Agriculture and Agri-Food Canada
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Crop Profile for Greenhouse Lettuce in Canada, 2014

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Canada

First Edition –2006
Crop Profile for Greenhouse Lettuce in Canada
Catalogue No.: A118-10/19-2006E-PDF

Second Edition – 2013
Crop Profile for Greenhouse Lettuce in Canada, 2011
Catalogue No.: A118-10/19-2013E-PDF
ISBN: 978-1-100-22014-7
AAFC No.: 11997E

Third Edition - 2016
Crop Profile for Greenhouse Lettuce in Canada, 2014
Catalogue No.: A118-10/19-2014E-PDF
ISBN: 978-0-660-05464-3
AAFC No.: 12503E

Electronic version available at www.agr.gc.ca/pmc-cropprofiles

Paru également en français sous le titre: « Profil de la culture de la laitue de serre au 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. 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.

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

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Lettuce (*Lactuca sativa*), is a member of the Asteraceae. Lettuce was cultivated as early as 4500 BC in the Mediterranean region 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. General production information

Canadian production (2014)[1,3]	103,610 tonnes 19.9 hectares
Farm gate value (2014)[1]	$ 31.7 million
Food available in Canada (fresh) (2014)[2]	9.14 kg/person (fresh)
Exports (2014)[3]	38,030 tonnes
Imports (2014)[3]	283,770 tonnes

[1]Source: Statistics Canada. Table 001-0006 - Production and value of greenhouse vegetables, annual CANSIM (database) (www.statcan.gc.ca) (accessed 2016-02-22).
[2]Source: Statistics Canada. Table 02-0011- Food available in Canada, annual, CANSIM (database) (accessed 2016-02-22).
[3]Source: Statistics Canada. Table 02-0010- Supply and disposition of food in Canada, annual, CANSIM (database) (accessed 2016-02-22).

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. Quebec is the leading producer of greenhouse lettuce, growing 14.37 hectares or 72% of the national acreage, followed by British Columbia with 2.07 hectares or 10% of the national hectares.

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

Production Regions	Area harvested (hectares)	Percent national production
British Columbia	2.07	10%
Alberta	0.46	5%
Saskatchewan	.06 E	0.3%
Manitoba	x	x
Ontario	F	F
Quebec	14.37	72%
New Brunswick	x	x
Nova Scotia	0.15	1%
Prince Edward Island	x	x
Newfoundland and Labrador	x	x
Canada	19.9	100%

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

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

F Too unreliable to be published.

E Use with caution.

Cultural Practices

A two-stage production system is used in the growing of greenhouse lettuce: plant raising (production of seedlings) and crop 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 in 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. Seedlings grown in peat-perlite are transplanted to rockwool mini-blocks or foam media when the first true leaves appear (seven to ten 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 (three to four leaf stage) are placed in permanent NFT troughs. Depending on the variety, six to seven weeks or ten to twelve weeks are required from seeding to harvest for summer and winter crops, respectively. Generally, there are eight to ten production cycles per year.

There are many different NFT trough systems. All consist of a support or cover which holds the transplant in place, with the plant roots suspended in a trough through which the nutrient solution flows. An alternative system is the 'Floating Culture' system, 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.

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 to18^{o}C and a day temperature ranging from 18 to19^{o}C on cloudy days, to 19 to 22^{o}C on sunny days.

To optimize plant growth rate, supplemental, artificial lighting in the form of 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 during cloudy periods and winter months.

Humidity is also closely monitored and controlled for greenhouse lettuce crops. A relative humidity (RH) of 75to 85% is generally targeted during production. The RH in storage should be 80 to 90%. For optimal growth and development, the levels of CO_2 are also monitored to maintain a concentration of 1000 ppm.

The concentration of nutrient salts (EC) (electrical conductivity) and the pH of the nutrient solution are tested and monitored regularly as these have a significant impact on the growth of greenhouse lettuce. 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.

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.

