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Crop Profile for Greenhouse Tomato in Canada, 2014

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Preface

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

Information on pest management practices and pesticides is provided for information purposes only. The discussion of any pesticide or pest control technique does not imply endorsement. Product names may be included and are meant as an aid for the reader, to facilitate the identification of pesticides in general use. The use of product names does not imply endorsement of a particular product by the authors or any of the organizations represented in this publication.

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

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

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Crop Profile for Greenhouse Tomato in Canada

The tomato, *Lycopersicon esculentum*, is a member of the Solanaceae (nightshade) family. The tomato is a perennial plant in tropical climates, but is grown as an annual in North America. The tomato is native to South America and was originally cultivated in the Andes Mountains of Peru, Bolivia and Ecuador.

All greenhouse-grown tomatoes are sold for fresh consumption. Tomatoes are eaten raw on their own, in salads or sandwiches and as a garnish. They are also cooked and used in sauces, soups and casseroles. Tomatoes are a good source of vitamin C and beta carotene and contain lycopene, an antioxidant that may help to prevent cancer.

Canadian greenhouse tomatoes are generally available from March to November with peak production in the summer months. There is an increasing move toward providing a year-round supply, but producing a crop when light levels and temperatures are at their lowest increases costs.

Crop Production

Industry Overview

Table 1. General production information

Canadian production (2014)¹	280,332 tonnes 554.1 ha
Farm gate value (2014)¹	\$507.1 million
Food available (2014)²	8.68 kg/person (fresh)
Exports (2014)³	146,790 tonnes (fresh)
Imports (2014)³	202,630 tonnes (fresh)

¹Source: Statistics Canada. Table 001-0006 - Production and value of greenhouse vegetables, annual CANSIM (database) (accessed 2016-05-20).

²Source: Statistics Canada. Table 002-0011 - Food available in Canada, annual CANSIM (database) (accessed 2016-05-20).

³Source: Statistics Canada. Table 002-0010 - Supply and disposition of food in Canada, annual (tonnes), CANSIM (database) (accessed 2016-05-20).

Production Regions

Ontario is the largest producer of greenhouse tomatoes (66% of national acreage), followed by British Columbia (19%) and Quebec (11%). There is minor production in Alberta. (Refer Table 2.)

Table 2. Distribution of greenhouse tomato production in Canada (2014)¹

Production Regions	Harvested area (hectares)	Percent national production
British Columbia	104.7	18.9%
Alberta	14.9	2.7%
Saskatchewan	0.7	<1%
Manitoba	x	x
Ontario	367.5	66.3%
Quebec	60.1	10.9%
New Brunswick	F	F
Nova Scotia	4.3	<1%
Prince Edward Island	x	x
Newfoundland and Labrador	0.2	<1%
Canada	554.1	100.0%

¹Source: Statistics Canada. Table 001-0006 - Production and value of greenhouse vegetables, annual, CANSIM (database) (accessed 2016-05-20).

x - Suppressed to meet confidentiality requirements of the Statistics Act.

F -Too unreliable to be published.

Cultural Practices

Greenhouse structures

In Ontario, about half of greenhouse tomatoes are produced in structures covered with double-layered polyethylene sheets. These greenhouses are equipped with gutter vents that can be opened and closed to regulate greenhouse temperature without the use of forced-air ventilation. In British Columbia, most of the greenhouse tomato production in the lower mainland is in glass-covered greenhouses but polyethylene is used in the BC Interior. In Quebec, 85% of the greenhouse area for tomato production is of polyethylene construction. Whether glass or polyethylene is used, temperature, humidity, ventilation and nutrient solution feeding are all computer-controlled.

Growing media

Most greenhouse tomatoes are produced in soil-less, hydroponic growing systems. Types of soil-less media available include rockwool, sawdust, coconut fibre, peat moss and foam. A low acreage of greenhouse tomato is produced in actual soil.

Rockwool is a manufactured product created from basaltic rock, coke and lime. The specific density and fibre orientation of the rockwool determines the water management strategy and number of crops grown. Rockwool has a potential life span of up to ten years, but is rarely used for more than one growing season. Coconut fibre is becoming more popular in part due to its physical characteristics and its environmental friendliness.

The raised-trough system for greenhouse tomato production has become popular. This system consists of steel troughs that are hung from the greenhouse structure at specific heights. The trough system improves labour efficiency in set up, production and clean-up and is more energy efficient. This design also improves water management capabilities, thereby reducing root disease problems. Newer operations using a trough system recycle nutrient solutions to reduce costs.

Seedlings are started in plugs and transplanted into blocks. Seedlings are commonly bent 90 or 180 degrees when transplanted into the rockwool block to allow rooting along the stem and greater stability. The blocks are then rooted into beds or bags of the growing medium.

Nutrients, temperature, CO₂ levels and other parameters are manipulated to meet the specific needs of different growth stages. In the winter (November and December in the most common production cycle), the main focus is on vegetative growth. Growers strive for maximum leaf area and a high dry matter content before the fruit is initiated on the plant. In the early spring (January and February), the goal is to develop strong trusses and flowers (generative growth). In mid-spring (February through April), the focus is on plant balance. At this time the plant is setting fruit and there is a draw of nutrients and energy toward the developing fruit. In summer (May through July), the focus is on the quality of the flowering truss while in fall conditions are adjusted to optimize fruit quality.

Crop Production Cycle

The greenhouse tomato crop cycle may adhere to one of the following scenarios:

Cycle 1:

- Young plants are placed in the greenhouse between mid-December and the end of February
- Crop terminated in July
- Second crop planted in August
- Second crop terminated in December.

Cycle 2:

- Young plants are placed in the greenhouse between mid-December and the end of February
- Crop is terminated in mid-November

Cycle 3:

- Young plants are placed in the greenhouse late June to early August
- Crop terminated the following June.

Growers in each province will use one of these scenarios depending mainly on climate. Growers with a raised trough system are able to interplant to minimize downtime and supply the market with high quality product most of the year. There is increased interest in using artificial lights for the cropping season. Artificial lighting is used in the production of most transplants.

Most greenhouse tomatoes are seeded into rockwool plugs at specialized propagation facilities. Grafting tomato varieties onto resistant rootstocks has become very common. In this process, two varieties are sown: the rootstock and the producing variety. A cultivar with a strong root system is used as the rootstock and a cultivar with the desired fruit and plant habit is used as the scion. Grafting has the benefit of increasing the growing strength of the plant, improving roots, decreasing susceptibility to root rot pathogens and improving yields.

Throughout the production of greenhouse tomatoes a number of factors are tracked including physical and chemical characteristics of the nutrient solutions, temperature, light, humidity, and characteristics of the leaching solution. To increase the efficiency, many tomato greenhouses employ a recirculation system, which allows drainage water to be captured and re-used. Greenhouse tomatoes are pollinated artificially, in most cases by bumblebees housed within the greenhouse, although there are mechanical devices which may be used for pollination.

