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Crop Profile for Greenhouse Lettuce in Canada, 2011

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Canada

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Preface

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

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

For detailed information on growing greenhouse lettuce, 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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Table of Contents

List of Tables

Crop Profile for Greenhouse Lettuce in Canada

Lettuce was cultivated as early as 4500 BC in the Mediterranean for the oil extracted from the seeds. Since then, production of the annual plant has spread world-wide. Today, lettuce is grown almost exclusively for the fresh market. It is used in salads, sandwiches and as a garnish. Lettuce can be split into two main groups: head lettuce (*Lactuca sativa* var. *captain*), which includes iceberg, crisphead and butterhead lettuce; and leaf lettuce (*L. sativa* var. *longifolia* and *L. sativa* var. *crispa*), which includes romaine, greenleaf, and redleaf lettuce. Only butterhead lettuce, also known as 'Boston' or 'Bibb' lettuce (*L. sativa* var. *capitata*) is grown in greenhouses; 'Prior' and 'Cortina' are the most common cultivars.

The primary product of greenhouse lettuce is the head or leaf, which is used mainly for salads. A good source of Vitamin A, E and folacin, lettuce is considered a healthy food and its popularity is on the rise as consumers make more healthy food choices. Pre-washed and pre-cut packaged salad mixes have become popular with consumers.

Crop Production

Industry Overview

Table 1: National greenhouse lettuce production statistics

Canadian production (2011)[1]	27,673,505 heads 32.4 hectares
Farm gate value (2011)[1]	$ 27.6 million
Domestic consumption (fresh) (2011)[2]	9.65 kg/person (fresh)
Exports (2011)	0
Imports (2011)[2,3]	307,123 tonnes $396 million

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

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

[3]Includes field and greenhouse lettuce.

Production Regions

Greenhouse lettuce is grown in Canada in areas where light and energy costs favour greenhouse crop production and where production is close to major markets. Major production areas by hectares (2009 data) are Quebec 16.19 ha or 70% of the national acreage and Ontario 3.69 ha or 16 % of the national acreage.

Table 2: Distribution of greenhouse lettuce production in Canada in 2009[1]

Production Regions	Area harvested (hectares)	Percent national production
Ontario	3.69	16%
Quebec	16.19	70%
Canada	23.0	100%

[1]Source: Statistics Canada. Table 001-0006 - production and value of greenhouse vegetables, annual CANSIM (database) (www.statcan.gc.ca) (accessed 2013-02-14).

Cultural Practices

The development of greenhouse procedures for producing lettuce has allowed growers to produce lettuce year round. The continual supply of lettuce is made possible by using a two-stage production system: plant raising and plant production.

Greenhouse lettuce is grown primarily in soil-less media, using a hydroponic nutrient film technique (NFT). In this system, plants are grown in a re-circulated, continuously flowing film of nutrient solution. Seeds are sown into seed trays in a mixture of peat and perlite, or directly into rockwool mini-blocks, foam medium or peat pellets that are placed in plastic trays. Seed trays in the growth room are covered with clear poly, transparent lids or misted frequently to ensure they do not dry out. Seedlings grown in peat-perlite are transplanted to rockwool mini-blocks or foam media when the first true leaves appear (7-10 days). Seedling plugs are then transplanted to temporary NFT troughs under supplemental lighting (24 hour photoperiod). At two to three weeks after germination during the summer, or four to six weeks after germination in the winter, the seedling plugs (3-4 leaves) are placed in permanent NFT troughs. Depending on the variety, 6 - 7 weeks or 10-12 weeks are required from seeding to harvest for summer and winter crops, respectively. Generally, there are 8 -10 production cycles per year.

There are many different NFT trough systems. All consist of a support or cover through which the transplant is placed, with the plant roots suspended in a trough through which the nutrient solution flows. An alternative system is Floating Culture, in which transplants are placed in holes in styrofoam sheets which are floated on a pool of nutrient solution. In both systems, the nutrient solution is re-circulated to mixing tanks where it is aerated and amended with nutrients.

Most greenhouse lettuce is harvested as a whole plant head with roots attached. Roots are tied off with a rubber band and the plant is placed in an open poly bag or clam-shell container. Some lettuce may be harvested and bagged without roots. Proper storage temperature and humidity is essential to maintain crop quality.

Different plant densities are used depending on the time of year and different pest management practices, pesticides and fertilizers are used at different stages of development. Water quality (salts and pH) and tissue and solution nutrient levels are checked frequently. Fungicides for root and stem rot diseases are often applied preventatively at transplanting.

Production Issues

Production of greenhouse lettuce requires strict control of temperature, light, carbon dioxide concentration and relative humidity (RH). Greenhouse lettuce is susceptible to tip burn when environmental and nutritional factors are imbalanced and the crop is under stress.