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

Time of Year	Activity	Action
Seeding and Transplant Production	Plant Care	Proper temperature, humidity and moisture for seed germination are maintained.
	Media Care	Good sanitation practices are followed; seedling medium and trays must be clean.
	Disease Management	Fungicides are applied to seedlings to prevent damping off and seedling rot.
	Insect Management	Conditions that favor fungus gnats and shore flies are corrected.
Crop Production	Plant Care	Appropriate temperature, light, RH and CO_2 levels are maintained to prevent diseases and tip-burn.
	Media Care	Media pH and nutrient content are monitored; good aeration of nutrient solution is maintained.
	Disease Management	Drenches with protectant fungicide for root and stem rot are applied after transplanting. Monitoring is conducted for botrytis, powdery mildew and downy mildew and registered fungicides are applied if necessary. Good aeration of re-circulating water is maintained to reduce pythium root rot. Correct temperature and humidity are maintained to minimize condensation on crop.
	Insect Management	The presence of aphids, cabbage loopers and whiteflies is monitored and insecticides applied as needed. A weed-free zone is maintained around the greenhouse. Cracks are sealed, doors kept closed and vents are screened to prevent insect entry into the greenhouse.
Harvest and Post-Harvest	Plant Care	Plants are harvested promptly and proper storage conditions maintained to ensure crop quality.
	Media Care	Reservoir tanks, lines, etc. are cleaned of algae and build-up between crops.
	Disease Management	The greenhouse is cleaned, sanitized and disinfected between crops. Plant debris is removed promptly and destroyed.
	Insect Management	The greenhouse is cleaned, sanitized and disinfected g between crops. Plant debris is removed promptly and destroyed.

Abiotic Factors Limiting Production

Temperature

Temperature is an important factor at all stages of lettuce growth. Too high a temperature will prevent seed germination and, in the production stage, will reduce leaf and head quality. Too high storage temperatures promote further leaf development, resulting in a less appealing product. Sudden changes in temperature can favour disease development by causing condensation on leaves or increase the incidence of tip burn. Lettuce is highly sensitive to freezing, which damages the leaves.

Humidity

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 reduce transpiration resulting in decreased nutrient transport.

Tip-burn and glassiness

Tip-burn of young, inner leaves of lettuce is caused by a calcium deficiency and is characterized by browning of the edges and tips of the 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 enable sufficient translocation of 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 and reduce the incidence of tip-burn of inner leaves, as will limiting growth by reducing the application of nitrogen, harvesting the lettuce slightly before maturity and maintaining proper humidity. Tip-burn of older, outer leaves can develop as a result of insufficient water, high salts, or excessive transpiration due to low humidity.

Glassiness results from excess water uptake by the roots, followed by inadequate water loss from the leaves. 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. Symptoms include tan to brown spots along leaf veins; numerous or large spots make the product unmarketable.

Premature leaf yellowing

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

Diseases

Key issues

- Non chemical control strategies, including the use of disease suppressing microorganisms, surfactants and pH adjustment, are required for pythium control in hydroponic growing systems.
- There is a need for the registration of new chemicals, including those for which application methods differ from traditional sprays (eg. sulfur burners), for the management of powdery mildew.

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

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

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

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

Practice / Pest		Damping off and root rot	Downy mildew	Grey mould	Powdery mildew
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 lettuce production in Canada[1] (continued)

Practice / Pest		Damping off and root rot	Downy mildew	Grey mould	Powdery mildew
Suppression	Biopesticides				
	Pesticide rotation for resistance management				
	Spot application of pesticides				
	Use of pesticides which are compatible with beneficials				
	Novel pesticide application techniques				
	Follow sanitation practices				
This practice is used to manage this pest by growers in at least one reporting province.					
This practice is not used to manage this pest in reporting provinces.					
This practice is not applicable for this pest					
Information regarding the practice for this pest is unknown.					

[1]Source: Stakeholders in provinces producing greenhouse lettuce (Ontario and Quebec).