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

Time of Year	Activity	Action
Preparation	Once per year	New plastic floor covering is laid down. Bags of growing media are placed in rows. Irrigation drippers are placed and the growing media is wetted.
Planting	Once or twice per year	Plants are received from the propagation greenhouse. They are placed on the growing media and the irrigation dripper is attached. The plants are tied to a support string as soon as they are set out. After about three weeks, a hole is cut in the plastic bags to allow the plants to root in the media.
Clipping and shoot removal	Once per week	Plants are trained to the support string with either a plastic clip or by winding the plant head around the string. Small side shoots are removed when they are five to ten cm long. Workers handle new growth (less than ten days old) in the top part of the plant, no tools are used.
Truss prune and support	Once or twice per week	Excess flowers are removed from the cluster after the desired number of fruit has set. Deformed fruit are removed at an early stage. Beefsteak tomatoes have heavy fruit – to prevent the cluster stem from kinking, an arched plastic support is placed over the cluster stem. Workers handle the newly formed clusters in the top of the plant (less than 17 days old). No tools are used.
Plant lowering	Usually once, sometimes twice per week	String is released from the bobbin and the plant is re-hung. No plant contact.
Leaf removal	Once per week	Two to three leaves are trimmed from the bottom of the vine to expose the ripening cluster. Workers handle the stem and leaves of the plant, which is six to eight weeks old. Knives or clippers may be used, some workers snap leaves off by hand. Leaves are removed from the greenhouse.
Harvest	Two to four times per week per plant; every day in greenhouse as a whole	Workers pick ripening fruit with the calyx attached or whole cluster and place fruit in crates for delivery to the packinghouse. Only fruit that is ready to pick is handled. Leaves are removed to expose the cluster.
Clean up: Remove plants	Once or twice per year	Support strings are cut, vines are laid in pathway, and the base of the vine is cut away from the growing media. Machinery is used to gather vines.
Clean up: Remove media	Once per year	The growing media and remaining plant debris are collected on carts, gathered together, and removed from the greenhouse. The plastic floor covering is rolled up and removed.
Clean up: Disinfection	Once per year	After all the old materials are removed, the irrigation system, heating pipes, and greenhouse structure are hosed down to remove any plant debris. The whole greenhouse is disinfected with bleach, a quaternary ammonium compound, or other type of disinfectant. The outside of glass greenhouses is washed about four times per year to help with light transmission.

NOTE: Although each plant is harvested two to four times per week, pickers work in the greenhouse every day (except in cases where they are not permitted due to restricted entry). If a single day of harvest is missed, there will be culls due to over-ripe fruit.

Source: Adapted from Selina and Bledsoe, “U.S. Greenhouse/Hothouse Hydroponic Tomato Timeline” (<http://www.cipm.info/croptimelines/pdf/USgreenhousetomato.PDF>) and provincial specialists.

Abiotic Factors Limiting Production

Temperature

Temperature extremes can affect flowering and fruit set in greenhouse tomato. Temperatures that are too high will lead to fruit softness and poor flavour. The large variations in outdoor temperature in Canada (from -25°C in winter to 30°C in summer) complicate the regulation of temperature and humidity and increase the risk of physiological disorders such as fruit softening, cracking and catface in the greenhouse. Improper root zone temperatures can result in the development of root rot pathogens.

Relative Humidity

Producers have a challenge to optimize plant transpiration rates while avoiding condensation on the foliage. High humidity can pose a problem in greenhouses because such conditions favour the development of many fungal and bacterial plant pathogens. However, if the humidity level is too low due to the entry of cold dry air into the greenhouse during the winter, stress on the plant is increased.

Oedema

Oedema (edema) can occur on leaves under cool conditions when roots take up more water than is lost through transpiration. Oedema appears as small, white spots on leaves where cells have ruptured due to excess water pressure.

Planting Density

Planting density is dependent on the amount of available solar radiation. If plant densities are too high relative to light intensity, poor fruit quality (including poor flavour and short shelf-life) may result. The decrease in light intensity and day length in the fall and winter will reduce fruit quality unless supplemental lighting is used.

Growing Media Water / Air Ratio and Imbalanced Humidity

Imbalanced water / air ratios in the growing media can result in chlorosis in the head. Imbalanced humidity may cause pale yellow flower colour (should be bright yellow), or 'sticky flowers' where the sepals do not roll back.

Nutritional Imbalances

Calcium deficiency, resulting from high pH, excessive nitrogen and / or low levels of calcium in the nutrient solution can result in blossom end rot or interior graywall in fruit. Graywall has also been linked to other nutrient imbalances. Uneven ripening may be caused by nutrient imbalances, particularly potassium deficiency. Symptoms of magnesium deficiency include yellow blotches on leaves between green veins, brittle leaves and leaf curling or cupping. Magnesium deficiency, while fairly common, rarely results in yield loss. Inadequate levels of micronutrients in the plant (e.g. iron) can result from poor root development or root disease, as well as other factors and will be manifested as chlorosis, followed by necrosis in later stages.

Diseases

Key issues

- New chemical controls are required for a number of greenhouse tomato diseases. It is important that new chemicals are suitable for use in both conventional and organic production systems and that they are compatible with biological controls.
- There is a need for the development of improved management practices and non-chemical options for powdery mildew control, including resistant varieties and biological controls suitable for use in organic systems.
- There is concern about the potential for the development of new races of fusarium crown and root rot that may overcome cultivar resistance, as there are currently no other effective solutions for the management of this disease for producers.

Table 4. Occurrence of diseases in greenhouse tomato production in Canada^{1,2}

Disease	British Columbia	Ontario	Quebec
Bacterial canker			
Fusarium crown and root rot			
Grey mould, canker and ghost spot			
Late blight			
Powdery mildew			
Pythium root rot			
Post-harvest diseases			
Virus diseases			
Pepino Mosaic Virus			
Tomato Mosaic Virus			
Widespread yearly occurrence with high pest pressure.			
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.			
Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pressure.			
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.			
Pest is present and of concern, however little is known of its distribution, frequency and importance.			
Pest not present.			
Data not reported.			

¹Source: Stakeholders in greenhouse tomato producing provinces.

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

Table 5. Adoption of disease management practices in greenhouse tomato production in Canada

Practice / Pest		Bacterial Canker	Fusarium crown and root rot	Grey mould canker, ghost spot	Powdery mildew	Pythium root rot
Avoidance	Crop rotation					
	Optimizing fertilization					
	Reducing mechanical damage or insect damage					
	Control of disease vector					
	Resistant varieties					
Prevention	Equipment sanitation					
	End of season disinfection of structure					
	Use of a sterile growing medium					
	Optimize ventilation and air circulation in crop					
	Maintain optimum temperature and humidity conditions					
	Modification of plant density (row or plant spacing; seeding rate)					
	Water/ irrigation management					
	Culling and proper disposal of infected plants and plant parts					
	Isolation of infected areas of the greenhouse and working in these sections last					
	Allocation of sections of the crop to specific workers to prevent disease spread					
Monitor-ing	Regular monitoring throughout crop cycle					
	Records to track diseases					
	Use of indicator plants					
Decision making tools	Economic threshold					
	Weather conditions					
	Recommendation from crop specialist or consultant					
	First appearance of pest or pest life stage					
	Observed crop damage					
	Crop stage					
	Calendar spray					

... continued

Table 5. Adoption of disease management practices in greenhouse tomato production in Canada (continued)

Practice / Pest		Bacterial Canker	Fusarium crown and root rot	Grey mould canker, ghost spot	Powdery mildew	Pythium root rot
Suppression	Biopesticides					
	Pesticide rotation for resistance management					
	Spot application of pesticides					
	Use of pesticides which are compatible with beneficials					
	Novel pesticide application techniques					
	Follow sanitation practices					
New practices (by province)	Disinfection of nutrient re-circulated solution (Ontario)					
	Closer pruning to stem (British Columbia)					
This practice is used to manage this pest by growers in at least one reporting province.						
This practice is not used to manage this pest in reporting provinces.						
This practice is not applicable for this pest						
Information regarding the practice for this pest is unknown.						

¹Source: Greenhouse tomato stakeholders in reporting provinces (British Columbia, Ontario and Quebec).

