Crop Profile for Greenhouse Cucumbers in Canada

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Pesticide Risk Reduction Program

Pest Management Centre

Agriculture and Agri-Food Canada

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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.

General Production Information

Canadian Production (2005)	136,222 metric tonnes 224 hectares
Farm gate value (2005)	$137 million
Domestic consumption (2004)[1]	3.41 kg/person (fresh)
Exports (2005)	$75.6 million (fresh)
Imports (2005)	$9.1 million (fresh)
Source(s): Statistics Canada	

[1]Includes both field-grown and greenhouse cucumbers.

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 2003, the major production areas for greenhouse cucumbers were ON (144 hectares or 67.7 % of the national acreage); BC (29 hectares or 11.7%); AB (23 hectares or 10.1%); QC (18.0 hectares or 8.0%); and NS (3.5 hectares or 1.9% of the national acreage). Some cucumber production also occurs in NB (0.5 hectares) and SK (0.3 hectares).

Cultural Practices

Greenhouse cucumbers are grown hydroponically, generally in rockwool blocks placed in rockwool slabs, or in sawdust or coir (coconut fibre) bags. The crop is trained along wires and 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 to ensure a hardy plant. 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 bags containing rockwool slabs, sawdust (generally in BC) 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. The main stem is trained along a twine or wire and lateral stems are trained along a framework of horizontal wires and vertical strings for support. Different training systems are used. 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.

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.

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 1. 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 thiram 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. Control fungus gnats that can spread Pythium and other root rot organisms.
	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.
	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°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 destroy plant debris and disinfect at end of the year.

Abiotic Factors Limiting Production

Key Issues

- The most common abiotic disorders are fruit curling, black fruit and soft neck. These are the result of poor environmental controls, *i.e.*, temperature extremes, inadequate or excess watering, lack of oxygen in the nutrient solution, low light intensity, excess CO_2 levels or nutrient deficiencies.
- Iron or manganese and calcium deficiencies are the most common nutritional problems. Excess of major or minor nutrients may also cause toxicity symptoms on the crop.

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 just before sunrise. 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 powdery mildew disease and sudden changes of temperature that lead to condensation on the leaves, favours the development of diseases such as botrytis grey mould. The levels of CO_2 are also monitored and modified according to the stage of development and cultivar type. Temperature, humidity and CO2 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 occurs 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 looses 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.

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

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 and botrytis grey mould.
- The lack of control products, as compared to those available to foreign competitors, affects the productivity and profitability of greenhouse cucumber production in Canada.
- The lack of control products prevents rotation of fungicide groups and increases the risk of pathogen resistance to registered fungicides.
- Insect vectors of virus diseases must be controlled to manage virus diseases.

Table 2. Degree of occurrence of diseases in Canadian greenhouse cucumber production

	Degree of occurrence				
Major Diseases	**BC**	**AB**	**ON**	**QC**	**NS**
Fusarium root and stem rot	E	E	E	E	E
Botrytis grey mould	E	E	E	E	E
Gummy stem blight	E	E	E	E	E
Pythium crown rot	E	E	E	E	E
Powdery mildew	E	E	E	E	E
Minor Diseases	**BC**	**AB**	**ON**	**QC**	**NS**
Seedling damping-off	E	E	E	E	E
Downy mildew	E	E	E	E	E
Penicillium stem rot	E	E	E	E	E
Scab (gummosis)	DNR	DNR	DNR	DNR	DNR
White mould (Sclerotinia)	DNR	DNR	DNR	DNR	DNR
Fusarium wilt	DNR	DNR	DNR	DNR	DNR
Verticillium wilt	DNR	DNR	DNR	DNR	DNR
Black root rot (*Phomopsis sclerotioides*)	E	DNR	E	DNR	DNR
Black rot (*Phomopsis cucurbitae)*	DNR	DNR	DNR	DNR	DNR
Alternaria leaf spot	DNR	DNR	E	DNR	DNR
Anthracnose (Colletotrichum) leaf spot	DNR	DNR	E	DNR	DNR
Angular leaf spot	DNR	DNR	DNR	DNR	DNR
Bacterial wilt	DNR	DNR	DNR	DNR	DNR
Cucumber mosaic	E	E	E	E	E
Zucchini yellow mosaic	E	E	E	E	E
Beet pseudo-yellows	DNR	DNR	E	DNR	DNR
Cucumber pale fruit viroid	E	DNR	DNR	DNR	DNR
Watermelon mosaic		DNR	DNR	DNR	DNR
Cucumber necrosis					

Widespread yearly occurrence with high pest pressure

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

Widespread yearly occurrence with low to moderate pest pressure

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

Pest not present

DNR - Data not reported

E – established

D – invasion expected or dispersing

Source(s): Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec; BC Ministry of Agriculture, Food & Fisheries Crop Profile for Greenhouse Cucumber (DRAFT); Ontario Ministry of Agriculture and Food Publ. 371.

Major Diseases

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

Chemical Controls: Propamocarb hydrochloride is registered for use on greenhouse cucumber as is metalaxyl-m.

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.

Alternative Controls: Streptomyces griseoviridis and *Trichoderma harzianum* are microbiological fungicides that are registered only for preventative treatment of seedlings. They are not effective or registered on producing crops.

Resistant Cultivars: None identified.

Issues for Crown and root rot

1. There is a need for the registration of new products to control pythium crown rot since the pathogen can become resistant to metalaxyl-m and other products with repeated use.
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 the 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

Chemical Controls: None.