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

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Bacillus amyloliquefaciens strain D747	microbial: *Bacillus* spp. and the fungicidal lipopeptides they produce	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	44	R	downy mildew, lettuce drop
Bacillus subtilis strain QST 713	microbial: *Bacillus* spp. and the fungicidal lipopeptides they produce	F3: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	44	R	sclerotinia rot, grey mould, powdery mildew, downy mildew
Bacillus subtilis var. *amyloliquefaciens* strain FZB24	microbial: *Bacillus* spp. and the fungicidal lipopeptides they produce	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	44	R	bottom rot
boscalid + pyraclostrobin	pyridine-carboxamide + methoxy-carbamate	C2: respiration + C3: respiration	complex II: succinate-dehydrogenase + complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	7 + 11	R + R	powdery mildew (suppression)
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

…. continued

Table 6. Fungicides and bio-fungicides registered for disease management in greenhouse lettuce 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]
fenhexamid	hydroxyanilide	G3: sterol biosynthsis in membranes	3-keto reductase, C4-demethylation (erg27)	17	RE	grey mould
ferbam	dithiocarbamate and relatives	multi-site contact activity	multi-site contact activity	M3	RE	grey mould
fosetyl-Al (in B.C.)	ethyl phosphonate	unknown mode of action	unknown	33	RE	downy mildew
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	blue mould, downy mildew
phosphorous acid (mono and di-potassium salts of phosphorous acid	phosphonate	unknown	unknown	33	R	downy mildew (suppression)

…. continued

Table 6. Fungicides and bio-fungicides registered for disease management in greenhouse lettuce 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]
Streptomyces griseoviridis strain WYEC 108	biological	unknown	unknown	N/A	R	suppression of seed rot, damping-off and root rot caused by pythium
Trichoderma harzanium Rifai strain KRL-AG2	biological	unknown	unknown	N/A	RE	botrytis blight (suppression)
Trichoderma harzianum Rifai strain T-22	biological	unknown	unknown	N/A	RE	damping-off (*Rhizoctonia solani*) (suppression)

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

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

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

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

Pest Information

Damage: Pythium spp. are soil and water-borne pathogens that attack the roots of lettuce, often killing 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. Infected plants develop brown, soft roots and may wilt, although in some cases obvious signs of disease may not be visible, for instance when the pathogen is affecting only the tiny feeder roots.

Life Cycle: The disease can spread rapidly through the nutrient solution. The fungus produces bodies called sporangia that release zoospores (motile spores) that infect root tips and wounds. Pythium can be spread by fungus gnats and shore flies.

Pest Management

Cultural Controls: Sowing seeds in sterile propagation media and taking care to minimize overcrowding and overwatering of seedlings can reduce the likelihood of disease development. The maintenance of good aeration of the re-circulating solution helps to minimize pythium pressure.

Resistant Cultivars: None available.

Chemical Controls: Fungicides and biofungicides registered for the control of pythium diseases are listed in *Table 6. Fungicides and bio-fungicides registered for disease management in greenhouse lettuce in Canada*.

Issues for pythium root rot

1. Non-chemical management strategies are required for pythium control in hydroponic growing systems, including the use of disease suppressing microorganisms, surfactants and pH control.
2. The registration of new fungicides is required for the management of pythium diseases in greenhouse lettuce.

Botrytis grey mould *(Botrytis cinerea)*

Pest Information

Damage: Grey mould of greenhouse lettuce 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. *B. cinerea* may infect the stems or the base of leaves of lettuce plants. Botrytis overwinters as black sclerotia (resting bodies) in soil, on perennial plants and on plant debris.

Pest Management

Cultural Controls: Avoiding injury of plants will reduce infections, as wounds provide entry sites for this disease. Sources for disease spread can be reduced by good sanitation practices when handling plants and by the frequent removal of crop residue from the greenhouse. Controlling ventilation and night temperatures to prevent condensation on the leaves will reduce disease development. Monitoring nitrogen levels to prevent lush growth more susceptible to the disease is also helpful in the management of grey mould.

Resistant Cultivars: None available.

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

Issues for botrytis grey mould

1. There is a concern that resistance to currently registered fungicides such as iprodione may be developing in the pathogen population, and that the effectiveness of these fungicides is decreasing.