Table 6. Fungicides and bio-fungicides registered for disease management in greenhouse tomato in Canada

Active Ingredient ¹	Classification ²	Mode of Action ²	Target Site ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
<i>Bacillus amyloliquefaciens</i> strain D747	microbial: <i>Bacillus</i> spp. and the fungicidal lipopeptides they produce	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	44	R	grey mould, early blight, phytophthora blight (partial suppression)
<i>Bacillus subtilis</i> strain QST 713	microbial: <i>Bacillus</i> spp. and the fungicidal lipopeptides they produce	F3: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	44	R	bacterial blight (<i>Pseudomonas syringae</i>), grey mould
<i>Bacillus subtilis</i> strain MBI 600	microbial: <i>Bacillus</i> spp. and the fungicidal lipopeptides they produce	F3: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	44	R	damping off and root disease caused by <i>Fusarium</i> spp., <i>Rhizoctonia solani</i> and <i>Pythium</i> spp. (suppression)
<i>Bacillus subtilis</i> var. <i>amyloliquefaciens</i> strain FZB24	microbial: <i>Bacillus</i> spp. and the fungicidal lipopeptides they produce	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	44	R	late blight (suppression)
boscalid + pyraclostrobin	pyridine-carboxamide + methoxy-carbamate	C2: respiration + C3: respiration	complex II: succinate-dehydrogenase + complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	7 + 11	R + R	grey mould, powdery mildew (suppression)

...continued

Table 6. Fungicides and bio-fungicides registered for disease management in greenhouse tomato in Canada (continued)

Active Ingredient ¹	Classification ²	Mode of Action ²	Target Site ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
copper octanoate	inorganic	multi-site contact activity	multi-site contact activity	M1	R	early blight, late blight, septoria leaf spot, bacterial speck, bacterial leaf spot, bacterial canker
cyprodinil + fludioxonil	anilino-pyrimidine + phenylpyrrole	D1: amino acids and protein synthesis + E2: signal transduction	methionine biosynthesis (proposed) (cgs gene) + MAP/histidine-kinase in osmotic signal transduction (os-2, HoG1)	9 + 12	RE + RE	powdery mildew, grey mould
fenhexamid	hydroxylanilide	G3: sterol biosynthesis in membranes	3-keto reductase, C4-demethylation (erg27)	17	RE	grey mould
ferbam	dithiocarbamate and relatives	multi-site contact activity	multi-site contact activity	M3	RE	grey mould
garlic powder	biological	unknown	unknown	N/A	R	powdery mildew (suppression), late blight (may inhibit symptoms), seed rot, damping-off and root rot (partial suppression)

...continued

Table 6. Fungicides and bio-fungicides registered for disease management in greenhouse tomato in Canada (continued)

Active Ingredient ¹	Classification ²	Mode of Action ²	Target Site ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
iprodione	dicarboximide	E3: signal transduction	MAP/ histidine-kinase in osmotic signal transduction (os-1, Daf1)	2	RE	grey mould
mancozeb	dithiocarbamate and relatives	multi-site contact activity	multi-site contact activity	M3	RE	early blight, late blight, septoria leaf spot
mandipropamid	mandelic acid amide	H5: cell wall biosynthesis	cellulose synthase	40	R	late blight
mineral oil	diverse	not classified	unknown	N/C	R	powdery mildew (suppression)
myclobutanil	triazole	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	3	R	powdery mildew
oxathiapiprolin	piperidiny-thiazole-isoxazoline	unknown	oxysterol binding protein (OSBP) inhibition (proposed)	U15	R	late blight, phytophthora blight
penthiopyrad	pyrazole-4-carboxamide	C2: respiration	complex II: succinate-dehydro-genase	7	R	grey mould, early blight (suppression)

...continued

Table 6. Fungicides and bio-fungicides registered for disease management in greenhouse tomato in Canada (continued)

Active Ingredient ¹	Classification ²	Mode of Action ²	Target Site ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
phosphorous acid (mono and di-potassium salts of phosphorous acid)	phosphonate	unknown	unknown	33	R	late blight (suppression), phytophthora foliar blight (suppression)
potassium bicarbonate	not classified	diverse	unknown	N/A	R	powdery mildew
propamocarb hydrochloride	carbamate	F4: lipid synthesis and membrane integrity	cell membrane permeability, fatty acids (proposed)	28		pythium root rot and damping-off
pyrimethanil	anilino-pyrimidine	D1: amino acids and protein synthesis	methionine biosynthesis (proposed) (cgs gene)	9	R	grey mould
<i>Reynoutria sachalinensis</i> (extract)	complex mixture, ethanol extract	P5: host plant defence induction	P5	P5	R	bacterial blight (suppression), powdery mildew (suppression), grey mould (suppression)
<i>Streptomyces griseoviridis</i> strain K61	biological	unknown	unknown	N/A	R	damping-off, root and crown rot and wilt caused by fusarium (suppression), root and stem rot and wilt caused by phytophthora (suppression)

...continued

Table 6. Fungicides and bio-fungicides registered for disease management in greenhouse tomato in Canada (continued)

Active Ingredient ¹	Classification ²	Mode of Action ²	Target Site ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
<i>Streptomyces griseoviridis</i> strain WYEC 108	biological	unknown	unknown	N/A	R	powdery mildew (suppression) and seed rot, damping off and root rot caused by pythium (suppression)
sulphur	inorganic	multi-site contact activity	multi-site contact activity	M2	R	powdery mildew
tea tree oil (<i>Melaleuca alternifolia</i>)	terpene hydrocarbons and terpene alcohols	F7: lipid synthesis and membrane integrity	cell membrane disruption (proposed)	46	R	powdery mildew, grey mould, late blight (suppression)
<i>Trichoderma harzianum</i> Rifai strain KRL-AG2	biological	unknown	unknown	N/A	RE	root rot caused by pythium, rhizoctonia and fusarium (suppression), botrytis blight (suppression)
<i>Trichoderma harzianum</i> Rifai strain T-22	biological	unknown	unknown	N/A	RE	fusarium root and crown rot (suppression)

¹Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of March 10, 2016. The product label is the final authority on pesticide use and should be consulted for application information. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

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

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

Bacterial Canker (*Clavibacter michiganensis* subsp. *michiganensis*)

Pest Information

Damage: Bacterial canker is a very destructive disease of greenhouse tomato. Wilting of plants and yellowing of leaflets in the lower third of the plant, particularly on only one side of the plant or on one side of the leaf is one of the first indications of bacterial canker. Leaves may exhibit small blisters or pale green spots between the veins. Older leaflets roll upward and turn brown from the margin inwards. Petioles and stems on wilting plants may develop light-coloured streaks which break open to form a canker. The pith sometimes disintegrates or becomes necrotic as the disease progresses. Young fruit may be small, marbled and malformed. Small white spots on fruit, called “bird’s eye”, occur only when the infected crop is watered by overhead irrigation.

Life Cycle: Bacteria are carried both on and within the coat of seeds from infected plants. Germinating seedlings are infected through the cotyledons. Wounds and stomata serve as points of entry to mature plants. The bacteria are spread by insects, splashing or running water and on worker’s clothing and tools. Bacteria can survive in or on seed for up to five years and in soil for a lesser period of time.

Pest Management

Cultural Controls: Minimizing stresses such as high temperatures, over-watering, low light and nutritional imbalances, will minimize the spread and impact of the disease. Planting only disease-free seed and transplants will reduce the likelihood of introduction of bacterial canker into the greenhouse. The removal of diseased plants, as well as asymptomatic adjacent plants will reduce the chance of disease spread. This can also be done by isolating rows in which diseased plants are located and limiting the movement of personnel and equipment into the diseased area. Thorough cleaning and sanitizing of the greenhouse between crops is an essential element of bacterial canker management. Regular monitoring is important for early detection of the disease. **Resistant Cultivars:** There are no resistant varieties, although some varieties have been observed to be “tolerant” to the disease, *i.e.*, yield reasonably well despite infection.