Table 3: Greenhouse lettuce production and pest management schedule in Canada

Time of Year	Activity	Action
Seeding and Transplant Production	Plant Care	Maintain proper temperature, humidity and moisture for seed germination.
	Media Care	Ensure seeding medium is clean and use clean trays; practice good sanitation.
	Disease Management	Treat seedlings with fungicide to prevent damping off and seedling rot.
	Insect Management	Minimize conditions favorable for fungus gnats and shore flies.
Crop Production	Plant Care	Maintain appropriate temperature, light, RH and CO_2 levels to avoid diseases and tip burn.
	Media Care	Monitor pH and nutrient content and ensure good aeration of nutrient solution.
	Disease Management	Drench with protectant fungicide for root and stem rot after transplanting. Monitor for botrytis, powdery mildew and downy mildew and apply registered fungicides if available. Ensure good aeration of re-circulating water to reduce pythium root rot. Maintain temperature and humidity to avoid condensation on crop.
	Insect Management	Monitor for aphids, cabbage loopers and whiteflies and apply insecticides as needed. Maintain weed-free zone around the greenhouse. Seal cracks and keep doors closed and screen vents when possible.
Harvest and Post-Harvest	Plant Care	Harvest promptly and ensure proper storage conditions to maintain crop quality.
	Media Care	Clean reservoir tanks, lines, etc. of algae and build-up between crops.
	Disease Management	Clean, sanitize and disinfect greenhouse between crops. Remove plant debris promptly and destroy.
	Insect Management	Clean, sanitize and disinfect greenhouse between crops. Remove plant debris promptly and destroy.

Abiotic Factors Limiting Production

Temperature

The temperature of the greenhouse is strictly regulated depending on the stage of development. Too high a temperature will prevent seed germination and in the production stage, will reduce leaf and head quality. Sudden changes in temperature can favour disease development by causing condensation on leaves or increase the incidence of tip burn. The temperature for germination and seedling production should be 15-18^{o}C. During crop growth and production, cooling fans, high pressure foggers, ventilation and moveable shade cloths or whitewash are used to maintain a night temperature of 15-18^{o}C and a day temperature ranging from 18-19^{o}C on cloudy days, to 19-22^{o}C on sunny days. In winter, when light levels are low, lettuce is often grown at cooler temperatures (10^{o}C night and 15-18^{o}C day), which lengthens the days to harvest. After harvest, lettuce must be stored at 2-4^{o}C under high relative humidity. Lettuce is highly sensitive to freezing, which damages the leaves. Too high storage temperatures promote further leaf development, resulting in a less appealing product.

Light

To optimize plant growth rate, supplemental, artificial lighting in the form of HPS (high pressure sodium) lights at 20 watts/m^2 on a 24 hour photoperiod, is often used when seedlings are placed in NFT troughs, especially in cloudy weather. During crop production, supplemental lighting is used to maintain an 18 hour photoperiod under low light conditions, such as cloudy periods and winter months.

Other climatic factors

Humidity is also closely monitored and controlled for greenhouse lettuce crops. Too high humidity, especially under cool temperatures, will favour condensation on the leaves and the development of diseases, such as botrytis grey mould. Excessive humidity will also increase the risk of tip burn by reducing transpiration. A relative humidity (RH) of 75-85% (VDP of 0.4-0.8 kPa) is generally targeted during production. The RH in storage should be 80-90%. For optimal growth and development, the levels of CO_2 are also monitored to maintain a concentration of 1000 ppm.

Nutrient solution quality

The concentration of nutrient salts (EC) and the pH of the nutrient solution are tested and monitored regularly as these have a significant impact on the growth of greenhouse lettuce. Fluctuations in EC levels will promote tip burn. A pH of 6.0 is optimal for plant growth. Fertilizer and acid are added to the reservoir tank to maintain pH and appropriate nutrient levels for each cultivar and stage of crop development. Good aeration of the re-circulating nutrient

solution is essential to provide oxygen to roots and reduce the incidence and severity of root rot diseases.

Tip burn and glassiness

Tip burn is caused by a calcium deficiency and is characterized by browning of the edges and tips of the young, inner leaves. To prevent this disorder, calcium levels in the nutrient solution must be high enough for sufficient calcium uptake by roots and transpiration rates must be high enough to provide sufficient calcium ions to the growing tips. Environmental conditions that reduce the transpiration rate, such as sudden temperature changes, too high RH, too low light or low temperature, can result in tip burn. Increasing ventilation and air circulation with fans will increase transpiration. In addition, limiting growth by reducing nitrogen application, harvesting the lettuce slightly before maturity and keeping the night-time humidity of the greenhouse at 75-85%, will reduce the incidence of tip burn.

Glassiness results from excess water uptake by the roots, followed by inadequate water loss from the leaves (evapo-transpiration). Good ventilation and the avoidance of high humidity will prevent glassiness.

Russet spot

Russet spot affects lettuce in storage and transport. It can be caused by too low storage temperature (chilling) or by exposure to ethylene in the storage facility. Tan to brown spots appear along leaf veins. Numerous or large spots make the product unmarketable.

Leaf yellowing

Premature leaf yellowing is associated with warm temperatures, high humidity and low light levels in late fall and early spring, which result in reduced CO^2 absorption, high respiration rates and thus leaf senescence. Lowering humidity and increasing ventilation and air circulation and using supplemental lighting will help to prevent this condition.

Diseases

Key Issues

- Research is needed to develop strategies (other than fungicides) for pythium control in hydroponic system, including the use of disease suppressing microorganisms, surfactants, control of pH), etc.
- There is a need to develop downy mildew resistant cultivars suitable for greenhouse production.
- There is concern that resistance to iprodione may be developing in the botrytis strains.
- The registration of new ways to apply fungicides for powdery mildew is needed (eg, sulfur burner).
- There is a need for the registration of fungicides for the management of bottom rot in greenhouse lettuce.
- There is a need for the registration of new insecticides for the control of aphids to reduce the incidence of lettuce mosaic virus.

