultural Controls: The use of good sanitation and water management practices will help reduce disease development. Pathogen-free seed should be used and the use of overhead irrigation avoided. Relative humidity must be kept low. Leaf injury and working in the crop when the foliage or fruit is wet should be avoided to minimize disease development.

Biological Controls: None available.

Resistant Cultivars: Differences in susceptibility have been noted among field cultivars but there is little information on resistance in greenhouse varieties.

Chemical Controls: Although registered in Canada for control of angular leaf spot in field cucumbers, copper-based bactericides are mostly ineffective and are not registered for use in greenhouse crops. Surface seed treatments may be only partially effective in killing the bacteria in and on the seed coat.

Issues for Angular leaf spot

None identified.

Cucumber Mosaic (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. On occasion, a "white pickle" symptom may develop.

Life Cycle: This virus is spread by aphids and in some cases, by tools such as pruning knives and handling. Cucumber mosaic has a wide host range covering more than 40 angiosperm 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. Weeds within a 100 m area around the greenhouse should be removed or controlled. Areas of the greenhouse with diseased plants should be worked in last.

Biological Controls: None available.

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

Chemical Controls: None available.

Issues for Cucumber mosaic virus

None identified.

Zucchini yellow mosaic (Zucchini Yellow Mosaic Virus)

Pest Information

Damage: This disease is characterized by severe mosaic, yellowing and distortion of the leaves and fruit. Infection early in plant development may result in failure to set fruit.

Life Cycle: Aphids vector this disease. It can also be spread on pruning knives, hands and the clothing of workers.

Pest Management

Cultural Controls: Infected plants should be removed and destroyed and pruning tools sterilized on a daily basis. Controlling aphid populations and maintaining a weed-free zone around the perimeter of the greenhouse will help to minimize disease spread.

Biological Controls: None available.

Resistant Cultivars: None available.

Chemical Controls: None available.

Issues for zucchini yellow mosaic

None identified.

Insects and Mites

Key Issues

- There is a need for the registration of new, reduced risk insecticides to manage a number of greenhouse pests, for resistance management. These materials and approaches must not be harmful to beneficial organisms. As greenhouse cucumbers are harvested daily or every-other day, chemical products with short re-entry intervals (REI) are required.
- Fungus gnats and shore flies are emerging issues. There is a need for the registration of new reduced risk products including insect growth regulators (IGR's) and biological controls for the management of these pests.
- There is resistance to the currently registered products in mite populations
- Lygus bugs are a potential threat to greenhouse cucumber production. There are currently no products registered for lygus control.

Table 7: Occurrence of insect and mite pests in greenhouse cucumber production in Canada by province[1,2]

Pest	British Columbia	Alberta	Ontario
Aphids			
Cotton/melon aphid			
Striped cucumber beetle			
Fungus gnats and shore flies			
Caterpillars (various species)			
Cabbage looper			
Mealybugs			
Lygus bugs			
Mites			
Carmine mite			
Two-spotted spider mite			
Western flower thrips			
Whiteflies			
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 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 importance.

Pest not present.

Data not reported.

[1]Source: greenhouse cucumber stakeholders in reporting provinces.

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

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

Practice / Pest		Cotton (melon) aphid	Cucumber beetles	Fungus gnats and shore flies	Caterpillars (various species)	Lygus bugs	Two-spotted spider mite	Thrips	Whiteflies
Avoidance	crop rotation								
	optimizing fertilization								
	reducing mechanical damage								
	trap crops								
	insect barriers at openings								
Prevent-ion	equipment sanitation								
	end of season crop residue removal and clean-up								
	pruning out / removal of infested material								
Monitor-ing	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								

Practice / Pest		Cotton (melon) aphid	Cucumber beetles	Fungus gnats and shore flies	Caterpillars (various species)	Lygus bugs	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 beneficial organisms								
	novel pesticide application techniques (eg. use of pollinating insects to carry biopesticides)								
	follow sanitation practices								
New practices	screened vents + dormant oil (British Columbia only)								

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: Greenhouse cucumber stakeholders in producing provinces (British Columbia and Ontario).