Chemical Controls: Pesticides registered for the control of bacterial canker are listed in *Table 6. Fungicides and bio-fungicides registered for disease management in greenhouse tomato in Canada.*

Issues for Bacterial Canker

1. There is a need for additional control products for bacterial canker, including those suitable for use in organic systems.
2. There is a need for the development of effective seed treatments. New seed treatments should have a minimal negative effect on seed germination and plant vigor.
3. To minimize risks due to seed-borne diseases, only seeds certified to International Seed Federation (ISF) standards should be used by propagators in the production of tomato transplants. It is important that growers who propagate their own transplants use ISF certified seeds.
4. There is a need to develop new, non-chemical approaches to the control of bacterial canker, including crop sanitation practices and cultivars resistant to bacterial canker.

Fusarium Crown and Root Rot (*Fusarium oxysporum* f. sp. *radicis-lycopersici*) (FORL)

Pest Information

Damage: Early symptoms of fusarium crown and root rot include wilting of the upper leaves on sunny days, especially when plants start bearing fruit. Stems develop dark brown cankers at the soil level and red-brown vascular discolouration that extends five to twenty-five cm above the soil line. Affected roots develop brown discolouration.

Life Cycle: The fungus produces abundant chlamydospores (resting spores) that can survive on tomato vines in cull piles. The fungus generally enters through wounds in the roots, although it can also enter roots with an intact epidermis. Fungus gnats may spread the fungus as they move around the greenhouse. Winter and early spring plantings are more severely affected than late spring plantings.

Pest Management

Cultural Controls: Strict greenhouse sanitation combined with the use of resistant rootstocks is used to manage the disease. Monitoring for the disease is done, especially in winter and early spring. The control of fungus gnats will eliminate a source of spread. The disinfection of the greenhouse between crops is important to eliminate any disease carry-over between crops.

Resistant Cultivars: Resistant rootstocks are available.

Chemical Controls: Biofungicides registered for the suppression of fusarium root and crown rot are listed in Table 6. *Fungicides and bio-fungicides registered for disease management in greenhouse tomato in Canada.*

Issues for Fusarium Crown and Root Rot

1. The development of new races of fusarium that may overcome cultivar resistance is of concern, as there are no other effective solutions for the management of this disease for producers.

Pythium Root Rot (*Pythium* spp.)

Pest Information

Damage: Pythium affects both mature plants and seedlings. On mature plants, tiny feeder roots are destroyed, causing crowns to wilt suddenly, especially during hot, sunny conditions. The small, infected roots are soft and water-soaked in appearance. On seedlings, pythium causes damping off and seed rot, often in conjunction with other pathogens such as *Phytophthora* spp. and *Rhizoctonia* spp. The incidence of seed rot and damping-off in seedlings is generally higher when media is moist and cold.

Life Cycle: Pythium propagules (sporangia, zoospores and oospores) can be present in soil, propagation and growing media, and untreated water. Spores can be spread in irrigation water, nutrient feed and by fungus gnats and shore flies.

Pest Management

Cultural Controls: It is important to ensure adequate drainage and ventilation and stable temperatures to minimize plant stress. Good water management strategies are required to ensure healthy, strong roots to minimize pythium infection. Good sanitation practices, including the removal of infected plants and sterilization of re-circulated nutrient solutions by pasteurization, UV, ozone, etc. will reduce the spread of pythium throughout the greenhouse. Controlling fungus gnats and shore flies will also help to reduce the spread of the disease. Regular monitoring for symptoms is important.

Resistant Cultivars: None available.

Chemical Controls: Fungicides registered for the control of pythium are listed in Table 6.

Fungicides and bio-fungicides registered for disease management in greenhouse tomato in Canada.

Issues for Pythium Root Rot

1. There is a need for the registration of chemical and biological fungicides with short pre-harvest intervals (PHI), for the management of pythium root rot.

Grey Mould, Canker and Ghost Spot (*Botrytis cinerea*)

Pest Information

Damage: Botrytis can infect leaves, petioles, stems and fruit. Older senescing tissues, such as stems, are more susceptible to infection. De-leafing scars and wounds from truss removal are also sites of infection. Infected leaves wither and die. The fungus forms spreading, girdling, dry, light brown cankers on stems and petioles that result in wilt and dieback above the canker. Fruit infections occur when the fruit is in direct contact with diseased foliage, calyxes or petals. Severely affected mature fruit will rot and drop. Fruit infections caused by spores may result in a ghost spot symptom on both green and mature fruit. Ghost spots appear as small necrotic spots with whitish halos and can result in downgrading of affected fruit.

Life Cycle: Leaf scars may be infected ten to twelve weeks before symptoms develop. Abundant, grey-brown spores (conidia) develop in infected plant tissues. Spores are primarily air-borne. Spore release is triggered by changes in relative humidity and infrared exposure. Optimum spore germination and disease development occur at 18 to 23°C in humid conditions. Botrytis survives as sclerotia, mycelia or spores on plant debris and on perennial plants and weeds.

Pest Management

Cultural Control: Sanitation practices are important to reduce disease levels in the greenhouse. The placement of cull piles far from the greenhouse or burying crop debris, will serve to eliminate a source of botrytis. The prompt removal of dead and dying plants will prevent the build-up of inoculum in the greenhouse. Ensuring adequate ventilation and heat, especially at night and maintenance of relative humidity below 80% will help to reduce disease development. The avoidance of tearing during pruning will minimize potential sites of infection. Disinfecting knives periodically between cuts while pruning, will limit the transmission of disease. Weekly monitoring for lesions can help keep disease under control. Thorough cleaning and disinfection of the greenhouse between crops will help to reduce the potential for disease carry-over.

Resistant Cultivars: None available.

Chemical Control: Fungicides registered for the control of botrytis are listed in *Table 6*.

Fungicides and bio-fungicides registered for disease management in greenhouse tomato in Canada.

Issues for Grey Mould, Canker and Ghost Spot

1. The development of resistance by botrytis to currently registered fungicides is of concern. There is a need for the registration of new classes of fungicides for control and for resistance management in botrytis.
2. There is a need for additional biological control products for the management of grey mould especially for use in organic production systems.
3. Studies are required to establish greenhouse climate management approaches that minimize the development and impact of botrytis on greenhouse tomato.

Late Blight (*Phytophthora infestans*)

Pest Information

Damage: Late blight in greenhouse tomato crops tends to develop in late summer or early fall. Symptoms first appear as water-soaked areas on leaves which rapidly enlarge to form oily, greyish or tan blotches. Entire leaves die. Dark grey to black lesions quickly spread down petioles and young stems. Large, brown blotches appear on green fruit, but these remain firm unless there is secondary bacterial soft rot.

Life Cycle: Late blight affects solanaceous plants such as potato, tomato, eggplant and nightshade weeds. Infected potato and tomato crops and cull piles in close proximity to the greenhouse can be the source of the disease. Under warm, humid conditions, the fungus produces spores on the surface of infected plant tissues which serve to spread the disease. Spores (sporangia) spread in air and water over long distances.