Downy mildew (*Bremia lactucae*)

Pest Information

Damage: Symptoms of downy mildew include yellow patches on leaves, which shrivel up and turn brown.

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

Pest Management

Cultural Controls: Maintaining low humidity and preventing dew formation on the leaves by controlling the night temperature and ensuring adequate greenhouse ventilation will reduce the occurrence of this disease. Avoiding the planting of new lettuce crops near older ones and removing crop debris from the greenhouse will reduce the chances of infection.

Resistant Cultivars: None available.

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

Issues for downy mildew

1. There is a need for the development of lettuce cultivars resistant to downy mildew, suitable for greenhouse production.

Powdery mildew (*Erysiphe cichoracearum*)

Pest information

Damage: Round, white powdery spots that develop on the upper surface of older leaves are the first symptoms of this disease. These spots enlarge and can eventually cover the entire surface of the leaf, occasionally spreading to leaf petioles and stems as well.

Life Cycle: Conidia are produced on the leaf surface of infected plants and are dispersed by air currents to new plant tissues where they cause new infections. The fungus survives between crops as cleistothecia (spore producing structures) and thick-walled mycelium in dry crop residue.

Pest Management

Cultural Controls: Maintaining a low, uniform relative humidity (70 to 80%) and prompt removal of infected leaves can help to prevent spread of infection. Disinfection of the greenhouse between crops is also helpful in reducing the incidence of powdery mildew. Spraying the plants every two to three 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 and biofungicides registered for powdery mildew control are listed in *Table 6. Fungicides and bio-fungicides registered for disease management in greenhouse lettuce in Canada.*

Issues for powdery mildew

1. There is a need for the registration of new chemicals, including those for which application methods differ from traditional spraying (eg. sulfur burners), for the management of powdery mildew.

Bottom rot (*Rhizoctonia solani*)

Pest Information

Damage: Symptoms of bottom rot 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 to cover 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 on the plant.

Life Cycle: Rhizoctonia 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.

Insects and Mites

Key issues

- There is a need for the registration of reduced-risk control products for a number of insects in lettuce including aphids, thrips, greenhouse whitefly and fungus gnats.
- There is a need for the development of biological control options for pests including whitefly, fungus gnats, shore flies, thrips, and aphids.

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

Insect	Ontario	Quebec
Aphids		
Green peach aphid		
Lettuce aphid		
Caterpillars (various species)		
Cabbage looper		
Fungus gnats and shore flies		
Greenhouse whitefly		
Thrips		
Onion thrips		
Western flower thrips		
Two-spotted spider mite		

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 Ontario and Quebec.

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

Table 8. Adoption of insect and mite pest management practices in greenhouse lettuce production in Canada

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

…. continued

Table 8. Adoption of insect and mite pest management practices in greenhouse lettuce production in Canada (continued)

Practice / Pest		Aphids	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				
New Practices (by province)	Turn-off artificial lighting (Quebec)				
	Use of cultivars resistant to the aphid (*Nasonovia ribisnigri*) (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.					

[1]Source: Stakeholders in provinces producing greenhouse lettuce (Ontario and Quebec).

Table 9. Arthropod biological control agents available for the management of insect and mite pests in greenhouse vegetable crops in Canada[1]

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

…. continued

Table 9. Arthropod biological control agents available for the management of insect and mite pests in greenhouse vegetable crops in Canada[1] (continued)

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

[1]References:

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

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

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

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

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

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

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Bacillus thuringiensis ssp. *aizawai* strain ABTS-1857	*Bacillus thuringiensis* and the insecticidal proteins they produce	microbial disruptors of insect midgut membranes	11A	R	beet armyworm, cabbage looper, corn earworm, tomato looper
imidacloprid (in seedling blocks only)	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	RES*	green peach aphid, lettuce aphid, melon aphid, whiteflies
lambda-cyhalothrin	pyrethroid, pyrethrin	sodium channel modulator	3A	RE	cabbage looper
malathion	organophosphate	acetylcholinesterase (AChE) inhibitor	1B	R	aphids, armyworm, greenhouse whitefly, spider mites, thrips
spinetoram	spinosyn	nicotinic acetylcholine receptor (nAChR) allosteric modulator	5	R	cabbage looper