Table 9: Arthropod biological control agents available for the management of greenhouse pests in Canada[1]

Pest	Biological Control Agent	Description
Aphids	*Aphelinus abdominalis*	parasitic wasp
	Aphidius spp.	parsitic wasp
	Aphidoletes aphidimyza	predatory midge
	Harmonia axyridis	predator (lady beetle)
	Hippodamia convergens	predator (lady beetle)
	Lacewings	predator
	Praying mantis	predator
	Syrphid flies	predator
Fungus gnats	*Atheta coriaria*	predatory rove beetle
	Hypoaspis spp.	predatory mite
	Hypoaspis aculeifer	predatory mite
	Steinernema feltiae	predatory nematode
Leafminers	*Dacnusa sibirica*	parasitic wasp
	Diglyphus isaea	parasitic wasp
Lepidopteran pests (cabbage looper, European corn borer)	*Coetesia marginiventris*	parasitic wasp
	Dicyphus hesperus	predatory bug
	Podisus maculiventris	predatory bug
	Trichogramma brassicae	parasitic wasp
	Trichogramma pretosium	parasitic wasp
Mites (broad)	*Amblyseius californicus*	predatory mite
	Amblyseius cucumeris	predatory mite
	Amblyseius swirski	predatory mite
Mites	*Amblyseius (Neoseiulus) fallacis*	predatory mite
	Amblyseius californicus	predatory mite
	Feltiella acarisuga	predatory midge
	Phytoseiulus persimilis	predatory mite
Potato (tomato) psyllid	*Dicyphus hesperus*	predatory bug
	Orius sp.	predatory bug
	Tamaraxia triozae	parasitic wasp
Thrips	*Neoseiulus cucumeris*	predatory mite
	Amblyseius barkeri	predatory mite
	Amblyseius cucumeris	predatory mite
	Deracicoris brevus	predatory bug
	Hypoaspis spp.	predatory mite
	Iphesius desgenerans	predatory mite
	Orius insidiosus	predatory bug
	Orius tristicolor	predatory bug
Whiteflies	*Delphastus pusillus*	predatory lady beetle
	Dicyphus hesperus	predatory bug
	Encarsia formosa	parasitic wasp
	Lacewings	predator
	Orius spp.	predatory bug

[1]References:

Management of Thrips in Greenhouse Crops (OMAFRA) (Order no. 03-095 08/09 Agdex 290/621) (www.omafra.gov.on.ca/english/crops/facts/03-075.htm) (accessed Feb. 25, 2013)

Management of Whitelflies in Greenhouse Crops (OMAFRA) (Order no. 03-067 Agdex 290/621) (www.omafra.gov.on.ca/english/crops/facts/03-067.htm) (Accessed Feb. 25, 2013)

Potato Psyllid - a New Pest in Greenhouse Tomatoes and Peppers (OMAFRA) (www.omafra.gov.on.ca/english/crops/facts/potato_psyllid.htm) (Accessed Feb. 25, 2013)

Pests of Greenhouse Sweet Peppers and their Biological Control (Alberta Agriculture) (www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/opp4527) (accessed Feb. 25, 2013)

Ontario Ministry of Agriculture, Food and Rural Affairs. Publication 836 Crop Protection Guide for Greenhouse Vegetables 2012-2013. www.omafra.gov.on.ca/english/crops/hort/greenhouse.html

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

Active Ingredient[1,2]	Classification[3]	Mode of Action[3]	Resistance Group[3]	Re-evaluation Status[4]	Targeted Pests[1,5]
abamectin	Avermectin, milbemycin	Chloride channel activators	6	R	two spotted spider mites, leafminer (*Liriomyza* spp.)
Bacillus thuringiensis subsp. *israelensis*	*Bacillus thuringiensis* or *Bacillus sphaericus* and the insecticidal proteins they produce	Microbial disruptors of insect midgut membranes	11A	R	fungus gnats
Bacillus thuringiensis subsp. *kurstaki*	*Bacillus thuringiensis* or *Bacillus sphaericus* and the insecticidal proteins they produce	Microbial disruptors of insect midgut membranes	11A	R	cabbage looper, *Duponchelia fovealis*, *Opogona sacchari*, tomato hornworm
beauveria-bassiana	Biological	unknown	N/A	R	aphids, thrips, whitefly
bifenazate	Bifenazate	Compounds of unknown or uncertain mode of action	un	R	two-spotted spider mite
chlorantraniliprole	Diamide	Ryanodine receptor modulators	28	R	cabbage looper
dichlorvos	Organophosphate	Acetylcholinesterase inhibitors	1B	RE	aphids, whiteflies
endosulfan	Cyclodiene organochlorine	GABA-gated chloride channel antagonists	2A	DI (last date of use Dec. 31, 2012)	aphids, whitefly