Pest Management

Cultural Controls: The elimination of nightshade weeds around the greenhouse will eliminate a source of disease. Avoiding high humidity and low temperatures which can result in condensation on the leaves will make conditions less conducive to disease development. Sanitation practices including thorough cleaning and disinfecting of the greenhouse between crops and the use of footbaths, will reduce the likelihood of disease carryover between crops and introduction of inoculum into the greenhouse. Monitoring for symptoms, especially in late summer or when the disease has appeared on field crops in the area, is important for early detection of late blight in the greenhouse.

Resistant Cultivars: There are some varieties that are resistant, but new races and genotypes of the disease continue to evolve in North America.

Chemical Controls: Fungicides registered for the control of late blight are listed in *Table 6*.

Fungicides and bio-fungicides registered for disease management in greenhouse tomato in Canada.

Issues for Late Blight

1. There is a need for the registration of fungicides for the control of late blight in greenhouse tomatoes given the potential for serious losses when outbreaks occur.

Powdery Mildew (*Oidium neolycopersici*)

Pest Information

Damage: Powdery mildew first appears as yellow spots or blotches on the upper leaf surface.

Powdery, white spores (conidia) and fungal hyphae develop on the blotches on both upper and lower leaf surfaces. Severe infections cause leaf senescence and reductions in yield. Fruit and stems are not infected.

Life Cycle: *Oidium neolycopersici* is an obligate parasite that can only infect living plant tissue. It infects a range of solanaceous, cucurbit and other species including potato, eggplant and tobacco. Conidia are air-borne or carried on worker clothing and equipment. The spores land on leaf surfaces, germinate and start new infections. High humidity favours spore germination and infection.

Pest Management

Cultural Controls: Ventilation, adequate spacing of plants and de-leafing to promote air circulation, will make conditions less favourable for infection. It is important to thoroughly clean and disinfect the greenhouse between crops. Monitoring for early signs of disease is important, since the pathogen can increase rapidly under favourable conditions.

Resistant Cultivars: A few resistant / tolerant cultivars are available.

Chemical Controls: Fungicides registered for the control of powdery mildew are listed in *Table 6. Fungicides and bio-fungicides registered for disease management in greenhouse tomato in Canada.*

Issues for Powdery Mildew

1. There is a need for the registration of new classes of fungicides for powdery mildew control and for use as resistance management tools.
2. Improved management practices including biological controls suitable for use in organic production systems are required for powdery mildew control.
3. Harmonized pest control options and maximum residue limits (MRL's) need to be established between Canada and the United States.
4. The development of varieties resistant to powdery mildew is needed.

Pepino Mosaic Virus (PepMV)

Pest Information

Damage: This disease does not kill tomato plants outright but can cause a decrease in yield of approximately 15%. Typical symptoms include stunted and spiky heads, distinctive yellow mosaic spotting on leaves and brownish streaks on stems. This browning can affect the developing flowers, causing them to abort. The calyx of developing fruit can also appear brown. Fruit may or may not show symptoms of marbling. Affected fruit is not marketable. Symptoms are often more apparent during fall and winter months when plants are under more stress.

Life Cycle: PepMV is readily spread mechanically on contaminated tools, shoes, clothing, hands, and by plant-to-plant contact. Symptoms usually appear two to three weeks after infection.

Pest Management

Cultural Controls: The use of virus-free seed and good crop hygiene are vital for successful disease control. Seed treatments are available that inactivate the virus on the seed coat. Monitoring for disease symptoms is important, especially in the fall and winter when plants are under stress. It is important to remove all plant material and thoroughly clean and disinfect the greenhouse at the end of every cropping season.

Resistant Cultivars: There is no known resistance to this disease in available tomato varieties.

Chemical Control: None available.

Issues for PepMV

1. There is a need for the development of tomato cultivars with resistance to PepMV given the high potential for spread and crop injury if it is introduced into the greenhouse.

Mosaic: Tomato Mosaic Virus (ToMV) / Tobacco Mosaic Virus (TMV)

Pest Information

Damage: Tomato mosaic virus and tobacco mosaic virus produce similar symptoms. The viruses can cause stunting and reduced yields, and also affect fruit quality. The symptoms depend on the strain of the virus and environmental conditions. The viruses cause leaf mottling and affected leaves may be fern-like or strap-like. Virus infection may result in a failure to set fruit or flower drop, although this is usually limited to trusses setting fruit at the time of infection. Fruit on cultivars with some resistance to mosaic may develop necrotic blotches. These blotches are restricted to the skin tissue and often only one or two trusses will be affected.

Life Cycle: The pathogens are soil and seed-borne and survive in infected plant residue. They are spread readily by handling of plants during transplanting, tying and pruning. Spread can also occur from contaminated clothing and the viruses may remain infective for years on unwashed clothing that has been stored in dark conditions.

Pest Management

Cultural Controls: The handling of plants as little as possible and the removal of plants that show mosaic symptoms early in the season will help to minimize spread of the disease. Sanitation practices including the elimination of other potential host plants from the greenhouse, the disinfection of the greenhouse and equipment between crops, the frequent disinfection of tools during use, and the use of disposable coveralls will help to minimize the spread of virus. Spraying seedlings with a milk solution and dipping hands in the milk solution when handling or working with the plants can reduce virus spread.

Resistant Cultivars: The most common tomato cultivars grown in Canadian greenhouses are resistant.

Chemical Controls: None available.

Issues for ToMV / TMV

None identified.

Post-harvest diseases

Pest Information

Damage: Symptoms of post-harvest diseases include fruit spotting and softening of tissues that can progress to complete breakdown of the fruit. Early lesions may appear water-soaked.

Sporulation and mould growth of the causal fungus often develops in the lesions, at breaks in the skin and around wound sites.

Life Cycle: The fungi that cause post-harvest diseases are found in crop debris and other organic matter. Under moist conditions, spores are produced in this material and are dispersed to healthy tomato fruit on air currents, when disturbed by workers, and by insects such as fungus gnats. Infection often occurs through wounds and stem scars; however *Botrytis cinerea* can invade directly through intact tissues. Depending on the pathogen, green, ripening or ripe fruit may be affected. Infection can spread by fruit to fruit contact in storage.

Pest Management

Cultural Controls: Following strict greenhouse sanitation and worker hygiene practices through the crop production, harvest and marketing phases is important in minimizing post-harvest diseases of tomato. Thorough cleaning and sanitizing of the greenhouse between crops will reduce the chance of disease carry-over.

Resistant Cultivars: None available

Chemical Controls: Fungicides registered for the management of post-harvest diseases are listed in Table 6. *Fungicides and bio-fungicides registered for disease management in greenhouse tomato in Canada.*

Issues for Post-harvest diseases

1. Continued monitoring and research into potential solutions is required.

Insects and Mites

Key issues

- There is a need for the registration of additional chemical and non-chemical controls for a number of insect pests of greenhouse tomato. It is important that new chemicals be compatible with biological controls and suitable for use in organic production systems.

Table 7. Occurrence of insect pests in Canadian greenhouse tomato production^{1,2}

Insect	British Columbia	Ontario	Quebec
Aphids			
Green peach aphid			
Potato aphid			
Mites			
Carmin mite			
Russet mite			
Two-spotted spider mite			
Caterpillars (various species)			
Cabbage looper			
Whiteflies			
Greenhouse whitefly			
Sweet potato whitefly			
Potato psyllid			
Thrips			
Onion thrips			
Western flower thrips			
Fungus gnats and shore flies			
Lygus bugs			
Widespread yearly occurrence with high pest pressure.			
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.			
Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pressure.			
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.			
Pest is present and of concern, however little is known of its distribution, frequency and importance.			
Pest not present.			
Data not reported.			

¹Source: Stakeholders in greenhouse tomato producing provinces (British Columbia, Ontario, Quebec).

