Crop Profile for Allium Vegetables in Canada, 2021

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Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada

Canada

Fourth Edition – 2023
Crop Profile for Allium Vegetables in Canada, 2021
Catalogue No.: A118-10/34-2021E-PDF
ISBN: 987-0-660-42158-2
AAFC No.: 13099E

Third Edition – 2020
Crop Profile for Allium Vegetables in Canada, 2018
Catalogue No.: A118-10/34-2018E-PDF
ISBN: 978-0-660-35836-9
AAFC No.: 13043E

Second Edition – 2018
Crop Profile for Allium in Canada, 2015
Catalogue No.: A118-10/34-2015E-PDF
ISBN: 978-0-660-27280-1
AAFC No.: 12849E

First Edition – 2014
Crop Profile for Allium in Canada, 2012
Catalogue No.: A118-10/34-2014E-PDF
ISBN: 978-1-100-24783-0
AAFC No.: 12231E

Electronic version available at agriculture.canada.ca/pest-management-centre

Paru également en français sous le titre: « Profil des cultures de légumes du genre Allium au Canada, 2021 »

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Preface

National crop profiles are developed by the Pest Management Centre of Agriculture and Agri-Food Canada (AAFC). The crop profiles provide baseline information on production and pest management practices and document growers' needs to address pest management gaps and issues for specific crops grown in Canada. This information is developed through extensive consultation with stakeholders and data collected from reporting provinces. Reporting provinces are selected based on their acreage of the target crop (>10 % of the national production) and provide qualitative data on pest occurrence and integrated pest management practices used by growers in those provinces. For allium vegetable production, the reporting provinces are Ontario and Quebec.

Information on pest issues and management practices is provided for information purposes only. For detailed information on growing alliums the reader is referred to provincial crop production guides and provincial ministry websites listed in the Resources Section at the end of the profile. For guidance about crop protection products registered for pests on alliums, the reader is referred to provincial crop production guides and Health Canada's Pesticide label database.

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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Crop Profile for Allium Vegetables in Canada

The Allium vegetables are members of the Allieae tribe and are cultivated and consumed world-wide. This tribe is represented by one genus (Allium) comprised of over 500 species. In Canada, several Allium vegetables are produced commercially including dry onion (*Allium cepa*), green onion (*A. cepa*), shallots (*A. cepa* var. *aggregatum*), leeks (*A. porrum*), garlic (*A. sativum*) and chives (*A. schoenoprasum*).

While some Allium species including wild garlic (*Allium canadense*) are native to North America, domesticated Allium crops are thought to have originated in central Asia and have been cultivated for over 5,000 years. Onion bulbs, leeks and shallots are believed to have been introduced into North America in the 1600s. More recently, in 1989 the United States Department of Agriculture collected a large number of garlic varieties from Russia and introduced them into the United States.

Onions are bulbous, shallow rooted, monocot vegetables. Onion seed is grown biennially while the vegetable is grown annually. Three main types of onions are grown in Canada: dry onions (including storage and sweet onions), onion sets and green onions. Long day varieties are best suited for production in Canada. Dry onions are grown only for the fleshy bulb, with the tops being discarded. Onions sets, such as multiplier onions or shallots, are sown closer together for smaller bulbs. Sets are grown mostly for the home-gardener market. Green onions, also known as bunching onions or scallions, are harvested while the tops are still green and before the bulb forms. Shallots are closely related to multiplier onions, but smaller and are comprised of two to three elongated cloves, each clove being enclosed in a gold or reddish brown skin.

Leeks do not develop a pronounced bulb, but are a cylindrical plant comprised of tight, flattened leaf sheaths. Leeks are characterized as summer leeks that are harvested in the same season they are planted, and overwintering leeks that are harvested the summer following the season they were planted. In Canada, summer leeks are predominant due to the climate, however some warmer areas allow for the successful production of overwintering leek. Because of their long growing season, leeks are more often planted as seedlings. Cultivars can differ significantly in growth habit, which affects the final product.