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.

Alternative Controls: None available.

Resistant Cultivars: None available.

Issues for Fusarium root and stem rot

1. There are no fungicides registered for the control of this disease in Canada.
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

Chemical Controls: Myclobutanil and iprodione are registered for control of this disease. Boscalid was granted emergency registration in British Columbia, Alberta and Ontario until December 31, 2005.

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.

Alternative Controls: None available.

Resistant Cultivars: None available.

Issues for Gummy stem blight

1. The registration of effective, new, reduced-risk fungicides is needed for control of gummy stem blight and to prevent the development of resistance within the pathogen population.
2. The development of resistant cultivars is required.

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

Chemical Controls: Myclobutanil, and sulphur fungicides are registered for control of powdery mildew. Resistance is a high risk with myclobutanil, and sulphur can damage leaves under high temperatures.

Cultural Controls: Sanitation practices such as the remove 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.

Alternative Controls: 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.

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.

Issues for Powdery mildew

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

Botrytis grey mould *(Botrytis cinerea = Sclerotinia fuckeliana)*

Pest Information

Damage: Botrytis is widespread in cucumber greenhouses across Canada. The disease 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

Chemical Controls: Iprodione is the only fungicide commonly used for control of botrytis on greenhouse cucumber. Ferbam is registered but not used because it damages cucumber plants.

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.

Alternative Controls: None available.

Resistant Cultivars: None available.

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.

Minor Diseases

Seedling damping-off (*Pythium* spp., *Fusarium, Rhizoctonia* 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

Chemical Controls: Seeds can be treated with a protectant fungicide (thiram).

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.

Alternative Controls: Trichoderma harzianum and *Streptomyces griseoviridis* are registered microbiological fungicides.

Resistant Cultivars: None available.

Issues for Damping-off

1. 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.

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

Chemical Controls: There are no fungicides registered for the control of downy mildew.

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.

Alternative Controls: None available.

Resistant Cultivars: None available.

Issues for Downy mildew

1. None identified.

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

Chemical Controls: None available.

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.

Alternative Controls: None available.

Resistant Cultivars: None available.

Issues for Penicillium stem rot

1. None identified.

Scab (*Cladosporium cucumerinum)*

Pest Information

Damage: Scab is not common in greenhouse crops but has been known to occur even on resistant cultivars under cool (17^{o}C), wet conditions. Water-soaked areas on leaves turn into tan-white, angular spots, similar to those of angular leaf spot, which then crack open giving the leaves a tattered appearance. Internodes are shortened giving the plant a rosette aspect, similar to that observed with cucumber mosaic virus infection. Elongated lesions develop on stems and petioles and tips may dieback. Water-soaked areas on fruit develop into large, deep cavities that often produce a golden-brown, gummy exudate that dries into brown beads. Lesions on fruit and leaves become covered with an olive-green, felt-like spore mass. On

older fruit, or resistant cultivars, a raised, corky, irregular, tan-coloured layer of plant tissue develops at the infection point that resembles a scab.

Life Cycle: Spores are produced in cool, humid conditions in infected tissues. They spread on air currents and require water on the plant tissue to infect. The fungus survives in crop debris.

Pest Management

Chemical Controls: None available.

Cultural Controls: Minimizing the duration of leaf wetness, by preventing condensation on the leaves,by raising the night temperature slowly before sunrise and ensuring adequate ventilation will help reduce scab development. Practicing good sanitation, including the removal of old crop debris promptly from the greenhouse will eliminate sources for disease spread. Maintaining proper day and night temperatures for crop growth and development will also help to minimize the disease.

Alternative Controls: None available.

Resistant Cultivars: Virtually all long English cucumber varieties are resistant to scab.

Issues for Scab (gummosis)

1. None identified.

White mould (*Sclerotinia sclerotiorum)*

Pest Information

Damage: This disease rarely occurs in well-managed greenhouses but can be quite destructive if present. The fungus rots the base of the stem and the spores can infect flowers also, leading to post-harvest fruit rot. The most significant crop loss results from flower infection.

Life Cycle: Tough, overwintering sclerotia develop on decaying plant tissue and produce spores in the spring which initiate new infections. Infection is favoured by wet, warm, humid conditions when the foliage does not dry out quickly.

Pest Management

Chemical Controls: None available.

Cultural Controls: Spacing plants adequately for good air circulation and preventing condensation on the leaves, particularly during flowering, by raising the temperature gradually before sunrise and ensuring adequate ventilation, will minimize the duration of leaf wetness, resulting in conditions less favourable for disease. Avoiding pruning and fertilizing practices that favour excessive soft, vegetative growth on the plant and avoiding stem wounding, will also reduce disease. Practicing good sanitation such as the removal of old crop debris promptly from the greenhouse will eliminate sources for disease spread.

Alternative Controls: None available.

Resistant Cultivars: None available.

Issues for White mould

1. 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 recently 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

Chemical Controls:. None available.

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.

Alternative Controls: Streptomyces griseoviridis, a microbial fungicide, can be used as a preventative treatment on seedlings .

Resistant Cultivars: None available.

Issues for Fusarium wilt

1. None identified.

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

Pest Information

Damage: These soil-borne pathogens rarely infect greenhouse crops grown in soilless media, although there have been recent reports of verticillium wilt in greenhouse tomatoes in the Netherlands. 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

Chemical Controls: None available.

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.

Alternative Controls: None available.

Resistant Cultivars: None available.