²Refer to Appendix 1, for a detailed explanation of colour coding of occurrence data.

Table 8. Adoption of insect pest management practices in greenhouse tomato production in Canada¹

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

...continued

Table 8. Adoption of insect pest management practices in greenhouse tomato production in Canada¹ (continued)

Practice / Pest		Aphids	Two-spotted spider mite	Caterpillars (various species)	Greenhouse whitefly	Potato psyllid	Thrips	Fungus gnats and shore flies
Suppression	Biopesticides							
	Arthropod biological control agents							
	Use of banker plants as reservoirs or refuges for beneficial insects							
	Trapping							
	Pesticide rotation for resistance management							
	Spot application of pesticides							
	Use of pesticides which are compatible with beneficials							
	Novel pesticide application techniques (eg. use of pollinating insects to carry bio-pesticides)							
	Follow sanitation practices							
New practices (by province)	Calendar introduction of beneficial insects (Quebec)							
	Increase humidity at ground level (Quebec)							
This practice is used to manage this pest by growers in at least one reporting province.								
This practice is not used to manage this pest in reporting provinces.								
This practice is not applicable for this pest								
Information regarding the practice for this pest is unknown.								

¹Source: Greenhouse tomato stakeholders in reporting provinces (British Columbia, Ontario and Quebec).

Table 9: Arthropod biological control agents available for the management of insect and mite pests in greenhouse vegetable crops in Canada¹

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

.... continued

Table 9: Arthropod biological control agents available for the management of insect and mite pests in greenhouse vegetable crops in Canada¹ (continued)

Pest	Biological Control Agent	Description
Whiteflies	<i>Delphastus catalinae</i>	predatory lady beetle
	<i>Delphastus pusillus</i>	
	<i>Dicyphus hesperus</i>	predatory bug
	<i>Encarsia formosa</i>	
	<i>Eretmocerus eremicus</i>	parasitic wasp
	<i>Eretmocerus mundus</i>	

¹References:

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

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

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

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

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

Table 10. Pesticides and bio-pesticides registered for insect and mite management in greenhouse tomato production in Canada

Active Ingredient ¹	Classification ²	Mode of Action ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
abamectin	avermectin, milbemycin	glutamate-gated chloride channel (GLUCL) allosteric modulator	6	RE	leafminer, two spotted spider mite, tomato psyllid
acequinocyl	acequinocyl	mitochondrial complex III electron transport inhibitor	20B	R	two spotted spider mite
acetamiprid	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	R	whiteflies
<i>Autographa californica</i> Nucleopolyhedrosis virus, FV11	biological	unknown	N/A	R	cabbage looper
<i>Bacillus thuringiensis</i> ssp. <i>aizawai</i> strain ABTS-1857	<i>Bacillus thuringiensis</i> and the insecticidal proteins they produce	microbial disruptors of insect midgut membranes	11A	R	beet armyworm, cabbage looper, tobacco budworm, tomato fruitworm, tomato leafminer, tomato looper
<i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> strain ABTS-351	<i>Bacillus thuringiensis</i> and the insecticidal proteins they produce	microbial disruptor of insect midgut membranes	11A	R	European pepper moth (<i>Duponchelia fovealis</i>), lepidopteran leafminers

...continued

Table 10. Pesticides and bio-pesticides registered for insect and mite management in greenhouse tomato production in Canada (continued)

Active Ingredient ¹	Classification ²	Mode of Action ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
<i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> strain EVB113-19	<i>Bacillus thuringiensis</i> and the insecticidal proteins they produce	microbial disruptor of insect midgut membranes	11A	R	European pepper moth (<i>Duponchelia fovealis</i>), Banana moth (<i>Opongona sacchari</i>)
<i>Beauveria bassiana</i> strain ANT-03	biological	unknown	N/A	R	whiteflies, aphids, thrips
bifenazate	bifenazate	mitochondrial complex III electron transport inhibitor	20D	R	two spotted spider mite
chlorantraniliprole	diamide	ryanodine receptor modulator	28	R	cabbage looper, lepidopteran leafminer
dichlorvos	organophosphate	acetylcholinesterase (AChE) inhibitor	1B	RES*	aphids, whiteflies
etoxazole	etoxazole	mite growth inhibitor	10B	R	two spotted spider mite, carmine mite
fenbutatin oxide	organotin miticide	inhibitor of mitochondrial ATP synthase	12B	R	two spotted spider mite
flonicamid	flonicamid	chlrdotonal organ modulator - undefined target site	29	R	whiteflies, aphids, thrips
imidacloprid	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	RES*	aphids, whiteflies

...continued

Table10. Pesticides and bio-pesticides registered for insect and mite management in greenhouse tomato production in Canada (continued)

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

...continued

Table10. Pesticides and bio-pesticides registered for insect and mite management in greenhouse tomato production in Canada (continued)

Active Ingredient ¹	Classification ²	Mode of Action ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
spinosad	spinosyn	nicotinic acetylcholine receptor (nAChR) allosteric modulator	5	R	cabbage looper, European corn borer, exposed western flower thrip (suppression)
spiromesifin	tetronic and tetramic acid derivative	inhibitor of acetyl CoA carboxylase	23	R	two spotted spider mite, sweet potato whitefly, silverleaf whitefly, greenhouse whitefly
spirotetramat	tetronic and tetramic acid derivative	inhibitor of acetyl CoA carboxylase	23	R	aphids, whiteflies
tebufenozide	diacylhydrazine	ecdysone receptor agonist	18	RE	cabbage looper

¹Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of March 9, 2016. The product label is the final authority on pesticide use and should be consulted for application information. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

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

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

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

Aphids: Green Peach Aphid (*Myzus persicae*), Potato Aphid (*Macrosiphum euphorbiae*) and Foxglove Aphid (*Aulacorthum solani*)

Pest Information

Damage: Aphids feed by sucking sap from plant tissues. They excrete a sticky waste known as honeydew that supports the growth of sooty moulds. Sooty moulds can reduce photosynthesis and make the fruit unmarketable. Large aphid infestations can cause leaf drop, stunting and foliar deformities. Aphid infestations can be a significant marketing problem on cluster tomato varieties, when living and dead aphids and cast skins are present in and on the cluster. When the foxglove aphid feeds, it injects a toxin into the plant tissue, resulting in abnormal growth, stunting and yellowing of leaves.

Life Cycle: Aphids survive on outdoor hosts and can enter greenhouses through vents and other openings. In the greenhouse, all aphids are females that reproduce without mating and bear live young (nymphs). The nymphs are able to reproduce in less than 10 days. In the spring under warm conditions, an aphid population can increase 12-fold over the period of one week in a greenhouse.

Pest Management

Cultural Controls: The removal of weeds and ornamental plants in and around the greenhouse will eliminate potential sources of aphids. The washing and disinfection of greenhouses between crops will minimize aphid carryover. Regular monitoring visually and through the use of yellow sticky cards will help the early detection of aphid populations.

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

Resistant Cultivars: None available.

Chemical Controls: Insecticides registered for the control of aphids are listed in *Table 10.*

Pesticides and bio-pesticides registered for insect and mite management in greenhouse tomato production in Canada.

Issues for Aphids

1. The development of effective, non-chemical management strategies, that are not harmful to biological control agents, is needed for aphid control in greenhouse tomato.
2. Additional chemical and biological controls that are also suitable for use in organic greenhouses are required for the control of aphids in greenhouse tomato.

Mites: Two-Spotted Spider Mite (*Tetranychus urticae*), Carmine Mite (*T. cinnabarinus*) and Russet Mite (*Aculops lycopersici*)

Pest Information

Damage: Mites feed on the underside of leaves by piercing leaf cells and sucking cell contents.