…. continued

Table 10. Pesticides and bio-pesticides registered for insect management in greenhouse lettuce 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
spirotetramat	tetronic and tetramic acid derivative	inhibitor of acetyl CoA carboxylase	23	R	aphids
tebufenozide	diacylhydrazine	ecdysone receptor agonist	18	RE	cabbage looper (early instars)

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

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

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

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

Pest Information

Damage: Plants severely infested with aphids may become stunted and develop discoloured foliage or curled leaves. The plants may also become covered in aphid secretions (honeydew), cast 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. As aphid populations can grow very quickly, failure to control populations at first appearance may result in severe damage to the crop or even total crop loss.

Life Cycle: Aphids overwinter as eggs on alternate 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 alternate 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 in the spring is important to detect the first aphids on the crop.

Biological controls: Arthropod biological control agents available for the management of aphids in greenhouse lettuce 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 and bioinsecticides registered for the control of aphids on lettuce are listed in *Table 10. Pesticides and bio-pesticides registered for insect management in greenhouse lettuce production in Canada.*

Issues for aphids

1. There is a need to develop effective, non-chemical options for aphids including additional biological control agents.
2. There is a need for the registration of reduced risk products for the control of aphids in lettuce.

Cabbage looper (*Trichoplusia 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 by feeding on leaf tissue during its development. Larval damage to leaves makes the crop unmarketable and may also provide entry sites for secondary disease organisms.

Life Cycle: The cabbage looper does not typically overwinter 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 outdoors, 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 three to four days. Larvae develop through five instars (stages) over the next two to three weeks and then pupate. The pupal stage lasts about two weeks, after which a mature moth emerges.

Pest Management

Cultural Controls: The screening of vents and keeping doors and other openings to the greenhouse closed, especially at night, will minimize the chances of entry by adult moths.

Biological controls: Arthropod biological control agents available for the management of cabbage loopers in greenhouse lettuce 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 and bioinsecticides registered for the control of cabbage looper are listed in *Table 10. Pesticides and bio-pesticides registered for insect management in greenhouse lettuce production in Canada.*

Issues for cabbage looper

1. The registration of new, reduced-risk products is needed for the control of cabbage looper in greenhouse lettuce.

Caterpillars (various species) (Order Lepidoptera)

Pest Information

Damage: Caterpillars chew holes in leaves of lettuce.

Life Cycle: Adult moths enter the greenhouse from outside and lay eggs on the leaves of lettuce. The eggs hatch and larvae feed and develop through a number of instars (stages) before pupating and eventually emerging as adults. Several generations may occur in the greenhouse compared with only one or two generations per year in the field.

Pest Management

Cultural Controls: The screening of vents and keeping doors and other openings to the greenhouse closed, especially at night, will minimize the chances of entry by adult moths.

Biological controls: Arthropod biological control agents available for the management of caterpillars in greenhouse lettuce 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 and bioinsecticides registered for the control of caterpillars are listed in *Table 10. Pesticides and bio-pesticides registered for insect management in greenhouse lettuce production in Canada.*

Issues for caterpillars

None identified.

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

Pest Information

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

Life Cycle: Thrips lay eggs inside leaf and bud tissue. Pupation occurs in soil or growing medium. Inside greenhouses thrips can spread rapidly by flying.

Pest Management

Cultural Controls: Screening vents and keeping doorways closed will minimize entry of thrips. A three metre wide, weed-free zone around the perimeter of the greenhouse will reduce the risk of thrips entry.

Biological controls: Arthropod biological control agents available for the management of thrips in greenhouse lettuce are listed in *Table 9. Arthropod biological control agents available for the management of insect and mite pests in greenhouse vegetable crops in Canada1*.

Resistant Cultivars: None available.