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

Disease	Ontario	Quebec
Bottom rot		
Damping off and root rot		
Downy mildew		
Drop (white mould)		
Grey mould		
Powdery mildew		
Lettuce mosaic		

Widespread yearly occurrence with high pest pressure.

Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.

Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pressure.

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.

Pest not present.

Data not reported.

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

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

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

Practice / Pest		Damping off and root rot	Downy mildew	Grey mould	Powdery mildew	Virus diseases
Avoidance	crop rotation					
	optimizing fertilization					
	reducing mechanical damage or insect damage					
	control of disease vector					
	resistant varieties					
Prevention	equipment sanitation					
	end of season disinfection of structure					
	use of a sterilized growing medium					
	optimize ventilation and air circulation in crop					
	maintain optimum temperature and humidity conditions					
	modification of plant density (row or plant spacing; seeding rate)					
	water / irrigation management					
	culling and proper disposal of infected plants and plant parts					
	isolation of infected areas of the greenhouse and working in these sections last					
	allocation of sections of the crop to specific workers to prevent disease spread					
Monitor -ing	regular monitoring throughout crop cycle					
	records to track diseases					
	use of indicator plants					
Decision making tools	economic threshold					
	weather conditions					
	recommendation from crop specialist or consultant					
	first appearance of pest or pest life stage					
	observed crop damage					
	crop stage					
	calendar spray					
Suppression	bio-pesticides					
	pesticide rotation for resistance management					
	spot application of pesticides					
	use of pesticides which are compatible with beneficial organisms					
	novel pesticide application techniques					
	follow sanitation practices					

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

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

This practice is not applicable for this pest

Information regarding the practice for this pest is unknown.

[1]Source: Greenhouse lettuce stakeholders in reporting provinces (Ontario and Quebec).

Table 6: Fungicides registered for disease management in greenhouse lettuce production in Canada

Active Ingredient[1,2]	Classification[3]	Mode of Action[3]	Target Site[3]	Resistance Group[3]	Re-evaluation Status[4]	Target Pests[1,5]
boscalid (+ pyraclostrobin)	pyridine carboxamide + methoxy carbamate	C2. respiration + C3. respiration	complex II: succinate-dehydro-genase + complex lll: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	7 + 11	R + R	powdery mildew (*Erysiphe cichoracearum*)- suppression
fenhexamid	hydroxyanilide	G3: sterol biosynthesis in membranes	3-keto reduc-tase, C4- de-methylation (erg27)	17	R	grey mould (*Botrytis cinerea*)
ferbam	dithio-carbamates and relatives	Multi-site contact activity	Multi-site contact activity	M3	RE	grey mould (*Botrytis cinerea*)
fosetyl-Al (British Colombia only)	ethyl phosphonate	unknown	unknown	33	R	downy mildew
Gliocladium catenulatum	biological	unknown	unknown	N/A	R	suppression of damping off caused by *Pythium* spp. and *Rhizoctonia solani*; suppression of crown and root rot caused by *Pythium* spp.

Active Ingredient[1,2]	Classification[3]	Mode of Action[3]	Target Site[3]	Resistance Group[3]	Re-evaluation Status[4]	Target Pests[1,5]
iprodione	dicarboximide	E3: signal transduction	MAP/Histidine-Kinase in osmotic signal transduction (os-1, Daf1)	2	RE	grey mould, sclerotinia drop
mandipropamid	mandelic acid amide	H5: cell wall biosynthesis	cellulose synthase	40	R	downy mildew (*Bremia lactucae)*, blue mold (*Peronospora effusa*)
pyraclostrobin (+ boscalid)	methoxy-carbamate + pyridine carbamate	C3. respiration + C2. respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene) + complex II succinate-dehydrogenase	11 + 7	R + R	powdery mildew (*Erysiphe cichoracearum*)- suppression

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

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

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

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

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

Pythium damping off and root rot *(Pythium aphanidermatum, Pythium* spp.)

Pest Information

Damage: This soil and water-borne pathogen (protist) attacks the roots of lettuce and can destroy seedlings before or after emergence. Infection after transplanting may also reduce yield. Pythium diseases can be a problem in NFT systems, if solution flow rate, temperature, and particularly aeration is poor, causing the plants to be stressed. Plants wilt and have brown, soft roots, although in some cases, obvious signs of disease may not be visible, if the pathogen is affecting only the tiny feeder roots.

Life Cycle: The disease can spread rapidly through the nutrient solution. Sporangia produce zoospores that infect root tips and wounds. Sporangia can be spread in and on fungus gnats and shore flies.

Pest Management

Cultural Controls: Seeds should be sown in sterile propagation media and care should be taken to minimize overcrowding and overwatering seedlings. The maintenance of good aeration of the re-circulating solution helps to minimize pythium pressure.

Biological Controls: Gliocladium catenulatum is a microbiological fungicide registered for the suppression of pythium.

Resistant Cultivars: None available.

Chemical Controls: There are no products registered for control of pythium in the production phase of the crop.