Issues for Verticillium wilt

1. None identified.

Black root rot *(Phomopsis sclerotioides)*

Pest Information

Damage: Although a minor disease, black root rot has caused up to 50% yield losses in cucumber greenhouses in BC on occasion. Symptoms include development of pale brown areas on roots. These areas darken and eventually turn black and a mosaic pattern of sclerotia can be observed with a hand-lens. The cortical tissue of roots is eventually sloughed off, and roots are girdled and killed. Above-ground symptoms vary depending on the degree of disease in the roots and plant stress. Stem infection is possible, if the fungus moves from the roots up the plant, resulting in lesions that secrete yellow, gummy exudates. Diseased plants are stunted and partially developed fruit will not mature. Plants may wilt at fruit set.

Life Cycle: The host range is restricted to members of the Cucurbitaceae family. This disease is associated with poor sanitation practices. Rockwool and other soilless media may become contaminated by black root rot through soil or old plant debris. Once present, the pathogen grows quickly and rapidly colonizes roots.

Pest Management

Chemical Controls: None available.

Cultural Controls: Black root rot can be minimize through good sanitation practices including avoiding the contamination of growing media with soil or old plant debris and growing seedlings and transplants on clean benches and trays beyond reach of soil splashing and flooding. If the disease is detected early (plants wilt during the day but recover at night), it maybe possible to salvage the plant by eliciting the formation of adventitious roots. This is done by mounding up the stem base with clean, peaty potting mix.

Alternative Controls: Grafting plants onto gourd rootstock (*Cucurbita ficifolia*) may help maintain crop yield if infection is not severe.

Resistant Cultivars: None available.

Issues for black root rot

1. None identified.

Black rot *(Phomopsis cucurbitae)*

Pest Information

Damage: This disease has been reported only occasionally in Ontario and BC greenhouse cucumbers. All above ground plant parts, including fruit, are susceptible to infection. Disease symptoms start with water-soaked, oily green areas on developing tissue arising from stem nodes, often accompanied by amber-coloured, gummy exudates. Nodal lesions spread, eventually penetrating the vascular system and girdling the stem. Infected fruit rots, shrinks, becomes mummified and secretes a lemon-like odour. Tiny, black spore structures may appear on the surface of infected tissue.

Life Cycle: Infection usually begins on dead and dying tendrils, peduncles, petioles and suckers arising from stem nodes in wet conditions. The survival mechanism for this fungus between crops is unknown. It is not believed to be seed-borne. Spores produced on the infected plant surface are spread by splashing water, tools and workers handling the plants.

Pest Management

Chemical Controls: None available.

Cultural Controls: Practicing good sanitation practices including ensuring plant media is disease free, the removal and destruction of infected crop material and thorough cleaning of the greenhouse after crop removal will help to control black rot. Good ventilation may prevent black rot infection by rapidly drying out senescing plant parts.

Alternative Controls: None available.

Resistant Cultivars: None available.

Issues for Black rot

1. None identified.

Alternaria leaf spot (*Alternaria and Ulocladium* spp.)

Pest Information

Damage: Small to large, circular, tan-brown spots scattered over the leaf can be caused by *Alternaria* or *Ulocladium* fungi. These fungi are generally weak pathogens and can also live as saprophytes on dead tissue. Leaf spots rarely cause significant damage to the crop.

Life Cycle: These fungi can contaminate the surface of the seed, when it is extracted from the fruit and carry over in and on the seed coat. Infection is favoured by warm days and cold nights, which result in condensation on leaves. The spores are spread by air currents, water and by handling. The fungus survives in plant debris.

Pest Management

Chemical Controls: Thiram seed treatments will help control the disease..

Cultural Controls: Disease-free seed or treated seed should be used when sowing the crop. Good sanitation practices including the removal old crop debris promptly from the greenhouse will help control this disease. Minimizing periods of leaf wetness such as by raising greenhouse temperatures slowly before sunrise to prevent condensation on leaves and ventilating and pruning to ensure good air circulation, lower humidity and facilitate quick leaf drying will also help to reduce disease development.

Alternative Controls: None available.

Resistant Cultivars: None available.

Issues for Alternaria leaf spot

1. None identified.

Anthracnose (*Colletotrichum* sp.)

Pest Information

Damage: Anthracnose disease of cucumber rarely causes significant losses but can damage fall crops. Circular, brown spots or blotches develop on the leaves, often with concentric rings inside the lesion. Lesions can resemble those of downy mildew. In severe cases, the blotches run together, destroying the leaves and resulting in yield loss.

Life Cycle: Anthracnose is more common in fall crops, when warm, humid days and cold nights favour the development of condensation or "sweating" of the foliage.

Pest Management

Chemical Controls: None available.

Cultural Controls: Cultural controls for anthracnose include good sanitation practices such as the removal of old crop debris promptly from the greenhouse. Minimizing the duration of leaf wetness by raising greenhouse temperatures slowly before sunrise to avoid condensation and venting and pruning to ensure good air circulation and reduce humidity, will also help reduce disease development.

Alternative Controls: None available.

Resistant Cultivars: None available.

Issues for Anthracnose

1. None identified.

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

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.

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.

Alternative Controls: None available.

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

Issues for Angular leaf spot

1. 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

Chemical Controls: None available.

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.

Alternative Controls: Raising the temperature briefly above 30ºC will activate defense mechanisms in the plant and may help to reduce disease symptoms.

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

Issues for Bacterial wilt

1. 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

Chemical Controls: None available.