Active Ingredient[1,2]	Classification[3]	Mode of Action[3]	Resistance Group[3]	Re-evaluation Status[4]	Targeted Pests[1,5]
fenbutatin oxide	Organotin miticide	Inhibitors of mitochondrial ATP synthase	12B	R	two-spotted spider mite
imidacloprid (soil drench)	Neonicotinoid	Nicotinic acetylcholine receptor (nAChR) agonists	4A	R	aphids, whiteflies
naled	Organophosphate	Acetylcholinesterase inhibitors	1B	R	aphids, leafrollers, mealybugs, spider mites, whiteflies
nicotine	Nicotine	Nicotinic acetylcholine receptor (nAChR) agonists	4B	DI (last date of use Dec. 31, 2012)	aphids, thrips
permethrin	Pyrethroid, pryrethrin	Sodium channel modulators	3A	RE	greenhouse whitefly
potassium salts of fatty acids				R	aphids, mites, whiteflies
pymetrozine	Pymetrozine	Selective homopteran feeding blockers	9A	R	green peach aphid, melon aphid
pyridaben	METI acaricides and insecticides	Mitochondrial complex I electron transport inhibitors	21A	R	two-spotted spider mite

Active Ingredient[1,2]	Classification[3]	Mode of Action[3]	Resistance Group[3]	Re-evaluation Status[4]	Targeted Pests[1,5]
pyriproxyfen	Pyriproxyfen	Juvenile hormone mimics	7C	R	silverleaf whitefly, sweet potato whitefly, greenhouse whitefly
spinosad	Spinosyn	Nicotinic acetylcholine receptor (nAChR) allosteric activators	5	R	cabbage looper, European corn borer, exposed western flower thrip (suppression only)
spiromesifen	Tetronic and tetramic acid derivative	Inhibitors of acetyl CoA carboxylase.	23	R	two-spotted spider mite, whiteflies (including sweet potato, silverleaf and greenhouse whiteflies

[1]Registrations confirmed on the PMRA Registered Products Database (www.hc-sc.gc.ca/cps-spc/pest/index-eng.php) November 5, 2012.

[2] Not all end use products containing this active ingredient may be registered for use on this crop. The information in these tables should not be relied upon for pesticide application decisions. Individual product labels must be consulted for up to date, accurate information concerning the use of these pesticides and specific registration details.

[3]Source: IRAC MoA Classification Scheme (Volume 7.2, issued April 2012) published by the Insecticide Resistance Action Committee (IRAC) International MoA Working Group (www.irac-online.org).

[4]PMRA re-evaluation status as of **October 31, 2012**: R – full registration, RE (yellow) – under re-evaluation, DI (red) – discontinued by registrant, PO (red) – being phased out as a result of re-evaluation.

[5]Please consult the pesticide label for a detailed listing of pests controlled by products containing each active ingredient. Information on registered pesticide uses is also available from the PMRA Registered Products Database (www.hc-sc.gc.ca/cps-spc/pest/index-eng.php).

Melon (cotton) aphid *(Aphis gossypii)*

Pest Information

Damage: The melon aphid occurs in greenhouses across Canada. This insect feeds on a variety of plants, including several vegetable crops. Infested leaves wilt and collapse under heavy infestation. Younger leaves may become dark green and stunted. Plants become covered in aphid secretions (honeydew) and molted skins. Black sooty mould develops on the honeydew, reducing fruit quality. Aphids may also transmit cucumber mosaic and watermelon mosaic viruses. Because aphid populations can increase very quickly, especially under warm, humid conditions, an unchecked infestation may result in severe yield reduction or even 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 10-12 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 greenhouse vents and maintaining a weed-free zone around the greenhouse will help to prevent aphids from entering the greenhouse. Avoiding the growing of ornamentals and other vegetable crops in the greenhouse will also eliminate a source of aphids.