Issues for pythium root rot

1. Research is needed to develop strategies (other than fungicides) for pythium control in hydroponic growing systems, including disease suppressing microorganisms, surfactants, hydrogen ion concentration (pH), etc.

Botrytis grey mould *(Botrytis cinerea)*

Pest Information

Damage: Grey mould is the most common disease of greenhouse lettuce. It is characterized by basal stem rot and grey-green, shrivelled leaves.

Life Cycle: Powdery, grey, spore masses produced by the causal agent under humid conditions, are the main source of new infections. *Botrytis cinerea* may infect lettuce by entering at the stem of a lettuce plant or at the base of leaves. Botrytis overwinters in soil, on perennial plants, and on plant debris as black sclerotia.

Pest Management

Cultural Controls: Avoiding injury of plants will reduce infections, as wounds provide an entry route for this disease. Sources for disease spread can be reduced by good sanitation practices when handling plants and the frequent removal of crop residue from the greenhouse. Controlling ventilation and night temperatures to prevent condensation on the leaves will reduce disease development. Nitrogen levels should be monitored to prevent lush growth that is more susceptible to the disease.

Resistant Cultivars: None available.

Chemical Controls: Registered fungicides are listed in table 6. Fungicides are applied before the onset of disease when cool and moist conditions prevail.

Issues for botrytis grey mould

1. There is a concern that resistance to iprodione may be developing in the pathogen population.

Downy mildew (*Bremia lactucae*)

Pest Information

Damage: This disease is more severe on greenhouse lettuce than field lettuce. Symptoms include yellow patches on leaves, which shrivel up and turn brown.

Life Cycle: Spores (sporangia) of downy mildew are produce d on the underside of infected leaves. Spores spread on air currents, in water and by handling. The optimum temperature for infection and disease development is 15-20ºC but these can occur at lower temperatures. The disease does not develop when the temperature is over 25ºC.

Pest Management

Cultural Controls: The prevention of dew formation on the leaves by controlling the night temperature and ensuring adequate ventilation will reduce the occurrence of this disease as will maintaining reduced humidity. New crops should not be planted near older ones and old crop debris should be removed from the greenhouse.

Resistant Cultivars: Some resistant cultivars may be available; these should be evaluated on a local basis to determine suitability.

Chemical Controls: Fungicides registered for the control of downy mildew are listed in table 6.

Issues for downy mildew

1. There is a need to develop downy mildew resistant cultivars suitable for greenhouse production.

Powdery mildew *(Erysiphe cichoracearum)*

Pest information

Damage: Round, white spots on the upper surface of older leaves are initial symptoms of this disease. These spots enlarge and cover the entire surface of the leaf, occasionally spreading to leaf petioles and stems as well. This disease has appeared in some greenhouses and is expected to be an increasing problem.

Life Cycle: Conidia are produced on the leaf surface of infected plants and are dispersed by air currents. The main survival stages of powdery mildew are the cleistothecia and thick-walled mycelium, which survive in dry crop residue and cause new infections in successive crops.

Pest Management

Cultural Controls: Maintaining a low, uniform relative humidity (70-80%), and prompt removal of infected leaves can help to prevent infection. Disinfection of the greenhouse between crops is also helpful in reducing the incidence of powdery mildew. Spraying the plants every 2-3 days with water may reduce spore buildup, but may also predispose plants to botrytis grey mould, downy mildew and other diseases.

Resistant Cultivars: None available.

Chemical Controls: Fungicides registered for powdery mildew control are listed in table 6.

Issues for powdery mildew

1. The registration of new ways to apply fungicides is needed (eg. sulfur burner).

Drop (white mould) *(Sclerotinia minor, S. sclerotiorum)*

Pest Information

Damage: This fungus rots the base of the stem and crown, resulting in collapse of the plant.

Life Cycle: The disease typically occurs when temperatures are above 22ºC and humidity is high. Tough, overwintering sclerotia develop on decaying plant tissue and produce spores in the spring for new infections.

Pest Management

Cultural Controls: The removal and destruction of all infected plants and trimmings and other sanitation practices, will help minimize this disease.

Resistant Cultivars: None available.

Chemical Controls: Fungicides registered for the control of sclerotinia drop are listed in table 6.

Issues for drop (Sclerotinia white mould)

None identified.

Bottom rot (*Rhizoctonia solani*)

Pest Information

Damage: Symptoms typically appear when head lettuce is reaching maturity. Rust-coloured, sunken lesions develop in the midrib of lower leaves and, if conditions are damp, these lesions expand over the entire midrib and cause the leaf blade to collapse. Under favorable conditions, this disease will rot the leaves one by one as it moves inward and upward.

Life Cycle: This fungal disease is less common in hydroponic crops. The disease can be spread by contaminated soil, tools, and equipment. Peat and loam potting mixes as well as contaminated planting trays may provide a source of inoculum.

Pest Management

Cultural Controls: The raising of seedling flats on benches, out of the range of splashing water or soil and other sanitation practices will help reduce disease development. Alternative controls include the application of registered disinfectants to greenhouse structures after cleaning between crops.

Resistant Cultivars: None available.

Chemical Controls: None available.

Issues for bottom rot

1. The registration of fungicides for the control of bottom rot is needed as there are no fungicides registered for the control of this disease.

Lettuce mosaic (Lettuce mosaic virus (LMV))

Pest information

Damage: Lettuce mosaic is the most important viral disease of greenhouse lettuce. This virus can have a significant impact on both plant size and quality.