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.

Alternative Controls: None available.

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

Issues for Cucumber mosaic virus

1. 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

Chemical Controls: None available.

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.

Alternative Controls: None available.

Resistant Cultivars: None available.

Issues for Zucchini yellow mosaic

1. None identified.

the Viruses and Viroids (Cucumber necrosis virus; Beet pseudo-yellows virus; Watermelon mosaic virus; Cucumber pale fruit viroid)

Pest Information

Damage: These viral and viroid diseases rarely occur in greenhouse cucumber crops in Canada, but can cause serious damage when present. Beet pseudo-yellows and cucumber pale fruit are the most common diseases.

Beet pseudo-yellows: Symptoms start as yellow areas and yellow spotting between the veins on older and mid-section leaves. Infected plants become unproductive.

Cucumber pale fruit: Symptoms caused by this viroid are more severe at high temperatures. Fruit are pale-green, small and slightly pear-shaped. Young leaves are small, blue-green and hairy. Leaf blades are undulating with edges and tips curled downward. Flowers may be stunted and crumpled with petals slightly notched. As the plant ages, leaf symptoms fade and the foliage becomes generally chlorotic; the plant is often somewhat stunted.

Watermelon mosaic: Symptoms include distortion of terminal growth, blister-like protrusions on leaf blades between veins and severe distortion and bump-like protrusions on fruit. This virus has been reported only in Ontario.

Cucumber necrosis: This virus is rare in greenhouse crops. Leaves develop yellowish-green to tan-coloured areas containing pinpoint necrotic flecks which often fall out, creating a shot-hole appearance. Symptoms often appear on only one side of the plant or one side of the leaf mid-rib. Severely affected leaves are malformed with dark-green, flap-like extrusions on the lower surface.

Life Cycle: Viral diseases are often spread by insect vectors, such as aphids or whiteflies. They can also be spread on pruning knives, hands and clothing of workers. They often survive on other weed and crop hosts outside the greenhouse. Beet pseudo-yellows virus is transmitted by whiteflies. Cucumber pale fruit viroid is transmitted by plant sap on contaminated tools and possibly on seed. It is not known to be transmitted by insects. Watermelon mosaic virus is aphid-transmitted. Cucumber necrosis is soil-borne and is spread by a root-infecting fungus *Olpidium radicale*.

Pest Management

Chemical Controls: None available.

Cultural Controls: Cultural controls for viral diseases include:, the removal and destruction of infected plants; the disinfection of pruning and harvesting tools regularly while working in the crop; maintaining a weed-free zone around the perimeter of the greenhouse; and screening vents to prevent the entry of aphids, whiteflies and other insect vectors.

Alternative Controls: None available.

Resistant Cultivars: Some resistant cultivars may be available for certain viruses.

Issues for other viruses

1. None identified.

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

Regulatory status as of May 12, 2006					Stakeholder comments	
Control active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action – resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**	**Performance of product according to recommended use[5]**	**Notes**
ferbam (Ferbam 76WDG)	Dithiocarbamate fungicide	M3	R	Botrytis		Not used; causes severe injury to long English cucumber
iprodione (Rovral WP)	Dicarboximide fungicide	2	R	Botrytis		To reduce the development of disease resistance, Rovral must be alternated with other fungicides
				Gummy stem blight		
metylaxyl-M (Ridomil Gold 480EC)	Acylalanine fungicide	4	RE	Pythium root rot		Registered for emergency use on greenhouse cucumber in Ontario and BC until Jan.31, 2005 only. A *proposed* supplemental label can be viewed on the PMRA website but the current registration status is uncertain.
myclobutanil (Nova 40W)	Triazole fungicide	3	R	Powdery mildew		
				Gummy stem blight		
propamocarb hydrochloride (Previcur N)	Carbamate fungicide	28	R	Pythium		

Regulatory status as of May 12, 2006					Stakeholder comments	
Control active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action – resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**	**Performance of product according to recommended use[5]**	**Notes**
***Pseudozyma flocculosa* (Sporodex L)**	Microbiological fungicide	NC	RR	Powdery mildew		Not available commercially.
***Streptomyces griseoviridis* strain K6 (Mycostop)**	gluopyransyl antibiotic fungicide	25	RR	Fusarium		Preventative treatment for seedlings only; Disease suppression only.
				Pythium		
sulphur (Microscopic, Kumulus DF)	Inorganic fungicide	M2	R	Powdery mildew		
oxine benzoate (No-Damp)		M2	R	Damping-off (Pythium, Fusarium, Rhizoctonia)		Preventative seedling drench for damping-off caused by Pythium, Fusaruim, Rhizoctonia and other fungi.
***Trichoderma harzianum* strain KRL-AG2 (Rootshield)**	Microbiological fungicide	NC	RR	Fusarium		Preventative treatment for seedlings only; disease suppression only.
				Pythium		
				Rhizoctonia		

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

[2]The classification and the mode of action group are based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action. The document is under revision and up-to-date information can be found on the following web sites: herbicides:http://www.plantprotection.org/HRAC/Bindex.cfm?doc=moa2002.htm ; insecticides:http://www.irac-online.org/documents/moa/MoAv5_1.pdf ; fungicides:http://www.frac.info/frac/index.htm

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

[4] Please consult the product label on the PMRA web site (http://www.eddenet.pmra-arla.gc.ca/4.0/4.0.asp) for specific listing of pests controlled by each active ingredient.