This causes a visible chlorotic flecking on the upper surface. Heavily infested leaves may develop a bronzed appearance and become covered with webbing. Mite feeding, even at low levels may result in leaf drop. Feeding by the carmine mite can cause extensive leaf yellowing and drop. Feeding by the tomato russet mite, results in leaf yellowing, leaf curling, flower abortion and bronzed, cracked fruit.

Life Cycle: Mites spread rapidly between plants by walking and “parachuting” on fine silken strands or are carried on worker’s clothing and hands. Female mites lay eggs on foliage or in the growing points of the plants. Immature mites develop through three larval stages as they mature to adults. Dry conditions are the most favourable for mite development.

Pest Management

Cultural Controls: Regular monitoring of the crop is important for the early detection of mite problems. Proper humidity needs to be maintained in the greenhouse as mite populations are suppressed at higher humidity. The misting of plants at mid-day, especially when humidity is low is helpful in suppressing mite populations. Bush beans can be used as a trap crop for monitoring. It is important to wash and disinfect greenhouses between crops.

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

Resistant Cultivars: None available.

Chemical Controls: Pesticides registered for the control of spider mites are listed in *Table 10.*

Pesticides and bio-pesticides registered for insect and mite management in greenhouse tomato production in Canada.

Issues for Mites

1. Spider mites have become resistant to most miticides. New reduced risk miticides, that are safe for beneficial organisms, are required for mite control and for resistance management.
2. The development of non-chemical controls is required for russet mite.

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

Pest Information

Damage: Whiteflies feed by sucking sap from the plant. They can cause severe damage by reducing plant vigour and by coating the growing points, leaves, and fruit with honeydew, which becomes a food source for sooty mould growth. Sooty moulds coat the tomatoes, resulting in a need for extra cleaning, increasing costs prior to sale. *B. tabaci* can also transmit viruses and cause fruit discolouration.

Life Cycle: Whiteflies lay eggs on the underside of leaves. A mobile “crawler” stage hatches in five to ten days. The crawlers find a suitable site to settle down and feed. They develop through two immobile nymph stages before pupating and becoming adults. The entire life cycle can take up to 35 days depending on temperature. Adults begin to lay eggs about four days after emergence, and survive for 30 to 40 days.

Pest Management

Cultural Controls: Weekly monitoring by visual inspection and the use of yellow sticky traps is important for the early detection of whiteflies. Sticky boards and tapes can be used in ‘hot spots’ to trap and reduce populations. The removal of weeds in and around the greenhouse will eliminate sources of the pest. Pruning of severely infested plants will help to reduce populations. Enough lower leaflets should be allowed to grow to support the development of beneficial organisms, such as parasitic wasps. It is important to wash and disinfect the greenhouse between crops.

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

Resistant Cultivars: None available.

Chemical Controls: Insecticides registered for the control of whiteflies are listed in *Table 10. Pesticides and bio-pesticides registered for insect and mite management in greenhouse tomato production in Canada*.

Issues for Whitefly

1. There is a lack of effective control products for adult whiteflies. Products that are compatible with predators and additional biological controls are needed to manage whitefly populations.

Thrips: Onion Thrips (*Thrips tabaci*) and Western Flower Thrips (*Frankliniella occidentalis*)

Pest Information

Damage: Thrips feed by piercing plant cells and removing plant sap. Feeding results in silvery white streaks or specks on the leaves and shoulders of fruit. Thrips damage in tomatoes usually starts on the lower leaves and progresses slowly up the plant. If the damage is extensive, the photosynthetic ability of the plant may be reduced, resulting in a lowered yield. The western flower thrips also vectors tomato spotted wilt virus.

Life Cycle: Adult females have a life span of up to 30 days and can lay two to ten eggs per day. Eggs are inserted individually into the plant leaves, stems and flowers, and hatch in three to six days. Thrips larvae (nymphs) develop through two instars (stages) before dropping to the ground to pupate.

Pest Management

Cultural Controls: The removal of weeds and elimination of ornamental plants which can be hosts for thrips, from the vicinity of the greenhouse, will eliminate potential sources of the pest. Heating of the greenhouse as well as thorough washing and disinfection at the end of the cropping season after all plant material has been removed, will control any remaining thrips. Very fine screens placed over vents will prevent thrips from entering the greenhouse. It is important to monitor the crop weekly, beginning when the plants are moved into the greenhouse. Yellow or blue sticky traps can be used to monitor adult activity and the lower portion of the crop can be examined for thrips or signs of feeding.

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

Resistant Cultivars: None available.

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

Pesticides and bio-pesticides registered for insect and mite management in greenhouse tomato production in Canada.

Issues for Thrips

1. There is a need for additional chemical controls for thrips. Thrips have developed resistance to most chemical controls available.

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

Pest Information

Damage: Adult lygus bugs and nymphs pierce and suck sap from flowers, young fruit and stems, often at the terminal and lateral stem tips. Feeding can cause distorted stem tips and flower buds and aborted fruit.

Life Cycle: Lygus bugs overwinter outdoors as adults in sheltered locations. They become active in the spring. Following mating, females lay eggs in soft plant tissues such as petioles or leaf midribs. The eggs hatch in seven to ten days. Nymphs develop through five stages before the final moult to become adults. Adults may enter greenhouses any time throughout the growing season. Plant bugs may also overwinter in greenhouses and infest and spread on transplants in early spring.

Pest Management

Cultural Controls: The screening of vents and other openings into the greenhouse helps prevent the entry of lygus bugs. Maintaining a weed-free zone around the perimeter of the greenhouse by regular mowing or herbicide application will help to reduce lygus bug numbers in the immediate vicinity of the greenhouse and minimize their entry. Yellow or white sticky traps can be used to monitor for adults, and plants can be monitored regularly for feeding damage.

Biological controls: None available.

Resistant Cultivars: None available.

Chemical Controls: Insecticides registered for the control of lygus bugs are listed in *Table 10*.

Pesticides and bio-pesticides registered for insect and mite management in greenhouse tomato production in Canada.

Issues for Lygus bugs

None identified.

Potato Psyllid (*Paratrioza cockerelli*)

Pest Information

Damage: Psyllids feed by piercing plant tissues with their mouthparts and sucking plant sap.

Feeding of large numbers of nymphs can cause excessive accumulation of honeydew on the foliage and fruit. Honeydew supports the growth of sooty mould and can decrease marketability of the fruit. When feeding, nymphs inject a toxin that causes a symptom known as “psyllid yellows”. This can also lead to loss of vigour, lower yield, reduced growth, and distortion of foliage.

Life Cycle: Potato psyllids are predominantly pests of potatoes and tomatoes, but have many other hosts including eggplant, pepper, and some common weeds. They have three life stages: egg, nymph, and adult. Eggs are usually laid on the underside of the leaf along the edge and in the upper plant canopy. Females can produce as many as 500 eggs in three weeks. Nymphs resemble immature soft scales or immature whiteflies. Development time from egg to adult is 15 to 30 days depending on temperature.

Pest Management

Cultural Controls: Adults can be monitored using yellow sticky traps hung near the top of the plant canopy. It is important to wash and disinfect greenhouses between crops.

Biological Controls: None available.

Resistant Cultivars: None available.

Chemical Controls: Insecticides registered for the control of potato psyllid are listed in *Table 10*.

Pesticides and bio-pesticides registered for insect and mite management in greenhouse tomato production in Canada.

Issues for Potato Psyllid

None identified.