Life Cycle: Lettuce mosaic virus is vectored by aphids.

Pest Management

Cultural Controls: Indexed seed that is free of mosaic virus should be used. Blocks of lettuce should be isolated to minimize the spread of the virus from crop to crop. Diseased plants should be removed and destroyed and aphid populations destroyed. A number of alternative controls are available for aphids. *Resistant Cultivars:* None available.

Chemical Controls: None available.

Issues for Lettuce mosaic

1. There is a need for the registration of new insecticides for the control of aphids to reduce the incidence of lettuce mosaic virus.

Insects and Mites

Key Issues

- There is a need to develop effective, non-chemical options, including the use of biological control agents for aphids, fungus gnats and shore flies.
- There are very few registered pesticides effective against aphids, cabbage looper, fungus gnats, shore flies, whiteflies, thrips and mites.
- The registration of new, reduced-risk, products, available in the U.S. and Europe, is needed to replace organophosphates and reduce the risk of resistance to tebufenozide (cabbage looper).
- The two spotted spider mite has developed resistance to many miticides in other crops.

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

Pest	Ontario	Quebec
Aphids (general)		
Green peach aphid		
Lettuce aphid		
Leafminers		
Caterpillars (various species)		
Cabbage looper		
Fungus gnats and shore flies		
Whiteflies (general)		
Sweet potato whitefly		
Onion thrips		
Poinsettia/impatiens thrips		
Western flower thrips		
Two-spotted spider mite		
Slugs and snails		

Widespread yearly occurrence with high pest pressure.

Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.

Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pressure.

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.

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

Pest not present.

Data not reported.

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

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

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

Practice / Pest		Aphids	Leafminers	Caterpillars (various species)	Fungus gnats and shore flies	Whiteflies
Avoidance	crop rotation					
	optimizing fertilization					
	reducing mechanical damage					
	trap crops					
	insect barriers at openings					
Prevention	equipment sanitation					
	end of season crop residue removal and clean-up					
	pruning out / removal of infested material					
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					

Practice / Pest		Aphids	Leafminers	Caterpillars (various species)	Fungus gnats and shore flies	Whiteflies
Suppression	biopesticides					
	arthropod biological control agents					
	use of banker plants as reservoirs or refuges for beneficial insects					
	trapping					
	pesticide rotation for resistance management					
	spot application of pesticides					
	use of pesticides which are compatible with beneficials					
	novel pesticide application techniques (eg. use of pollinating insects to carry bio-pesticides)					
	follow sanitation practices					

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

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

This practice is not applicable for this pest

Information regarding the practice for this pest is unknown.

[1]Source: Greenhouse lettuce stakeholders in reporting provinces (Ontario and Quebec).

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

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

Whiteflies	*Delphastus pusillus*	predatory lady beetle
	Dicyphus hesperus	predatory bug
	Encarsia formosa	parasitic wasp
	Lacewings	predator
	Orius spp.	predatory bug

[1]References:

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

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

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

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

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

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

Active Ingredient[1,2]	Classification[3]	Mode of Action[3]	Resistance Group[3]	Re-evaluation Status[4]	Targeted Pests[1,5]
Bacillus thuringiensis subsp. *Israelensis*	Bacillus thuringiensis or Bacillus sphaericus and the insecticidal proteins they produce	Microbial disruptors of insect midgut membranes	11A	R	fungus gnats
Bacillus thuringiensis subsp. *kurstaki*	Bacillus thuringiensis or Bacillus sphaericus and the insecticidal proteins they produce	Microbial disruptors of insect midgut membranes	11A	R	cabbage looper, tomato hornworm
Beauveria bassiana	Biological	unknown	N/A	R	aphids, thrips, whitefly
cyromazine	Cyromazine	Moulting disruptor, Dipteran	17	R	fungus gnats (Bradysia spp.)
endosulfan	Cychlorcyclodiene	Antogonistes du canal chlorure activé par un acide gamma-N-aminobutyrique (GABA)	2A	DI (registration expires Dec. 31, 2016)	green peach aphid
imidacloprid (transplant tray plug drench)	Neonicotinoid	Nicotinic acetylcholine receptor (nAChR) agonists	4A	R	aphids (including green peach aphid, lettuce aphid and melon aphid), whiteflies
lambda-cyhalothrin	Pyrethroid, Pyrethrin	Sodium channel modulators	3A	RE	cabbage looper
malathion	Organophosphate	Acetylcholinesterase inhibitors	1B	RE	aphids, armyworm, greenhouse whitefly, Mexican bean beetle, spider mites, thrips

Active Ingredient[1,2]	Classification[3]	Mode of Action[3]	Resistance Group[3]	Re-evaluation Status[4]	Targeted Pests[1,5]
nicotine	Nicotine	Nicotinic acetylcholine receptor (nAChR) agonists	4B	DI (last date of use Dec. 31, 2012)	aphids, thrips
potassium salts of fatty acids					aphids, mites, whitefly
spinosad	Spinosyn	Nicotinic acetylcholine receptor (nAChR) allosteric activators	5	R	cabbage looper
spirotetramat	Tetronic and Tetramic acid derivatives	Inhibitors of acetyl CoA carboxylase.	23	R	aphids
tebufenozide	Diacylhydrazine	Ecdysone receptor agonists	18	R	cabbage looper