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

[6]Source(s): Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec; BC Ministry of Agriculture, Food & Fisheries; Ontario Ministry of Agriculture and Food

Table 4. Adoption of disease management approaches for Canadian greenhouse cucumber production

	Practice \ Pest	Pythium crown rot	Fusarium crown and root rot	Botrytis grey mould	Gummy stem blight	Powdery mildew
Prevention	tillage					
	residue removal / management					
	water management					
	equipment and greenhouse sanitation					
	row spacing / seeding depth					
	removal of alternative hosts (weeds/volunteers)					
Avoidance	resistant varieties					
	planting / harvest date adjustment					
	crop rotation					
	trap crops - perimeter spraying					
	use of disease-free seed					
	optimizing fertilization and nutrient solution quality					
	reducing mechanical damage / insect damage					
	thinning / pruning					
Monitoring	scouting - monitoring					
	records to track pests					
	soil analysis					
	environmental monitoring for disease forecasting					
	grading out infected produce					
Suppression	use of thresholds for application decisions					
	biological pesticides					
	beneficial organisms & habitat management					
	pesticide rotation for resistance management					
	ground cover / physical barriers					
	controlled atmosphere storage					
	forecasting for applications					

no information regarding the practice is available

available/used

available/not used

not available

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

Insects and Mites

Key Issues

- Several species of insects and mites have developed resistance to insecticides.
- Because greenhouse cucumbers are harvested daily or every other day, chemical products with short re-entry intervals (REI) are required.
- The NutriClean ® plan (BC only) requires the cucumber fruit to be completely free of pesticide residues. There is a need for more biological pest control products to ensure that growers are able to continue to access the plan.
- Control products and application methods that do not harm beneficials are required.
- Tolerance and thresholds for disease vectors during warmer months are zero due to the high incidence of beet pseudo yellows virus, cucumber mosaic virus and bacterial wilt.
- Controls of insects that are disease vectors, such as cucumber beetles, whiteflies and aphids are often damaging to biocontrol agents used for other pests. Suitable controls need to be found for these vectors.

Table 5. Degree of occurrence of insect and mite pests in Canadian greenhouse cucumber production

	Degree of occurrence				
Major Pests	**BC**	**AB**	**ON**	**QC**	**NS**
Whiteflies	E, D	E	E, D	E, D	E
Cabbage looper	E	E	E	E	E
Thrips	E	E	E	E	E
Spider mites	E	E	E	E	E
Fungus gnats & Shore flies	E	E	E	E	E
Melon aphid	E	E	E	E	E
Minor Pests	**BC**	**AB**	**ON**	**QC**	**NS**
Cucumber beetles	E	E	E	E	E
Leafminers	E	E	E	E	E
Lygus bugs (Tarnished plant bug)	E	E	E	E	E

Widespread yearly occurrence with high pest pressure

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

Widespread yearly occurrence with low to moderate pest pressure

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

Pest not present

E – established

D – invasion expected or dispersing

Source(s): Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec; BC Ministry of Agriculture, Food & Fisheries Crop Profile for Greenhouse Cucumber (DRAFT); Ontario Ministry of Agriculture and Food Publ. 371

Major Insects and Mites

Whiteflies: Greenhouse whitefly *(Trialeurodes vaporariorum)*; silverleaf whitefly (*Bemisia argentifolii*) 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. The greenhouse whitefly occurs across Canada and the silverleaf whitefly also occurs in Ontario. The sweet potato whitefly has recently been found in BC and threatens to become an increasing problem.

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

Chemical Controls: Imidacloprid is the only registered insecticide currently used. The organophosphate endosulfan is occasionally used for spot sprays only. DDVP (dichlovos) is sometimes used as a fogging treatment (not available in BC). Other registered products such as permethrin and naled are not used as they can be damaging to the crop and harmful to beneficials. However, naled may be used as a post-crop clean up treatment. Insecticidal soap can burn leaves in high temperatures and is not very effective.

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.

Alternative 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.

Issues for whiteflies

1. There is a need for the registration of new, reduced-risk insecticides that are not harmful to beneficials (imidacloprid is damaging to some beneficials).
2. The sweet potato whitefly is an increasing problem in BC and Ontario and may spread in Canada.

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

Chemical Controls: Spinosad has an emergency label for BC only until Dec. 31, 2005.

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.

Alternative Controls: The bacterial insecticide *Bacillus thuringiensis* var. *kurstaki* is registered for control of cabbage looper. A nuclear polyhedrosis virus has been effective in controlling cabbage looper larvae in research trials, but has not yet been developed as a commercial insecticide.

Resistant Cultivars: None available.

Issues for cabbage looper

1. The registration of new, reduced-risk products is needed to reduce the risk of resistance.

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

Chemical Controls: None available.

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.

Alternative Controls: The bacterial insecticide *Bacillus thuringiensis* var. *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.

Issues for fungus gnats

1. None identified.

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

Chemical Controls: Imidacoprid is available for aphid control when necessary but is damaging to some beneficials. Since products under re-evaluation, such as organochlorines (endosulfan), are highly toxic to beneficials, they are rarely used except as spot sprays. Naled is not used. The organophosphate dichlorvos (DDVP) may be used as a fogging treatment occasionally. Insecticidal soap is not used. Nicotine fumigant (Plant fume) is also registered.

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.

Alternative 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.

Issues for melon (cotton) aphid

1. There is a need for the registration of new, reduced-risk pesticides that are not harmful to beneficials and to permit the rotation of chemicals, to prevent pest resistance development.