Lepidoptera: Cabbage Looper (*Trichoplusia ni*), Alfalfa Looper (*Autographa californica*), Hornworm (*Manduca* spp.), Variegated Cutworm (*Peridroma saucia*) and other cutworm species

Pest Information

Damage: The larval stages of lepidopteran pests cause damage by feeding on foliage of greenhouse crops.

Life Cycle: These pests enter the greenhouse through vents and other openings as adult moths or butterflies. The moths and butterflies lay eggs on the plants. After egg hatch, the larvae (caterpillars) feed on foliage and fruit, developing through a number of instars (stages) before pupating and emerging as adults. Several generations are possible per crop cycle if control measures are not implemented. Inadequate end-of-season clean-up can lead to pupae overwintering inside greenhouses and emerging as moths or butterflies at the start of the next production cycle.

Pest Management

Cultural Controls: The screening of vents and other openings to the greenhouse will minimize the potential for butterflies and moths to gain entry. Visual inspection can be used to detect the presence of caterpillar pests. Thorough washing and disinfection of the greenhouse between crops will eliminate carry-over of insect problems to the next crop.

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

Resistant Cultivars: None available.

Chemical Controls: Insecticides registered for the control of lepidopteran pests are listed in *Table 10. Pesticides and bio-pesticides registered for insect and mite management in greenhouse tomato production in Canada*.

Issues for Lepidoptera and Cutworm

1. There is a need for the registration of products for the control of cabbage looper and for use as resistance management tools.

Fungus Gnats: Sciaridae (*Bradysia* spp. and *Corynoptera* spp.) and shore flies (*Ephydriidae*)

Pest Information

Damage: Larvae of fungus gnats and shore flies may be found in growing media and wet areas where they feed on decaying organic matter, fungi and algae. They may also feed on roots and root hairs of greenhouse plants. Feeding wounds can provide entry points for root pathogens such as pythium, phytophthora and fusarium. Adult fungus gnats and shore flies are nuisance pests.

Life Cycle: Mature female fungus gnats lay eggs in moist soils, potting mixes and hydroponic media. The eggs hatch in two to four days. The larvae feed for about two weeks before pupating and maturing into an adult. The life cycle takes 15 to 20 days to complete at normal greenhouse temperatures. The life cycle of shore flies is similar to that of fungus gnats.

Pest Management

Cultural Controls: Screening vents and keeping doorways and other openings to the greenhouse closed will minimize entry by adult insects. Other cultural controls include avoiding overwatering, removing waste plant material and following good sanitation practices. Adult flies can be monitored with the use of yellow sticky traps. Thorough washing and disinfection of greenhouses between crops helps to minimize problems of fungus gnat and shore fly carry-over to the next crop.

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

Resistant Cultivars: None available.

Chemical Controls: None available.

Issues for Fungus Gnats and Shore flies

None identified.

Weeds

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

Vertebrate Pests

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

Pest Information

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

Life Cycle: These rodents are primarily outdoor pests. They are attracted to sources of food, water and shelter for nesting, such as garbage containers, cull piles, piles of sawdust, old planting media, building debris, burlap and styrofoam which are left outdoors or where bags of seed or slug bait are stored.

Pest Management

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

Resistant Cultivars: None available.

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

Issues for Rodents

None identified.

Resources

IPM resources for production of greenhouse tomato in Canada

Agri-Réseau www.agrireseau.qc.ca

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

Centre de Référence en Agriculture et Agroalimentaire du Québec (CRAAQ) www.craaq.qc.ca

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

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

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

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

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

Provincial Crop Specialists and Provincial Minor Use Coordinators

Province	Ministry	Crop Specialist	Minor Use Coordinator
British Columbia	British Columbia Ministry of Agriculture and Lands www.gov.bc.ca/al	David Woodske david.woodske@gov.bc.ca	Caroline Bédard caroline.bédard@gov.bc.ca
Ontario	Ontario Ministry of Agriculture, Food and Rural Affairs www.omafra.gov.on.ca/	Cara McCreary cara.mccreary@ontario.ca	Jim Chaput jim.chaput@ontario.ca
		Shalin Khosla shalin.khosla@ontario.ca	
Quebec	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec www.mapaq.gouv.qc.ca	André Carrier andre.carrier@mapaq.gouv.qc.ca	Luc Urbain luc.urbain@mapaq.gouv.qc.ca

National and Provincial Greenhouse Grower Organizations

Alberta Greenhouse Growers Association; <http://agga.ca/>

British Columbia Greenhouse Growers' Association; www.bcgreenhouse.ca

Greenhouse Nova Scotia; www.greenhousenovascotia.com/

Le Syndicat des producteurs en serre du Québec; <http://www.spsq.info/>

Ontario Greenhouse Vegetable Growers; www.ontariogreenhouse.com/

Saskatchewan Greenhouse Growers Association; www.saskgreenhouses.com

National:

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

Appendix 1

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

Information on the occurrence of disease, insect and mite and weed pests in each province is provided in Tables 4, 7 and 11 of the crop profile, respectively. The colour coding of the cells in these tables is based on three pieces of information, namely pest distribution, frequency and importance in each province as presented in the following chart.

Presence	Occurrence information				Colour Code
Present	Data available	Frequency	Distribution	Pressure	
		Yearly - Pest is present two or more years out of three in a given region of the province.	Widespread - The pest population is generally distributed throughout crop growing regions of the province. In a given year, outbreaks may occur in any region.	High - If present, potential for spread and crop loss is high and controls must be implemented even for small populations.	Red
				Moderate - If present, potential for spread and crop loss is moderate: pest situation must be monitored and controls may be implemented.	Orange
				Low - If present, the pest causes low or negligible crop damage and controls need not be implemented.	Yellow
			Localized - The pest is established as localized populations and is found only in scattered or limited areas of the province.	High - see above	Orange
				Moderate - see above	White
				Low - see above	White
		Sporadic - Pest is present one year out of three in a given region of the province.	Widespread - as above	High - see above	Orange
				Moderate - see above	Yellow
				Low - see above	White
			Localized - as above	High - see above	Yellow
				Moderate -see above	White
Low - see above	White				

... continued

Appendix 1 (continued)

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

Presence	Occurrence information		Colour Code
Present	Data not available	Not of concern: The pest is present in commercial crop growing areas of the province but is causing no significant damage. Little is known about its population distribution and frequency in this province; however, it is not of concern.	White
		Is of concern: The pest is present in commercial crop growing areas of the province. Little is known about its population distribution and frequency of outbreaks in this province and due to its potential to cause economic damage, is of concern.	Blue
Not present	The pest is not present in commercial crop growing areas of the province, to the best of your knowledge.		Black
Data not reported	Information on the pest in this province is unknown. No data is being reported for this pest.		Grey

References

British Columbia Ministry of Agriculture. 2016. Tomato Chlorotic Dwarf Viroid on Greenhouse Tomato www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/animal-and-crops/plant-health/phu-tomatochlorotic-dwarfviroidss.pdf (Accessed July 20, 2016).

Buonassisi, Andrea J., S. Sabaratnam, D. Woodske and Iris Bitterlich. 2013. *Biosecurity Guidelines for Post-harvest Greenhouse Tomatoes: prevention of Post-harvest and Storage Rot*. Report submitted to British Columbia Ministry of Agriculture and British Columbia Greenhouse Growers' Association. www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/agriculture-and-seafood/animal-and-crops/plant-health/biosecurity-tomato.pdf (Accessed July 20, 2016).

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

Selina, P. and Michael E. Bledsoe. 2002, *U.S. Greenhouse/Hothouse Hydroponic Tomato Timeline*. <http://www.cipm.info/croptimelines/pdf/USgreenhousetomato.PDF>

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