Biological Controls: Commercially available predators for the melon aphid include the predatory midge, *Aphidoletes aphidimyza* and Aphelinus and Aphidius wasps. Lacewing larvae and ladybeetles also feed on aphids.

Resistant Cultivars: None available.

Chemical Controls: Insecticides registered for aphid control are listed in table 10.

Issues for melon (cotton) aphid

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

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

Pest Information

Damage: Outbreaks of 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 occurs across southern Canada and has a broad host range, but greenhouse cucumber is a preferred host. The five developmental stages of spider mites are the egg, larva, protonymph, deutonymph and adult. Adult females lay approximately 100 eggs on the lower leaf surface (5-8 eggs per day). The time required to complete the life cycle is shorter at warmer temperatures. The cycle may be completed in as little as 3-4 days at 32ºC, but typically takes two weeks to complete. 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: Routine monitoring for spider mite infestation should be conducted by 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 3-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: The predatory mite *Phytoseiulus persimilis* is widely used and is effective in controlling the two-spotted spider mite. To be successful, *P. persimilis* must be introduced when the mite population is low. *Amblyseius fallacis* and *Amblyseius californicus* (predatory mites) and the predatory midge, *Feltiella acarisuga*, are also used.

Resistant Cultivars: None available.

Chemical Controls: Insecticides registered for the control of spider mites are listed in table 10.

Issues for two-spotted spider mites and carmine mites

1. There is resistance to the currently registered products in mite populations.
2. The registration of new reduced-risk miticides that are not harmful to beneficials is needed for resistance management.

Western flower thrips *(Frankliniella occidentalis)*

Pest information

Damage: The western flower thrips has a very broad host range. Immature and mature 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 3-6 days and larvae feed on leaves and flowers. After 6-9 days, the larvae move into the soil and enter the non-feeding pre-pupal and pupal stages. Adults emerge after 5-7 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 ornamentals from around the perimeter of the greenhouse and avoiding moving non-crop material into the greenhouse will eliminate sources of spread. The greenhouse should be cleaned and sanitized thoroughly between crops. If thrips become a problem at the end of the growing season, the infested crop should be fumigated and then removed and destroyed. Heating empty greenhouses to 35ºC for five days or 40ºC for 2-3 days will starve any emerging adults.

Biological Controls: Several biological control agents are available including the predatory mites *Amblyseius cucumeris* and *Amblyseius barkeri* and the predatory bugs *Orius insidiosus* and *Orius tristicolor*. The predatory mite *Hypoaspis* also preys on pre-pupae and pupae of western flower thrips and can reduce adult emergence by 40-60%.

Resistant Cultivars: None available.

Chemical Controls: Insecticides registered for the control of thrips are listed in table 10.

Issues for thrips

1. Thrips quickly become resistant to most insecticides. Chemical control is difficult because the adults and immatures feed in the crevices of blossoms and fruit on the leaf undersides, which reduces contact with applied insecticides. There is a need for the registration of new, reduced-risk insecticides that are not harmful to beneficials.

Whiteflies: Greenhouse whitefly *(Trialeurodes vaporariorum)* and sweet potato whitefly (*Bemisia tabaci)*

Pest Information

Damage: Whiteflies cause severe damage to greenhouse cucumbers by decreasing fruit yield and quality. Adults vector beet pseudo yellows virus in Ontario and this virus can persist and be a year round problem. Adults suck sap from the plant and fruit, reducing plant vigour and coating the plant with honeydew. Secondary fungi (sooty mould) grow on the honeydew reducing fruit quality. Feeding injury provides an entry point for other diseases.

Life Cycle: The adult female whitefly lays eggs on the underside of leaves. Eggs hatch within 10-14 days and the larvae moult three times in about 14 days. They then pupate and the adult emerges about six days later. Adults live for 30-40 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. Yellow sticky traps will reduce the adult population and should be used at a rate of 1-2 traps per 2-5 plants.