The garlic bulb is an aggregation of eight to 20 bulblets or cloves enclosed in a whitish or pinkish papery skin. The two main types of garlic grown in Canada are hardneck (*A. sativum* var. *ophioscorodon*) and softneck (*A. sativum* var. *sativum*). Hardneck varieties produce four to 12 cloves per bulb and softneck produce eight to 12 cloves per bulb. Hardneck varieties are more winter hardy but have a shorter storage life than softneck varieties. The cloves are used to vegetatively propagate the crop as garlic does not produce true seed. Hardneck varieties produce 'scapes' at the leaf tip, which are edible when cooked, contributing a mild garlic flavour to foods.

Due to the biological similarity of the allium crops, the information presented in this crop profile is largely relevant for all of the above mentioned crops; however pest occurrence and integrated pest management information presented was collected specifically for dry bulb onions and leeks.

Crop Production

Industry Overview

In 2021, the total Canadian acreage of commercial alliums (dry onions, shallots and green onions, leeks and garlic) was 7,696 hectares, with a total production of 266,948 metric tonnes and a total farm gate value of $187.8 million. Dry onions accounted for 91 percent of production and 63 percent of the farm gate value while garlic accounted for less than one percent of production and 12 percent of the farm gate value (Table 1).

Dry onion, shallots and green onion exports grew by approximately 18 percent in 2021 compared to exports recorded in 2018. Leek and garlic exports grew by 54 percent and 44 percent, respectively, compared to exports recorded in 2018 (Table 1).

Table 1. General production information, 2021

	Dry Onions	**Shallots and Green Onions**	**Leeks**	**Garlic**
Canadian Production[1]	244,015 metric tonnes	14,210 metric tonnes	6,785 metric tonnes	1,938 metric tonnes
	5,633 hectares	801 hectares	342 hectares	920 hectares
Farm Gate Value[1]	$118.6 million	$31.8 million	$14.4 million	$23.0 million
Export[2]	$69.3 million[3]		$2.89 million	$0.99 million
Imports[2]	$29.5 million	$1.2 million[4]	$15.6 million	$70.5 million

[1]Statistics Canada. Table 32-10-0365-01 - Area, production and farm gate value of marketed vegetables (accessed April 21, 2022).
[2]Statistics Canada. Canadian International Merchandise Trade Web Application (accessed April 21, 2022). Exports: 0703.10.00 – onions and shallots, fresh or chilled, 0703.90.00 - Leeks and other alliaceous vegetables, 0703.20.00 - Garlic, fresh or chilled. Imports: 0712.20.00.00 – onions, dried, but not further prepared, 0703.10.49.00 – Shallots, dry fresh or chilled, nes, 0703.90.00 - Leeks and other alliaceous vegetables, 0703.20.00 - Garlic, fresh or chilled.
[3]Data reported for onions and shallots only.
[4]Data reported for shallots only.

Production Regions

In 2021, a total of 6,041 hectares of dry onions were grown in Canada with Ontario and Quebec growing 80 percent of the national acreage. A total of 801 hectares of shallots and green onions and leeks were grown in 2021, with 62 percent of the total national acreage grown in Quebec. Leek was grown on 337 hectares during the same time period with 60 percent of national production occurring in Quebec. A total of 641 hectares of garlic was grown in 2021, with 50 percent of production in Ontario and 29 percent of production in Quebec. A detailed breakdown of production regions is provided in Table 2.

Table 2. Distribution of allium production by province, 2021[1]

Production Regions	Planted Area (percent national production)			
	Dry Onions	Shallots and Green Onions	Leeks	Garlic
Nova Scotia	204 hectares (3%)	9 hectares (1%)	2 hectares (1 %)	13 hectares (1%)
Quebec	2,315 hectares (38%)	136 hectares (17%)	94 hectares (26%)	490 hectares (50%)
Ontario	2,521 hectares (42%)	495 hectares (62%)	214 hectares (60%)	283 hectares (29%)
Manitoba	183 hectares (3%)	43 hectares (5%)	3 hectares (1%)	7 hectares (1%)
Alberta	668 hectares (11%)	42 hectares (5%)	2 hectares (1%)	36 hectares (4%)
British Columbia	113 hectares (2%)	67 hectares (8%)	41 hectares (11%)	137 hectares (13%)
Canada	**6041 hectares**	**801 hectares**	**337 hectares**	**641 hectares**

[1]Statistics Canada. Table 032-10-065-01 - Area, production and farm gate value of marketed vegetables (accessed April 21, 2022).