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

Issues for thrips

1. The registration of new products compatible with biological control agents is needed for thrips control
2. There is a need for the development of additional biological controls for thrips.

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

Pest Information

Damage: Adults of these insects are occasionally a nuisance to workers through sheer numbers. Larvae are found in growing media where they feed on decaying organic matter, fungi and algae. They may also feed on roots and root hairs of young seedlings, which can be damaged or stunted from root feeding. Feeding wounds provide entry points for fungal pathogens such as pythium, phytophthora, fusarium and rhizoctonia. Fungus gnats have also been shown to transmit pythium.

Life Cycle: Mature female fungus gnats lay eggs in moist soils, potting mixes and hydroponic media. The eggs hatch in two to four days. The larvae feed for about two weeks, before pupating and maturing to the adult form. The life cycle of shore flies is similar.

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 removing waste plant material and practicing good sanitation. Adult flies can be monitored with the use of yellow sticky traps.

Biological Controls: Arthropod biological control agents available for the management of fungus gnats in greenhouse lettuce are listed in *Table 9. Arthropod biological control agents available for the management of insect and mite pests in greenhouse vegetable crops in Canada1*.

Resistant Cultivars: None available.

Chemical Controls: None available.

Issues for fungus gnats and shore flies

1. The registration of reduced-risk products is required for the management of fungus gnats.
2. There is a need to develop effective, non-chemical control options, including biological controls, for fungus gnats and shore flies.

Two spotted spider mite *(Tetranychus urticae)*

Pest Information

Damage: Symptoms of mite feeding on lettuce include small, yellow or white, speckled lesions. Severe feeding damage can result in leaf death and yield reduction. Fine webbing may be present on the underside of the leaf and a silver sheen on damaged surfaces may be apparent. 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.

Life Cycle: The two spotted spider mite has a broad host range. Adult females lay approximately 100 eggs on the lower leaf surface (five to eight eggs per day). The life cycle may be completed in as little as three and a half 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 readily attach to people and equipment. The female overwinters in dark crevices in the greenhouse.

Pest Management

Cultural Controls: Spider mite infestations can be monitored by examination of the leaves. Sanitation in the greenhouse is an important means to control this pest. A three metre wide weed-free zone maintained around the perimeter of the greenhouse will reduce the risk of mite invasion. Restricting movement of workers, equipment and plants from infested to non-infested areas will also help to minimize spread of the pest.

Biological controls: Arthropod biological control agents available for the management of spider mites in greenhouse lettuce are listed in *Table 9. Arthropod biological control agents available for the management of insect and mite pests in greenhouse vegetable crops in Canada1*

Resistant Cultivars: None available.

Chemical Controls: Insecticides and biopesticides registered for spider mite control are listed in *Table 10. Pesticides and bio-pesticides registered for insect management in greenhouse lettuce production in Canada.*

Issues for two-spotted spider mite

None identified.

Greenhouse whitefly (*Trialeurodes vaporariorum*)

Pest Information

Damage: Whiteflies suck sap from the plant, reducing plant vigour. They also excrete a surgary waste product called honeydew that supports the growth of secondary fungi called sooty moulds that reduce photosynthesis and detract from the appearance of the plants.

Life Cycle: The adult whitefly lays eggs on the underside of leaves. Eggs hatch within five to ten days. The first nymphal stage, called crawlers, move around and find a suitable spot to feed where they remain throughout the development of the second and third nymphal stages. They then pupate and the adults emerge. The entire life cycle can take between 18 and 35 days depending on temperature.

Pest Management

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

Biological controls: Arthropod biological control agents available for the management of whitefly in greenhouse lettuce are listed in *Table 9. Arthropod biological control agents available for the management of insect and mite pests in greenhouse vegetable crops in Canada1*.

Resistant Cultivars: None available.

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

Issues for whitefly

1. The registration of new, reduced risk insecticides is needed, especially for the management of greenhouse whitefly, as alternative controls provide suppression only.
2. There is a need to develop additional biological controls for whitefly in lettuce which has a short production cycle.