Western flower thrips *(Frankliniella occidentalis),* onion thrips *(Thrips tabaci)* and *Echinothrips americanus*

Pest information

Damage: The western flower thrips is the most common thrips species on greenhouse cucumber across Canada. It 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. Onion thrips is generally restricted to the lower strata of cucumber crops and rarely causes fruit curling or direct feeding damage to the fruit. *Echinothrips americanus* has also been found in BC greenhouses.

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 propupal 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

Chemical Controls: Only methomyl and nicotine fumigant are registered for control of thrips on greenhouse cucumbers. Both are very toxic to beneficials. Chemical control may be necessary towards the end of the growing season. Several applications, about four days apart, are required to control both immature and mature thrips.

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 to starve any emerging adults.

Alternative 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 propupae and pupae of western flower thrips and can reduce adult emergence by 40-60%.

Resistant Cultivars: None available.

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.

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. A related species, the carmine mite also affects greenhouse crops in BC. 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

Chemical Controls: Pyridaben, fenbutatin oxide and abamectin are registered for control of two-spotted spider mites.The emergency registration of bifenazate was granted for control of mites in Ontario until March 15, 2006. Spider mites are commonly resistant to fenbutatin oxide and this product is not allowed on crop exported to the U.S. DDVP and nicotine fogs are used for post-cropping clean-up but are not specifically registered for mites and not used during crop production. Insecticidal soap can damage leaves under high temperatures and is not very effective. Naled is also registered for mite control on greenhouse cucumbers.

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.

Alternative 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.

Issues for two-spotted spider mites and carmine mites

1. There is risk of resistance to abamectin and pyridaben with repeated use. Both products can be harmful to beneficials.
2. The registration of new reduced-risk miticides, that are not harmful to beneficials is needed to enable pesticide rotation to avoid pest resistance development.

Minor Insects and Mites

Spotted cucumber beetle *(Diabrotica undecimpunctata howardi)* and 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 from either of these beetles is generally minimal on older, established plants.

Life Cycle: Cucumber beetles occur in central and eastern Canada. 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 plantsand 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 merge after two weeks. There is typically only one generation per year.

Pest Management

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

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.

Alternative Controls: There are no biological control agents are available

Resistant Cultivars: None available.

Issues for spotted cucumber beetle and striped cucumber beetle

1. There are no registered pesticides for this pest in greenhouse crops.

Chrysanthemum leafminer (*Liriomyza trifolii),* Vegetable leafminer *(L. sativae)* and other species

Pest Information

Damage: Leafminers can cause extensive mining damage to leaves, thereby reducing yields. These pests are more problematic in eastern Canada than in BC or Alberta.

Life Cycle: Eggs are laid inside leaf tissue and hatch into larvae. Larvae tunnel between the upper and lower leaf surfaces for the next 4-7 days. Once mature, larvae drop to the soil to pupate and adults emerge 5-10 days later.

Pest Management

Chemical Controls: Abamectin is registered for control of leafminers in greenhouse cucumber.

Cultural Controls: Strict sanitation will help reduce the occurrence of this pest. Mined leaves should be pruned from infested plants. Yellow sticky traps can be used to monitor the occurrence of adult leaf miners.

Alternative Controls: The parasitic wasps *Diglyphus isaea* and *Dacnusa sibirica* are available commercially.

Resistant Cultivars: None available.

Issues for chrysanthemum leafminer and vegetable leafminer

1. New insecticides and biological controls are needed for leafminer pests.

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

Chemical Controls: None available.

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

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

Resistant Cultivars: None available.

Issues for caterpillars

1. None identified.

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

Chemical Controls: None available.

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.

Alternative Controls: None available.

Resistant Cultivars: None available.

Issues for Lygus bugs

1. None identified.

Slugs and snails

Pest Information

Damage: Slugs and snails feed on leaf and stem tissues of a wide range of plants and leave silvery, slime trails. On leaves, tissue is eaten between the veins and the resulting skeletonization can be extensive. Slugs and snails are only rarely pests of greenhouse cucumber.

Life Cycle: Slug eggs, immatures and adults can be spread through contaminated material, soil and debris and can enter the greenhouse through unsealed cracks and doorways.

Pest Management

Chemical Controls: Slug baits of ferric phosphate (low toxicity) or metaldehyde can be used.

Cultural Controls: Trapping with boards and baits can be effective near entry-ways. Keeping the greenhouse sealed and doorways closed and practicing good sanitation help to reduce problems due to these pests.

Alternative Controls: None available.

Resistant Cultivars: None available.

Issues for slugs and snails

1. None identified.

Table 6. Insecticide, miticide and molluscicide control products, classification and performance for Canadian greenhouse cucumber production

Regulatory status as of May 12, 2006					Stakeholder comments[6]	
Control active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action – resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**	**Performance of product according to recommended use[5]**	**Notes**
abamectin (Avid 1.9% EC)	Avermectin insecticide	6	R	Two-spotted Spider Mites		Risk of resistance. PHI 3 days. Damaging to beneficials.
				Leafminers (*Liriomyza* spp.)		
***Bacillus thuringensis spp. kurstaki* (Foray 48BA, Bioprotec)**	*B.t.* subsp. *kurstaki*	11B2	RR/RE	Cabbage Loopers		Low hazard to predatory mites, predatory insects, and parasitoids.
***Bacillus thuringensis israelensis* (Vectobac 600 L)**	*B.t.* subsp. i*sraelensis*	11A1	RR/RE	Fungus Gnats		Low hazard to predatory mites, predatory insects, and parasitoids.
dichlorvos (DDVP-5, DDVP-10 Fogging Insecticide; Vapona Industrial Fogging Solution)	Organophosphate insecticide	1B	RE	Aphids		Highly toxic to beneficials. Not available in BC.
				Whiteflies		