Cultural Practices

Allium crops grow best on fertile, well-drained soils with a pH between 6.0 and 7.5. All types of soil may be suitable; however, heavy soils that drain more slowly and are prone to crusting and compaction should be avoided. Soils with a high organic content are also preferable because of their increased ability to retain moisture and nutrients. Black soils (high organic soils) are well suited to growing allium vegetables, as they allow for more uniform growth and facilitate mechanical harvesting; exceptions include Spanish onions and garlic, which mature better in mineral soil than in organic soil. Coarse sands are also to be avoided for leek production because sand particles may accumulate under the leaf sheaths.

In the spring or fall, a soil test can be performed to determine pH and nutrient requirements. Lime, fertilizer, or other amendments are made to the soil to make the necessary adjustments. Generally, the initial fertilization is broadcast and then incorporated before seeding or planting. In mineral soils, nitrogen applications are split to reduce leaching and are incorporated into strips along the rows. Lime is often applied in the fall prior to onion production.

For most allium vegetables, the optimum growth temperature is between 20 and 25 °C. Onions may be grown from seeds, sets, or transplants. Onions require a long growing season in order to produce good, high quality bulb yields. Leaf growth occurs in the spring, then the shorter day length beginning in July triggers bulb formation of the onion. It is essential to establish the crop early in the spring so that the plants have a sufficiently long leaf development phase. Onions are usually planted from mid-April to May and harvested in August and September. Early market bulbs are usually started from sets or transplants and large Spanish onions are usually started from transplants, as they require a longer time to mature. Green onions have a shorter growth cycle (45 to 70 days). Several consecutive plantings are grown to obtain multiple harvests spread over the entire growing season. This crop may be directly seeded or produced from transplants planted between mid-April and the end of July.

Shallots can be grown from seed or small bulbs. True shallots are propagated vegetatively with a mother bulb producing a clump of 4-15 shallot sets depending on the cultivar. Most commercially grown shallots are seed shallots, which are not true shallots, but an onion hybrid with some characteristics of shallots. True shallots have a root plate scar, where it was separated from the shallot cluster. Seed shallots are seeded in early spring, while true shallots are planted in late fall or early spring, depending on the region. Earlier maturity and harvest can be achieved by starting true shallot bulbs 30 to 45 days ahead in the greenhouse, then transplanting in the field.

Leeks are usually produced from transplants; the seeds are sown in the greenhouse in early spring, approximately 60 days before the date of transplant. Seedlings are transplanted in the field between late April and mid-June. Soil is hilled around the base of the plants as the plants develop, to obtain leeks with a white portion of at least 15 cm.

Garlic is vegetatively propagated by manually or mechanically separating cloves from the bulbs shortly before planting. Cloves are most often planted in the fall and bulbs harvested the following summer. In some areas with a sufficiently long growing season, spring planting may occur, with cloves planted as early as soil and weather conditions allow. The timing of the fall planting is critical to ensure that the plants do not bolt and develop past the two-leaf stage, but adequate roots develop to support the plant over the winter. Use of mulches and good snow cover will enhance winter survival of garlic crops.

Green onions can be harvested in three to 10 weeks. Mature shallot bulbs are usually ready for harvest 10 to 16 weeks after planting, while dry onions take 16 to 20 weeks to fully mature. Whole leek plants are harvested once they reach a desired size in August-October. Roots are trimmed close to the base of the bulb and older, and outer scales are removed. Garlic is ready for harvesting when 30 to 50 percent of the leaves have wilted. Around mid-June, the flower heads appear and must be harvested before the inflorescence bursts to promote the development of the bulbs.