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

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

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

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

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

Aphids: Lettuce aphid *(Nasonovia ribisnigri)* and green peach aphid *(Myzus persicae)*

Pest Information

Damage: Most damage is caused by the lettuce aphid, but other aphids can affect lettuce also. Severely-infested plants may be stunted, have discoloured foliage or curled leaves and buds may be damaged or malformed. Plants may also become covered in aphid secretions (honeydew), shed aphid skins and black, sooty mould, which often grows on the honeydew. Aphids can also transmit lettuce mosaic virus (LMV). Even in small numbers, the presence of aphids may make the crop unmarketable. Because aphid populations can grow very quickly, failure to control populations at first appearance may result in severe yield reduction or even total crop loss.

Life Cycle: Aphids overwinter as eggs on alternative hosts, usually outdoors on a variety of weed or garden plants. In the spring, winged aphids enter greenhouses where they start new colonies on lettuce. Several winged and wingless generations occur each summer. In the fall, winged aphids return to their alternative hosts outdoors, mate and lay eggs.

Pest Management

Cultural Controls: Screening of greenhouse vents and maintenance of a weed and garden-free area around the greenhouse can help to control aphids. Close monitoring should be conducted in the spring for the appearance of first aphids on the crop.

Biological controls: Several predatory mites (*Amblyseius* spp. and *Phytoseiulus* spp.) and parasitic wasps, as well as lady beetles, are available commercially for biological control of aphids in greenhouse vegetable production. These provide suppression of the aphid population, but do not provide a commercially acceptable level of control on greenhouse lettuce. The microbial insecticide, *Beauvaria bassiana*, is also registered for aphid control.

Resistant Cultivars: None available.

Chemical Controls: Insecticides registered for the control of aphids on lettuce are listed in table 10.

Issues for aphids

1. There are very few (if any) registered pesticides effective against aphids.
2. There is a need to develop effective, non-chemical options for aphids including the use of biological control agents.

Cabbage looper (*Trichopulsia ni*)

Pest Information

Damage: An important pest of cruciferous crops in some regions, the cabbage looper can also be a problem on greenhouse lettuce. The larval stage can cause significant damage through feeding on leaf tissue during its development. Larval damage to leaves makes the crop unmarketable and may also provide entry for secondary disease organisms.

Life Cycle: The cabbage looper does not typically over-winter in Canada, usually moving north as an adult moth from the south in July and August. However it has been known to overwinter in greenhouses. One generation per season is typical, but in greenhouses under

warmer temperatures, as many as three generations are possible. Eggs are laid near the edge or underside of a leaf and larvae hatch in 3-4 days. Five instars follow over the next 2-3 weeks. Pupae encase themselves in a loose cocoon for about two weeks, after which a mature moth emerges.

Pest Management

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

Biological controls: The bacterial insecticide *Bacillus thuringiensis* var. *kurstaki* (Btk) is registered for the management of cabbage looper.

Resistant Cultivars: None available.

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

Issues for cabbage looper

1. The registration of new, reduced-risk products available in the U.S. and Europe is needed to replace organophosphates and reduce the risk of resistance to tebufenozide.
2. There is a general lack of effective control products.

Fungus gnats (*Bradysia* spp. *Corynoptera* spp.)

Pest Information

Damage: Although adults are occasionally a nuisance to workers through sheer numbers, larvae are the most damaging stage and feed on roots and root hairs. Growth reduction may occur but plants are rarely killed by these insects. In addition, fungus gnats can carry and facilitate the introduction of soil-borne diseases such as pythium root rot.

Life Cycle: Mature females lay eggs in moist soils, potting mix and hydroponic media. Two to four days later, the eggs hatch and the resulting larvae feed on roots, root hairs and mycelium. Pupation occurs 14-16 days later, and adults emerge about 3-5 days later.

Pest Management

Cultural Controls: Good sanitation, including the removal of waste material, is used to minimize fungus gnats. Vents are screened and doorways and other openings to the greenhouse are closed to minimize entry by adult gnats.

Biological controls: Only Vectobac (*Bacillus thuringiensis* var. *israelensis*) is specifically labelled for the control of fungus gnats in greenhouse vegetable crops. Fungus gnat larvae may be suppressed by predatory nematodes (*Heterorhabditus* spp., *Steinernema feltiae*) or a predatory mite (*Hypoaspis miles*) but predators alone do not provide commercially acceptable control in greenhouse lettuce.

Resistant Cultivars: None available.

Chemical Controls: Insecticides registered for the control of fungus gnats are listed in table 10. A spray or drench application of insecticides to control other pests may also control fungus gnat larvae and adults.

Issues for fungus gnats

1. There are very few (if any) registered pesticides that are effective against these insects.

There is a need to develop effective, non-chemical options for fungus gnats, including the use of biological control agents.

Shore flies (Ephydridae)

Pest Information

Damage: Although shore flies do not feed directly on lettuce, they are widespread and can be a nuisance to workers and may contaminate lettuce at harvest. Shore flies can also spread fungal diseases.

Life Cycle: The life cycle is similar to that of fungus gnats, (above), although shore flies prefer wetter environments. The larvae feed on algae.