Biological Controls: The parasitic wasps *Encarsia formosa* and *Eretmocerus eremicus* are commonly used to control whitefly larvae. The eggs of greenhouse whitefly are also preyed upon by a beetle, *Delphastus pusillus*. The predatory bug, *Dicyphus hesperus* is being developed as a biological control. Lacewing larvae and predatory bugs such as *Orius* spp. will also prey on whiteflies.

Resistant Cultivars: None available.

Chemical Controls: Insecticides registered for the control of whiteflies are listed in table 10.

Issues for whiteflies

1. There is a need for the registration of new, reduced-risk insecticides that are not harmful to beneficials, as there is resistance to currently registered insecticides.
2. The sweet potato whitefly is a potential threat to greenhouse cucumber production.

Lygus bugs*:* Tarnished plant bug (*Lygus lineolaris)* and other species

Pest Information

Damage: Adults and nymphs feed on plant sap from stems, often from the tip of the stem. Feeding slows growth and causes substantial yield loss. The stem tip may also be killed, and developing flowers and fruit may abort.

Life Cycle: Adults enter greenhouses in late summer and can be a problem in fall crops. Lygus bugs may overwinter in greenhouses and infest transplants in early spring. The tarnished plant bug (*Lygus lineolaris*) occurs in Eastern Canada; other *Lygus* spp. occur in the west.

Pest Management

Cultural Controls: Greenhouse vents and other entry points into the greenhouse should be screened and a weed-free zone around the perimeter of the greenhouse, maintained.

Biological Controls: None available.

Resistant Cultivars: None available.

Chemical Controls: None available.

Issues for Lygus bugs

1. Lygus bugs are a potential threat to greenhouse cucumber production. There are currently no products registered for lygus control.

Striped cucumber beetle (*Acalymma vittatum)*

Pest Information

Damage: Adult cucumber beetles are effective vectors of bacterial wilt and cucumber mosaic virus. The adults feed on the leaves of host plants, resulting in a "shot-hole" appearance of the leaves. Adult beetles will also feed on stems and flowers, which reduces yield and may cause broken stems. Larvae feed on plant roots and tunnel into the base of the plant, which may cause wilting. Damage is generally minimal on older, established plants.

Life Cycle: The adult beetles overwinter in weeds and trash 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 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 and maintaining a weed and trash free barrier around the greenhouse, minimizes beetle entry.

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 are no registered pesticides for this pest in greenhouse crops.

Caterpillars (various species) (Order: Lepidoptera)

Pest Information

Damage: Caterpillars and cutworms can cause defoliation of the plant, but are usually only casual pests.

Life Cycle: Adult moths enter the greenhouse from outside. Several generations may occur in the greenhouse compared with only one or two generations per year in the field.

Pest Management

Cultural Controls: Vents and other entry points into the greenhouse should be screened.

Biological Controls: The microbial insecticide, *Bacillus thuringiensis* subsp. *kurstaki*, is recommended for control of caterpillars. If available, a non-specific egg parasite (*Trichogramma* sp.) may also be used.

Resistant Cultivars: None available.

Chemical Controls: None available.

Issues for caterpillars

None identified.

Cabbage looper *(Trichoplusia ni)*

Pest Information

Damage: An important pest of cruciferous crops, the cabbage looper has also caused significant damage to greenhouse cucumber Canada-wide. The larvae can cause significant damage; one cabbage looper larva can eat 65 cm^2 of leaf tissue during its development. Larval 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. One generation per season is typical, but in greenhouses under warmer temperatures, as many as three generations are possible. Eggs are laid near the edge or underside of a leaf and larvae hatch in 3-4 days. Five instars follow over the next 2-3 weeks. Pupae encase themselves in a loose cocoon for about two weeks, after which a mature moth emerges.

Pest Management

Cultural Controls: Vents should be screened and doorways and other openings to the greenhouse kept closed, especially at night, to minimize entry of adult moths.

Biological Controls: The bacterial insecticide *Bacillus thuringiensis* var. *kurstaki* is registered for control of cabbage looper.

Resistant Cultivars: None available.

Chemical Controls: Insecticides registered for the control of cabbage looper are listed in table 10.