For dry bulb onions intended for sale after mid-November, a sprout inhibitor is applied to facilitate long term storage. Onions are undercut into windrows several days prior to harvest, to allow the onion leaves to senesce and the skins to dry out as the onion cures, this improves onion quality. Care is taken to not wound or bruise the bulbs during harvest; damage during harvest will increase susceptibility to pathogens in storage. Onions can be cured in pallet boxes in the field, if weather conditions are favourable, or artificially in an air-controlled storage facility for two weeks with heated forced air at temperatures between 24 and 27 °C. Curing allows the outer scales and the neck of the bulb to dry, forming a seal that helps to prevent entry of pathogens during storage. Once cured, onions are stored at 0 °C and at 65 percent relative humidity. Many dry onion cultivars are well suited to long-term cold storage and are typically stored for marketing/exporting throughout the fall, winter, and early spring.

At garlic harvest, plants are lifted, bulbs are cleaned, roots are cut, and bulbs are cured in slotted vegetable bins in a barn or storage facility. Forced air with reduced relative humidity is practiced to cure the crop quickly. Curing is complete when the bulb wrappers are crispy, the middle of the cut stem is hard, and the base of the stem is dry when cloves are removed.

Alliums are susceptible to microbial diseases, insect pests and weed infestations both during the growing season and once they have been placed into storage. Crop rotation plays an important role in helping to reduce the incidence and magnitude of diseases, insect pests and weed populations. The length of crop rotation will vary depending on the allium crop. In dry onions, crop rotation can range from two to three years with a rotation to unrelated crops such as carrots, celery, brassicas, potatoes, corn, cereals and beans. Crop rotation is not effective for managing soil-borne diseases such as white rot and Fusarium basal rot, or for mobile pests such as thrips or diseases such as Botrytis or Stemphylium leaf blights.

Table 3. General dry onion production and pest management schedule in Canada

Time of Year	Activity	Action
Winter (December to late March)	Disease management	Monitor onions in storage; remove culls
Spring (late March to May)	Plant care	Plant cover crop (e.g., barley) before seeding onions if not planted the previous fall; irrigate as needed. Seed the crop April through May; if used, seed nurse crop (e.g., barley) at the same time
	Soil care	Conduct soil tests in early spring for nutrient levels (if not done the previous fall). Prepare the soil (plowing, harrowing, etc.) and fertilize; continue application of N and K splits until June 25 (QC)
	Disease management	Use seed treated with fungicides; monitor for smut and nematodes, if necessary
	Insect management	Use seed treated with insecticides
	Weed management	Monitor for weeds, apply pre-emergence herbicides, if necessary
Summer (June to August)	Plant care	Eliminate cereal nurse crop with selective herbicide; make additional N applications, if needed; irrigate as needed
	Disease management	Continually monitor for disease; spray if necessary
	Insect management	Monitor for insects; apply insecticides, as needed
	Weed management	Monitor weeds and weed stage and crop stage to properly time post-emergence herbicide applications, if necessary; weed manually, as needed
End of summer-harvest season (August and September) **Fall – harvest period (September to October)**	Plant care	Stop irrigation; apply sprout inhibitor; cut, mow or lift plants, harvest and dry onions
	Disease control	Eliminate clumps of discarded onions and infected debris in the field; monitor onions in storage, remove damaged onions
	Soil care	Conduct soil tests for pH and nutrient levels. Apply lime, as needed. Sow a cover crop

Abiotic Factors Limiting Production

Temperature Extremes

Alliums are extremely temperature sensitive. Allium crops grow best at temperatures ranging from 20 to 25 °C in moist conditions. Bulbs will not grow at temperatures below 12 °C, bolting occurs below 10 °C, and growth is slowed when temperatures exceed 32 °C. Exposure of bulbs to below freezing temperatures can lead to soft, water-soaked, fleshy scales and rapid decay.