Weeds

Weed management in and around greenhouses is important as weeds can be an alternate host for insects and diseases. Weeds within the greenhouse are eliminated by hand weeding and through the use of ground coverings. Weeds exterior to the greenhouse can be reduced by mowing and by maintenance of a ten 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 in greenhouses.

Life Cycle: These rodents are primarily outdoor pests, but house mice and Norway rats can invade indoor facilities. Field mice prefer weedy, covered areas. These rodents are attracted to sources of food, water and shelter for nesting, such as garbage containers, cull piles, piles of sawdust, old planting media, building debris, burlap or styrofoam which are left outdoors or where bags of seed or slug bait are stored.

Pest Management

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

Resistant Cultivars: None available.

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

Issues for Rodents

None identified.

Resources

IPM/ICM resources for production of greenhouse lettuce in Canada

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

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

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 836 Growing Greenhouse Vegetables in Ontario www.omafra.gov.on.ca/english/crops/hort/greenhouse.html

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

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
Ontario	Ontario Ministry of Agriculture, Food and Rural Affairs www.omafra.gov.on.ca/	Cara McCreary cara.mccreary@ontario.ca Shalin Khosla shalin.khosla@ontario.ca	Jim Chaput jim.chaput@ontario.ca
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 : www.spsq.info/

Ontario Greenhouse Vegetable Growers: www.ontariogreenhouse.com/

Saskatchewan Greenhouse Growers Association: www.saskgreenhouses.com

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

National:

Canadian Horticultural Council: www.hortcouncil.ca

Appendix 1

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

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

<table>
<tr><th>Presence</th><th colspan="4">Occurrence information</th><th>Colour Code</th></tr>
<tr><td rowspan="13">Present</td><td rowspan="10">Data available</td><td>Frequency</td><td>Distribution</td><td>Pressure</td><td></td></tr>
<tr><td rowspan="5">**Yearly** - Pest is present 2 or more years out of 3 in a given region of the province.</td><td rowspan="3">**Widespread** - The pest population is generally distributed throughout crop growing regions of the province. In a given year, outbreaks may occur in any region.</td><td>**High** - If present, potential for spread and crop loss is high and controls must be implemented even for small populations.</td><td>Red</td></tr>
<tr><td>**Moderate** - If present, potential for spread and crop loss is moderate: pest situation must be monitored and controls may be implemented.</td><td>Orange</td></tr>
<tr><td>**Low** - If present, the pest causes low or negligible crop damage and controls need not be implemented.</td><td>Yellow</td></tr>
<tr><td rowspan="3">**Localized** - The pest is established as localized populations and is found only in scattered or limited areas of the province.</td><td>**High** - see above</td><td>Orange</td></tr>
<tr><td>**Moderate** - see above</td><td>White</td></tr>
<tr><td>**Low** - see above</td><td>White</td></tr>
<tr><td rowspan="5">**Sporadic** - Pest is present 1 year out of 3 in a given region of the province.</td><td rowspan="3">**Widespread** - as above</td><td>**High** - see above</td><td>Orange</td></tr>
<tr><td>**Moderate** - see above</td><td>Yellow</td></tr>
<tr><td>**Low** - see above</td><td>White</td></tr>
<tr><td rowspan="3">**Localized** - as above</td><td>**High** - see above</td><td>Yellow</td></tr>
<tr><td>**Moderate** -see above</td><td>White</td></tr>
<tr><td>**Low** - see above</td><td>White</td></tr>
<tr><td rowspan="2">Data **not** available</td><td colspan="3">**Not of concern:** The pest is present in commercial crop growing areas of the province but is causing no significant damage. Little is known about its population distribution and frequency in this province; however, it is not of concern.</td><td>White</td></tr>
<tr><td colspan="3">**Is of concern:** The pest is present in commercial crop growing areas of the province. Little is known about its population distribution and frequency of outbreaks in this province and due to its potential to cause economic damage, is of concern.</td><td>Blue</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). Canadian Phytopathological Society and Entomological Society of Canada, Ottawa. pp.534.

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

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

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

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