Regulatory status as of May 12, 2006					Stakeholder comments[6]	
Control active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action – resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**	**Performance of product according to recommended use[5]**	**Notes**
endosulfan (Thiodan 50WP, 4EC; Thionex 50WP, Thionex EC)	Cyclodiene organochlorine insecticide	2A	RE	Aphids		PHI 2 days. Workers can re-enter after 12 hours if wearing protective clothing and if workers do not handle plants. High hazard for beneficials. Toxic to bees. Used for spot sprays only.
				Whiteflies		
fenbutatin oxide (Vendex 50WP, 50W)	Organotin miticide-	12B	RE	two-spotted spider mites		Does not control diapausing forms. No tolerance for US exports. Widespread resistance.
imidacloprid (Merit 60WP, Intercept 60WP)	Neonicotinoid insecticide	4A	R	Aphids		Phytotoxic to immature plants. Repels some beneficial insects such as *Orius* sp. PHI 1 day for Merit and Intercept. Two applications permitted per season.
				Whiteflies		
insecticidal soap (Safer's)	Organic insecticide		RR	Aphids		Low hazard for predatory mites, predatory insects, and parasitoids. Can burn leaves under high temperatures.
				Spider Mites		
				Whiteflies		

Regulatory status as of May 12, 2006					Stakeholder comments[6]	
Control active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action – resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**	**Performance of product according to recommended use[5]**	**Notes**
metaldehyde (Slug-Em)	Molluscicide		R	Slugs		Bait.
ferric phosphate (Ferramol, Sluggo)	Inorganic molluscicide		RR	Slugs		Low toxic bait.
methomyl (Lannate L)	Carbamate insecticide	1A	RE	Western flower thrips		Long-lasting with residual effects; not compatible with an IPM program. Very toxic to bees.
naled (Dibrom)	Organophosphate insecticide	1B	RE	Mealybugs		For application to greenhouse heating pipes between crops only. Not used in BC. May damage flowers and reduce fruit set. Not compatible with an IPM program. Very toxic to bees.
				Leafrollers		
				Aphids		
				Spider Mites		
				Whiteflies		
nicotine (Plant-Fume Nicotine)	Nicotine insecticide	4B	R	Aphids		Ventilate after application. Toxic to beneficials.
				Thrips		
permethrin (Ambush 50EC, Pounce EC)	Pyrethroid insecticide	3	R	Whiteflies		Long-lasting residual effects; not compatible with an IPM program. Very toxic to bees.

Regulatory status as of May 12, 2006					Stakeholder comments	
Control active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action – resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**	**Performance of product according to recommended use[5]**	**Notes**
pyridaben (Sanmite, Dyno-Mite)	METI miticide	21	R	Two-spotted Spider Mites		High risk of pest resistance. PHI 2 days. Can harm beneficials. Max. 2 applications per crop cycle.

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

[2]The classification and the mode of action group are based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action. The document is under revision and up-to-date information can be found on the following web sites:
herbicides:http://www.plantprotection.org/HRAC/Bindex.cfm?doc=moa2002.htm ; insecticides:http://www.irac-online.org/documents/moa/MoAv5_1.pdf ; fungicides:http://www.frac.info/frac/index.htm

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

[4] Please consult the product label on the PMRA web site (http://www.eddenet.pmra-arla.gc.ca/4.0/4.0.asp) for specific listing of pests controlled by each active ingredient.

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

[6]Source(s): Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec; BC Ministry of Agriculture, Food & Fisheries; Ontario Ministry of Agriculture and Food

Table 7. Adoption of insect and mite pest management approaches for Canadian greenhouse cucumber production

	Practice \ Pest	Fungus gnats	Whiteflies	Melon aphid	Western flower thrips	Two-spotted spider mites
Prevention						
	residue removal / management					
	water management					
	equipment and greenhouse sanitation					
	row spacing / seeding depth					
	removal of alternative hosts (weeds/volunteers)					
Avoidance	resistant varieties					
	planting / harvest date adjustment					
	crop rotation					
	trap crops – perimeter (spot) spraying					
	optimizing fertilization					
	reducing mechanical damage / insect damage					
Monitoring	scouting - trapping					
	records to track pests					
	grading out infected produce					
Suppression	use of thresholds for application decisions					
	biological pesticides					
	pheromones					
	sterile mating technique					
	beneficial organisms & habitat management					
	pesticide rotation for resistance management					
	screens / physical barriers					
	forecasting for applications					

no information regarding the practice is available

available/used

available/not used

not available

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

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

Chemical Controls: Poison bait stations containing diphacinone (highly toxic to dogs), chlorophacinone or zinc phosphide baits can be used for field mice. These products, plus brodifacoum, bromadiolone or warfarin can be used for both house mice and rats. Scilliroside can be used for rats. (Scilliroside is a toxic glycoside derived from the bulb of the Mediterranean squill plant). 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.

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.

Alternative Controls: Various trapping methods exist but are not consistently effective.

Resistant Cultivars: None available.