Ozone Injury

Elevated ground-level ozone concentrations can cause injury to onions. Injury is more prevalent when air masses are stagnant and during hot, humid weather as these conditions lead to elevated ozone concentrations. Common symptoms are small, irregular spots that range in colour from light tan to white. Very young and old leaves are less susceptible to ozone injury compared to mature leaves. Ozone injury may lead to a reduced bulb size and an increase in incidence and severity of purple blotch and Botrytis leaf blight.

Moisture Stress

Summer droughts negatively impact allium crop growth. Due to their shallow and limited root systems, a constant moisture supply is required. If plants dry out, they may “bulb out” early, resulting in smaller bulb sizes. Irrigation is often used to supply the crop’s need for 25 to 50 mm of water each week. Conversely, excessive irrigation can result in leaching and nitrate loss, and may promote rot diseases in storage. Inconsistent irrigation of onion fields, for example, fields that are subjected to over-irrigation, then allowed to dry completely and then over-irrigated again can also lead to split bulbs. Irrigation late in the bulbing stage may delay maturity and reduce bulb quality due to skin splitting and rotting. Harvesting after a rainfall or when the humidity is high will increase susceptibility to post-harvest diseases.

Other Climatic Stress

Wind can break or destroy seedlings and can lead to crop loss early in the season. Later in the season, heavy winds can cause premature bending of the leaves. Wind can also disturb dry soil (wind erosion), expose bulbs and lead to sunscald, which kills the outer soft scale tissue, disfigures the bulbs and may allow bulb-rotting organisms to develop.

Strong sunshine and high temperatures in fields during onion curing may cause sunscald. Bulbs can be protected from direct insolation by covering them with leaves while they are being cured. Greening of onion bulbs can occur if bulbs are exposed to sunlight during the growing season or if bulbs are allowed to cure for extended periods under moderate light.

Hail and rain can damage leaves by cutting and shredding or cause white spots, and make plants more susceptible to pathogen entry.

Nutrients

Excessive or limited fertilizer applications can have negative effects on crops. An excess of nitrogen can lead to delayed maturity, soft bulbs, greening of onion bulbs, and an increase in storage losses due to diseases. Nitrogen insufficiency can lead to stunted plants with pale green or yellow leaves that dieback from the tips. Phosphorus, potassium, copper, magnesium, manganese, zinc and boron are also important nutrients, which must be present in soil at sufficient, but not excessive levels for allium crops to grow robustly.

Harvest and Storage Practices

Dry onions are susceptible to damage during harvesting, curing, and storage, which can lead to reduced marketable yields and the development of storage diseases. Extra care to minimize bruising and cuts to the bulbs is required during undercutting and mechanical harvesting, especially for bulbs intended for long-term storage. Late harvesting, insufficient curing, long drying periods, and failing to promptly store onions properly after curing can lead to physiological disorders such as watery scales and translucent scales. These disorders render onions more susceptible to microbial growth. Storing onions in a controlled-atmosphere where the carbon dioxide concentration exceeds seven percent can also lead to the development of translucent scales. The accumulation of condensation on onion bulbs in storage can encourage decay and degradation of the surface colour.

Chemicals

Sprout inhibitors (e.g., maleic hydrazide) applied too early on dry onions can cause bulbs to become spongy and make them unmarketable. Conversely, if applied too late when plants have fewer than three green leaves remaining, the result will be poor absorption, and the bulbs will be more prone to sprouting.

Several herbicides may also cause injury. Care must be taken to avoid spray drift during herbicide applications to nearby crops or hedgerows, and to ensure allium crops are not planted in fields containing herbicide residues from previous years, which may lead to injury. Symptoms such as yellowing, browning, stunted growth and death may occur.

Diseases

Key Issues

- New and/or multi-site fungicides are needed to control diseases such as Botrytis neck rot, Fusarium basal rot, white rot, onion smut, downy mildew (curative products) and Stemphylium leaf blight.

- There is the need for more research on bacterial diseases including the source of bacterial inoculum, and the development conditions of the bacterial diseases at harvest and in storage. This research would allow development and implementation of a more effective control program.