Pest Management

Cultural Controls: The entry of adult shore flies can be minimized by screening vents and keeping doorways and other openings to the greenhouse closed. Minimizing open standing water and algal growth will also reduce shore fly numbers.

Resistant Cultivars: None available.

Chemical Controls: None available. Insecticides applied for fungus gnats will generally control shore flies also.

Issues for shore flies

1. There is a need to develop effective, non-chemical options for shore flies, including the use of biological control agents.

Thrips: Onion thrips (*Thrips tabaci*), western flower thrips (*Frankliniella occidentalis)* and poinsettia thrips *(Echinothrips americanus)*

Pest Information

Damage: Thrips are rasping feeders. Feeding on leaves causes white, bleached to brown flecks or streaks on leaves. Thrips may also feed in growing buds causing distorted leaves and buds. Plant growth may be reduced by severe infestations.

Life Cycle: Thrips lay eggs inside leaf and bud tissue. Pupation occurs in soil or potting media. Outdoors, thrips often move on wind currents, but inside greenhouses they can spread rapidly by flying.

Pest Management

Cultural Controls: Vents are screened and doorways kept closed, to minimize entry of thrips. A 3-metre-wide weed-free zone, around the perimeter of the greenhouse, is maintained to reduce the risk of thrips entry.

Biological controls: Several biological predators will help to control thrips, if released early, before populations build up. These include the predatory mites *Amblyseius cucumeris*, other *Amblyseius spp.* and *Hypoaspis miles* and predatory bugs, such as the minute pirate bug, *Orius* sp. or other species such as *Deraeocoris brevis*. The microbial insecticide, *Beauvaria bassian*a is also registered for thrips control.

Resistant Cultivars: None available.

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

Issues for thrips

1. There is concern of the lack of effective control products; control with malathion is poor, and biologicals provide population suppression only.

Two-spotted spider mite *(Tetranychus urticae)*

Pest Information

Damage: Outbreaks of the two-spotted spider mite can result in moderate to severe losses and under some circumstances can result in total loss of a crop. Symptoms of mite feeding on the plant include small, yellow or white, speckled lesions and if severe, leaf death and yield reduction occurs. Fine webbing may be present on the underside of the leaf and a silver sheen on damaged surfaces may also occur.

Life Cycle: The two-spotted spider mite occurs across southern Canada and has a broad host range. Adult females lay approximately 100 eggs on the lower leaf surface (5-8 eggs per day). The life cycle may be completed in as little as 3.5 days at 32ºC, but typically takes two weeks to complete. The two-spotted spider mite spreads by hanging from the plant by silken strands, which easily attach to people and equipment. The female overwinters in dark crevices in the greenhouse.

Pest Management

Cultural Controls: Spider mite infestations are monitored by examination of the leaves. Sanitation is very important to control this pest. A three metre wide weed-free zone is maintained around the perimeter of the greenhouse to reduce the risk of mite invasion. Movement of workers, equipment and plants from infested to non-infested areas is restricted. If the mite becomes a problem at the end of the growing season, the infested crop may be treated with a miticide, then removed and destroyed.

Biological controls: The predatory mite *Phytoseiulus persimilis* is widely used across Canada and is effective in suppressing two-spotted spider mite. To be successful, *P. persimilis* must be introduced when the two-spotted spider mite population is low. Other predatory mite species and predatory beetles may be used also.

Resistant Cultivars: None available.

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

Issues for two-spotted spider mite

1. The two-spotted spider mite has developed resistance to many miticides in other crops.
2. There is a lack of registered, effective control products for mites.

Whiteflies: Sweet potato whitefly (*Bemisia tabaci*)

Pest Information

Damage: Adults suck sap from the plant, thereby reducing plant vigour and excrete honeydew. The honeydew provides a food source for secondary fungi, and feeding injury also provides an entry point for secondary fungal moulds. The sweet potato whitefly transmits some plant viruses.

Life Cycle: The adult whitefly lays eggs on the underside of leaves. Eggs hatch within 10-14 days and the nymphs go through three moults in about 14 days. They then pupate and the adult emerges about 6 days later. Adults live for 30-40 days and can lay eggs as early as 4 days after emergence.

Pest Management

Cultural Controls: The entry of adult whiteflies can be minimized by screening off vents and keeping doorways and other openings to the greenhouse closed. Yellow sticky traps, distributed at a rate of 1-2 traps per 2-5 plants, can be used to monitor for whiteflies and may also be used to reduce the adult population.

Biological controls: A parasitic wasp, *Encarsia formosa* is often released as a biocontrol agent. *Eretmocerus* spp. and the minute pirate bug, *Orius* sp., are also used. These will suppress the greenhouse whitefly but may be less effective on the sweet potato whitefly. The eggs of greenhouse whitefly are also preyed upon by a lady beetle, *Delphastus pusillus,* and many general predators, such as lacewing larvae and predatory bugs. The microbial insecticide, *Beauvaria bassiana,* is also registered for whitefly control.

Resistant Cultivars: None available.

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

Issues for whitefly

1. Since alternative controls provide suppression only, the registration of new, reduced-risk insecticides is needed.

Slugs and snails

Pest Information

Damage: Slugs and snails feed on leaf and stem tissue of a wide range of plants and leave a silvery slime trail. On leaves, tissue is generally removed between the veins and leaf skeletonization can be extensive. Slugs and snails are rarely a pest of greenhouse lettuce.