Issues for cabbage looper

1. The registration of new, reduced-risk products is needed 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 feed on roots and root hairs of young seedlings which can be damaged or stunted from root feeding. Feeding wounds provide entry points 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. Two to four days later, the eggs hatch and the resulting larvae feed on roots, root hairs and mycelium. Pupation starts 14-16 days later and after 3-5 days the pupa moves to the surface of the growing medium before maturing to an adult. The life cycle of shore flies is similar, but they prefer wetter conditions than fungus gnats.

Pest Management

Cultural Controls: Screening vents and keeping doorways and other openings to the greenhouse closed will minimize entry by adult gnats. 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: The bacterial insecticide *Bacillus thuringiensis* subsp. *israelensis* can be applied as a soil drench for control of fungus gnat larvae. Commercially available biocontrol agents for larvae include a predatory nematode (*Steinernema feltiae*), the predatory mites *Hypoaspis miles and H. aculeifer,* and the predatory rove beetle, *Atheta coriaria*.

Resistant Cultivars: None available.

Chemical Controls: None available.

Issues for fungus gnats

1. Fungus gnats and shore flies are emerging issues. There is a need for the registration of new, reduced-risk products, including insect growth regulators (IGR's) and bio-pesticides.

Weeds

Weed control is not needed in greenhouses. A three metre wide vegetation-free zone is maintained around the outdoor perimeter of the greenhouse by use of general, broad-spectrum herbicides, such as glyphosate.

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, for instance areas where garbage containers, cull piles, piles of sawdust, old planting media, building debris, burlap or styrofoam 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 and installing tight-fitting screens over doors and windows and wire screens over basement windows and vents. Sheet-metal plates at the base of wooden doors will prevent rodents from chewing through. Feeding and nesting sites should be eliminated by cleaning up debris and cull piles around the greenhouse and storage buildings. Feed and seed, including slug bait should be stored in metal, rodent-proof containers and all garbage containers should have tight-fitting lids. Various trapping methods exist but are not consistently effective.

Biological Controls: None available.

Resistant Cultivars: None available.

Chemical Controls: Poison bait stations containing chlorophacinone or zinc phosphide baits can be used for field mice. These products, plus brodifacoum or warfarin can be used for both house mice and rats. Bait stations are constructed and 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 dogs and cats, birds or children.

Issues for Rodents

None identified.

Resources

IPM/ICM resources for production of greenhouse cucumber in Canada

Alberta Agriculture and Rural Development. www.agric.gov.ab.ca/index.html

Agriculture and Agri-Food Canada, Greenhouse and Processing Crops Research Centre, Harrow, ON. www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1180624240102

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

Centre d'information et de développement expérimental en serriculture (Québec).
www.cides.qc.ca

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). The Canadian Phytopathological Society and the 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 Growing Greenhouse Vegetables in Ontario www.omafra.gov.on.ca/english/crops/hort/greenhouse.html

Ontario Ministry of Agriculture, Food and Rural Affairs. Publication 836 Crop Protection guide for greenhouse Vegetables 2012-2013
www.omafra.gov.on.ca/english/crops/hort/greenhouse.html

Provincial Greenhouse 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/	-	Jim Broatch jim.broatch@gov.ab.ca
Ontario	Ontario Ministry of Agriculture, Food and Rural Affairs www.omafra.gov.on.ca/	Gillian Ferguson gillian.ferguson@ontario.ca Shalin Khosla shalin.khosla@ontario.ca	Jim Chaput jim.chaput@ontario.ca
Quebec	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec www.mapaq.gouv.qc.ca	André Carrier andre.carrier@mapaq.gouv.qc.ca	Luc Urbain luc.urbain@mapaq.gouv.qc.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/

Ontario Greenhouse Marketers Association; http://www.ontariogma.com/

Saskatchewan Greenhouse Growers Association www.saskgreenhouses.com

Red Hat Cooperative (Alberta). http://www.redhatco-op.com/

National:

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

Appendix 1

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

Information on the occurrence of disease, insect and mite and weed pests in each province is provided in Tables 4, 7 and 11 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 importance 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="6">**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="6">**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

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

Ontario Ministry of Agriculture, Food and Rural Affairs. Publication 836 Crop Protection Guide for Greenhouse Vegetables 2012-2013
www.omafra.gov.on.ca/english/crops/hort/greenhouse.html