- Pink root is prominent in onion fields in Ontario. There is a need for new tools including fungicides and the development of pink root resistant cultivars for management.

Table 4. Occurrence of diseases in dry onion in Canada[1,2]

Disease	Ontario	Quebec
Botrytis leaf blight		
Downy mildew		
Purple blotch		
Stemphylium leaf blight		
Rust		
Damping-off		
Pink root		
Fusarium basal rot		
White rot		
Onion smut		
Slippery skin		
Sour skin		
Soft rot		
Neck rot		
Aster yellows		
Iris yellow spot virus (IYSV)		
Stem and bulb nematode (onion bloat)		
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 pest 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: Onion stakeholders in reporting provinces (Ontario and Quebec); the data reflect the 2019, 2020 and 2021 production years.

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

Table 5. Occurrence of diseases in leek in Canada[1,2]

Disease	Ontario	Quebec
Botrytis leaf blight		
Downy mildew		
Purple blotch		
Stemphylium leaf blight		
Rust		
Damping-off		
Pink root		
Fusarium basal rot		
White rot		
Onion smut		
Slippery skin		
Sour skin		
Soft rot		
Neck rot		
Aster yellows		
Iris yellow spot virus (IYSV)		
Stem and bulb nematode (onion bloat)		
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 pest 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 pressure.		
Pest not present.		
Data not reported.		

[1]Source: Leek stakeholders in reporting provinces (Ontario and Quebec); the data reflect the 2019, 2020 and 2021 production years.

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

Table 6. Adoption of disease management practices in dry onion crop production in Canada[1]

Practice / Pest		Botrytis leaf blight	Damping off	Fusarium basal rot	Downy mildew	Purple blotch	Stemphylium leaf blight
Avoidance	Varietal selection / use of resistant or tolerant varieties	green	green	green	green	red	green
	Planting / harvest date adjustment	red	red	red	red	red	red
	Rotation with non-host crops	green	green	green	green	green	green
	Choice of planting site	green	green	green	green	green	green
	Optimizing fertilization for balanced growth and to minimize stress	green	green	green	green	green	green
	Minimizing wounding and insect damage to limit infection sites	green	green	green	green	green	green
	Use of disease-free propagative materials (seed, cuttings or transplants)	green	green	green	green	green	green
Prevention	Equipment sanitation	green	green	green	green	green	green
	Canopy management (thinning, pruning, row or plant spacing)	green	green	green	green	green	green
	Manipulating seeding / planting depth	red	red	red	red	red	red
	Irrigation management (timing, duration, amount) to minimize disease infection periods and manage plant growth	green	green	green	green	green	green
	Management of soil moisture (improvements in drainage, use of raised beds, hilling, mounds)	green	green	green	green	green	green
	End of season or pre-planting crop residue removal / management	green	green	green	green	green	green

…continued

Table 6. Adoption of disease management practices in dry onion crop production in Canada[1] (continued)

Practice / Pest		Botrytis leaf blight	Damping off	Fusarium basal rot	Downy mildew	Purple blotch	Stemphylium leaf blight
Prevention	Pruning out / removal of infected material throughout the growing season						
	Removal of other hosts (weeds / volunteers / wild plants) in field and vicinity						
Monitoring	Scouting / spore trapping						
	Maintaining records to track diseases						
	Soil analysis for the presence of pathogens						
	Weather monitoring for disease forecasting						
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of diseases						
Decision making tools	Economic threshold						
	Use of predictive model for management decisions						
	Crop specialist recommendation or advisory bulletin						
	Decision to treat based on observed disease symptoms						
	Use of portable electronic devices in the field to access pathogen / disease identification / management information						
Suppression	Use of diverse product modes of action for resistance management						
	Soil amendments and green manuring involving soil incorporation as biofumigants, to reduce pathogen populations						

…continued

Table 6. Adoption of disease management practices in dry onion crop production in Canada[1] (continued)