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

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

Resistant Cultivars: None available.

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

Issues for slugs and snails

None identified.

Weeds

A three metre wide vegetation-free zone should be maintained around the outdoor perimeter of the greenhouse by the use of general, broad-spectrum herbicides such as glyphosate (Round-up).

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. All of these rodents are attracted to sources of food, water and shelter for nesting, for example areas where garbage containers, cull piles, piles of sawdust, old planting media, building debris, burlap or styrofoam are left outdoors, or where bags of seed or slug bait are stored.

Pest Management

Cultural Controls: 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 will reduce rodent problems in the greenhouse. Sheet-metal plates at the base of wooden doors will prevent rodents from chewing through. Cleaning up debris and cull piles around the greenhouse and storage buildings will eliminate feeding and nesting sites. Feed and seed, including slug bait should be stored in metal, rodent-proof containers. All garbage containers must have tight-fitting lids. Various trapping methods exist but are not consistently effective.

Resistant Cultivars: None available.

Chemical Controls: Poison bait stations containing chlorophacinone or zinc phosphide baits can be used for field mice. These products, plus brodifacoum or warfarin can be used for both house mice and rats. Bait stations are placed in areas where rodents or their signs (droppings, chewing, burrows, or sounds) have been observed. Bait stations should be covered and secure from access by dogs and cats, birds or children.

Issues for Rodents

None identified.

Resources

IPM/ICM resources for production of greenhouse lettuce in Canada

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

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

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

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

Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Quebec (MAPAQ) www.mapaq.gouv.qc.ca

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

Ontario Ministry of Agriculture Food and Rural Affairs. Publication 835 Growing Greenhouse Vegetables in Ontario www.omafra.gov.on.ca/english/crops/hort/greenhouse.html

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

Provincial Greenhouse Crop Specialists and Provincial Minor Use Coordinators

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

National and Provincial Greenhouse Grower Organizations

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

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

Greenhouse Nova Scotia; http://greenhousenovascotia.com/

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

Ontario Greenhouse Vegetable Growers; www.ontariogreenhouse.com/

Ontario Greenhouse Marketers Association; www.ontariogma.com/

Saskatchewan Greenhouse Growers Association www.saskgreenhouses.com

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

National:

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

Appendix 1

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

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

<table>
<tr><th>Presence</th><th colspan="4">Occurrence information</th><th>Colour Code</th></tr>
<tr><td rowspan="12">Present</td><td rowspan="9">Data available</td><td>Frequency</td><td>Distribution</td><td>Pressure</td><td></td></tr>
<tr><td rowspan="4">**Yearly** - Pest is present 2 or more years out of 3 in a given region of the province.</td><td rowspan="3">**Widespread** - The pest population is generally distributed throughout crop growing regions of the province. In a given year, outbreaks may occur in any region.</td><td>**High** - If present, potential for spread and crop loss is high and controls must be implemented even for small populations</td><td>Red</td></tr>
<tr><td>**Moderate** - If present, potential for spread and crop loss is moderate: pest situation must be monitored and controls may be implemented.</td><td>Orange</td></tr>
<tr><td>**Low** - If present, the pest causes low or negligible crop damage and controls need not be implemented</td><td>Yellow</td></tr>
<tr><td rowspan="3">**Localized** - The pest is established as localized populations and is found only in scattered or limited areas of the province.</td><td>**High** - see above</td><td>Orange</td></tr>
<tr><td>**Moderate** - see above</td><td>White</td></tr>
<tr><td>**Low** - see above</td><td>White</td></tr>
<tr><td rowspan="6">**Sporadic** - Pest is present 1 year out of 3 in a given region of the province.</td><td rowspan="3">**Widespread** - as above</td><td>**High** - see above</td><td>Orange</td></tr>
<tr><td>**Moderate** - see above</td><td>Yellow</td></tr>
<tr><td>**Low** - see above</td><td>White</td></tr>
<tr><td rowspan="3">**Localized** - as above</td><td>**High** - see above</td><td>Yellow</td></tr>
<tr><td>**Moderate** -see above</td><td>White</td></tr>
<tr><td>**Low** - see above</td><td>White</td></tr>
<tr><td rowspan="2">Data **not** available</td><td colspan="3">**Not of concern:** The pest is present in commercial crop growing areas of the province but is causing no significant damage. Little is known about its population distribution and frequency in this province; however, it is not of concern.</td><td>White</td></tr>
<tr><td colspan="3">**Is of concern:** The pest is present in commercial crop growing areas of the province. Little is known about its population distribution and frequency of outbreaks in this province and due to its potential to cause economic damage, is of concern.</td><td></td></tr>
<tr><td>Not present</td><td colspan="4">The pest is not present in commercial crop growing areas of the province, to the best of your knowledge.</td><td>black</td></tr>
<tr><td>Data not reported</td><td colspan="4">Information on the pest in this province is unknown. No data is being reported for this pest.</td><td>grey</td></tr>
</table>

References

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

Growing Greenhouse Vegetables. Publication 371, Ontario Ministry of Agriculture, Food and Rural Affairs. Publication 836 Crop Protection Guide for Greenhouse Vegetables 2012-13. www.omafra.gov.on.ca/english/crops/hort/greenhouse.html