Issues for Rodents

1. None identified.

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2004 Report to Ontario Horticultural Crops Research & Services Committee. Ontario Greenhouse & Protected Crops Research and Services Sub-Committee, Dec. 8, 2004. (http://www.uoguelph.ca/research/omafra/forms/oascc.shtml

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Fruit and Vegetable Production in Canada, 2003. Statistics Canada, Agriculture Division, June 2004. Cat. No. 22-003-XIB, Vol. 73 no. 1; ISSN 1480-7602.

Growing Greenhouse Vegetables, Publication 371, Ontario Ministry of Agriculture, Food and Rural Affairs, Queen's Printer for Ontario, 2001. ISSN 1492-6601.

Pesticides Homologués dans les Cultures de Serres en 2004. Bulletin d'Information No. 19, March 2004. Réseau d'Avertissements Phytosanitaires. Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Quebec.

ICM resources for production of greenhouse cucumber in Canada

British Columbia Ministry of Agriculture, Food, and Fisheries. http://www.gov.bc.ca/agf

InfoBasket. British Columbia Ministry of Agriculture, Food and Fisheries. http://infobasket.gov.bc.ca/

BC Greenhouse Growers' Association. http://www.bcgreenhouse.ca/

Ontario Ministry of Agriculture and Food. Greenhouse crop production information, articles and factsheets. www.gov.on.ca/omafra/english/crops/hort/greenhouse.html

Ontario Greenhouse Vegetable Growers. http://www.ontariogreenhouse.com

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

Quebec centre d'information et développement expérimental en serriculture. http://www.cides.qc.ca

Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Quebec (MAPAQ); Le Groupe d'Experts en Protection des Cultures en Serres. Liette Lambert. Liette.lambert@agr.gouv.qc.ca

Alberta Greenhouse Grower's Association. http://www.agga.ca

Alberta. Red Hat Cooperative. http://www.rehatco-op.com

Alberta Ministry of Agiculture and Food. http://www.agric.gov.ab.ca/index.html

Canadian Horticulture Council. http://www.hortcouncil.ca/chcmain.htm

Agriculture and Agri-Food Canada, Greenhouse and Processing Crops Research Centre, Harrow, ON. http://res2.agr.ca/harrow/index_e.htm

Table 8 . Research contacts related to pest management in Canadian greenhouse cucumber

Name	Organization	Pest type	Specific pests	Type of research
Gillian Ferguson	Ontario Ministry of Agriculture and Food, Harrow, ON	all		extension and applied research on pests and diseases of greenhouse vegetables
Shalin Khosla	Ontario Ministry of Agriculture and Food, Harrow, ON			greenhouse crop management
Amandeep Bal (Mary-Margaret Gaye, director)	BC Greenhouse Growers' Association, Surrey, BC	all		research coordinator for the BC greenhouse vegetable industry
Jennifer Curtis	BC Ministry of Agriculture, Food and Fisheries, Abbotsford, BC	all		greenhouse vegetable industry specialist, extension and industry development
Dr. Bob Costello	BC Ministry of Agriculture, Food and Fisheries, Abbotsford, BC	insects		diagnosis and extension in pest management: all greenhouse crops
Dr. Siva Sabaratnum	BC Ministry of Agriculture, Food and Fisheries, Abbotsford, BC	diseases		diagnosis and extension in disease management: all greenhouse crops

Liette Lambert	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation, St. Rémi, Quebec	all		greenhouse vegetable industry specialist, extension and industry development
Dr. M. Andre Gosselin	Centre de recherche en horticulture de l'Université Laval	all		crop and pest management: all greenhouse vegetables
Michel Cournoyer (Claude Laniel, director)	Centre d'information et développement expérimental en serriculture (CIDES)	insects and mites		applied research and advisory services: all greenhouuse vegetable crops
Dr. Zamir Punja	Simon Fraser University, BC	diseases	all	plant pathology: all greenhouse vegetable crops
Dr. Raj Utkhede	Agriculture and Agri-Food Canada, Agassiz, BC	diseases	all	plant pathology: all greenhouse vegetable crops
Dr. David Gillespie	Agriculture and Agri-Food Canada, Agassiz, BC	insect and mite	all	entomology and biological control for pests of greenhouse vegetables
Dr. David Ehret	Agriculture and Agri-Food Canada, Agassiz, BC			greenhouse crop management
Dr. Tom Papadopoulos Dr. Xiuming Hao	Agriculture and Agri-Food Canada, Greenhouse and Processing Crops Research Centre, Harrow, ON			greenhouse crop management
Dr. Les Shipp Dr. David Hunt	Agriculture and Agri-Food Canada, Greenhouse and Processing Crops Research Centre, Harrow, ON	insects and mites		entomology, biological control, insect pest management: all greenhouse crops
Dr. Ray Cerkauskas Dr. Mike Tu	Agriculture and Agri-Food Canada, Greenhouse and Processing Crops Research Centre, Harrow, ON	diseases		plant pathology; biological control, disease management: all greenhouse crops
Dr. Martine Dorais	Agriculture and Agri-Food Canada, Greenhouse and Processing Crops Research Centre, Harrow, ON	plant physiology		greenhouse crop production
Dr. Albert Liptay	Agriculture and Agri-Food Canada, Greenhouse and Processing Crops Research Centre, Harrow, ON			greenhouse vegetable transplant production

Dr. Ron Pitblado, director	University of Guelph, Ridgetown College, ON	all		applied research on insect and disease pests of greenhouse vegetables and greenhouse transplant production