Practice / Pest		Botrytis leaf blight	Damping off	Fusarium basal rot	Downy mildew	Purple blotch	Stemphylium leaf blight
Suppression	Use of non-conventional pesticides (e.g., biopesticides)						
	Controlled atmosphere storage						
	Targeted pesticide applications (e.g., banding, spot treatments, use of variable rate sprayers)						
	Selection of pesticides that are soft on beneficial insects, pollinators and other non-target organisms						
This practice is used to manage this pest by at least some growers in the province.							
This practice is not used by growers in the province to manage this pest.							
This practice is not applicable for the management of this pest							

[1]Source: Dry onion crop stakeholders in reporting provinces (Ontario and Quebec); the data reflect the 2019, 2020 and 2021 production years.

Table 7. Adoption of disease management practices in leek crop production in Canada[1]

	Practice / Pest	Botrytis leaf blight	Damping off	Fusarium basal rot	Downy mildew	Purple blotch	Stemphylium leaf blight
Avoidance	Varietal selection / use of resistant or tolerant varieties						
	Planting / harvest date adjustment		Red				
	Rotation with non-host crops	Green	Green	Green	Green	Green	Green
	Choice of planting site	Green	Green	Green	Red	Green	Green
	Optimizing fertilization for balanced growth and to minimize stress	Green	Green	Green	Green	Green	Green
	Minimizing wounding and insect damage to limit infection sites	Green	Red	Red	Green	Green	Green
	Use of disease-free propagative materials (seed, cuttings or transplants)	Green	Green	Green	Green	Green	Green
Prevention	Equipment sanitation	Green	Green	Green	Red	Green	Green
	Canopy management (thinning, pruning, row or plant spacing)	Green	Green	Green	Red	Green	Green
	Manipulating seeding / planting depth				Green		
	Irrigation management (timing, duration, amount) to minimize disease infection periods and manage plant growth	Green	Green	Green	Green	Green	Green
	Management of soil moisture (improvements in drainage, use of raised beds, hilling, mounds)	Green	Green	Green		Green	Green

…continued

Table 7. Adoption of disease management practices in leek crop production in Canada[1] (continued)

Practice / Pest		Botrytis leaf blight	Damping off	Fusarium basal rot	Downy mildew	Purple blotch	Stemphylium leaf blight
Prevention	End of season or pre-planting crop residue removal / management						
	Pruning out / removal of infected material throughout the growing season						
	Removal of other hosts (weeds / volunteers / wild plants) in field and vicinity						
Monitoring	Scouting / spore trapping						
	Maintaining records to track diseases						
	Soil analysis for the presence of pathogens						
	Weather monitoring for disease forecasting						
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of diseases						
Decision making tools	Economic threshold						
	Use of predictive model for management decisions						
	Crop specialist recommendation or advisory bulletin						
	Decision to treat based on observed disease symptoms						
	Use of portable electronic devices in the field to access pathogen / disease identification / management information						

…continued

Table 7. Adoption of disease management practices in leek crop production in Canada[1] (continued)

	Practice / Pest	Botrytis leaf blight	Damping off	Fusarium basal rot	Downy mildew	Purple blotch	Stemphylium leaf blight
Suppression	Use of diverse product modes of action for resistance management	Green	Green	White	Green	Green	Green
	Soil amendments and green manuring involving soil incorporation as biofumigants, to reduce pathogen populations	White	White	White	White	White	White
	Use of non-conventional pesticides (e.g., biopesticides)	Green	Green	White	Red	White	Green
	Controlled atmosphere storage	Green	White	Green	White	White	White
	Targeted pesticide applications (e.g., banding, spot treatments, use of variable rate sprayers)	Green	Green	Red	Red	Green	Green
	Selection of pesticides that are soft on beneficial insects, pollinators and other non-target organisms	Green	Green	Green	Green	Green	Green

Green: **This practice is used to manage this pest by at least some growers in the province.**
Red: **This practice is not used by growers in the province to manage this pest.**
White: **This practice is not applicable for the management of this pest**
Grey: **Information regarding the practice for this pest is unknown.**

[1]Source: Leek crop stakeholders in reporting provinces (Ontario and Quebec); the data reflect the 2019, 2020 and 2021 production years.

Botrytis Leaf Blight (*Botrytis squamosa*)

Pest Information

Damage: Botrytis leaf blight is an important fungal disease of onions. Although the fungus rarely kills the infected plant, it will cause a dramatic reduction in onion bulb growth and yield, and the bulbs will not dry properly in storage. The first symptom is the appearance of greyish-white oval spots on infected leaves. The spots are surrounded by a greenish-white halo that initially appears water-soaked. Gradually the centers of the lesions become sunken, straw yellow coloured, and develop a characteristic lengthwise slit. The opening exposes the inner tissues of the leaf and provides a site of entry for other pathogens. Onions can tolerate losses of up to 10 percent of their photosynthetic area before yields are reduced. As the disease progresses, the plant will die back, which is characterized by browning and early death of leaves.

Life Cycle: Botrytis overwinters as sclerotia in the soil, on crop debris and in cull piles. The host range of this pathogen includes onion, garlic, shallots, chives, leeks and other Allium species. In the spring, conidia (spores) and ascospores (sexual spores) are produced when temperatures rise above 3 °C. The spores are spread by wind to new plants where they cause new infections under favourable conditions. Typically, such conditions occur after mid-June, when temperatures and leaf wetness are ideal for infection. Warm (16 to 28 °C), wet or humid weather is most favourable for disease development. The production of ascospores may result in new strains of the pathogen that have evolved some tolerance to fungicides.

Pest Management

Cultural Controls: A three year crop rotation out of allium crops, such as carrot or celery will help to reduce disease incidence and severity. The removal of crop residue, cull piles and allium volunteers from the field will minimize the spread of disease. Irrigation schedules that ensure leaves are wet no longer than eight hours may be helpful. When the disease is reported in the area, irrigation is suspended to minimize the spread. Reducing planting density and avoiding high rates of nitrogen fertilizer application will minimize disease development. BOTCAST, a blight prediction model available in Ontario can help determine if protective fungicide application is necessary. In Quebec, the modified Lacy model and spore traps are used to help determine if and when treatments are necessary. Field monitoring can also be used in decision making for fungicide application. Additional management practices for Botrytis leaf blight are listed in *Tables 6 and 7*.

Resistant Cultivars: Highlander is tolerant; *Norstar* is highly tolerant.

Issues for Botrytis Leaf Blight

1. The stick (spore collector) assessment is a useful tool for pathogen identification; however, there is an urgent need for a coordinated, national approach to the transport logistics of these sample sticks. Current processes are complicated, time consuming, and expensive.
2. Molecular techniques for plant pathogen identification and quantification, such as qPCR, are becoming more readily available to consumers. The accuracy of these analyses need to be assessed and standardized for use.
3. There continues to be a need for the development of conventional and non-conventional products, including biopesticides, for the management of Botrytis leaf blight.

Damping-off (*Pythium* spp., *Rhizoctonia* spp., *Fusarium* spp.)

Pest Information

Damage: Cold wet soils can result in damping-off of seedlings. The disease is caused by Pythium, Rhizoctonia or Fusarium fungi, either alone or in combination. Seedlings may collapse as a result of lesions at the soil line or may die before emergence from the soil.

Life Cycle: Soil-borne fungal pathogens that cause damping-off can persist for many years in soil and infected crop debris. Spores and fungal resting structures germinate in response to root secretions and infect plant seeds and roots under conditions of excessive soil moisture and poor drainage.

Pest Management

Cultural Controls: A five year crop rotation with non-host crops will reduce the incidence of damping-off. Onions should be planted into well-drained soil and environmental stresses minimized to reduce the potential for the development of damping-off. Additional management practices for damping-off are listed in *Tables 6 and 7*.

Resistant Cultivars: None available.

Issues for Damping-off

None identified

Downy Mildew (*Peronospora destructor*)

Pest Information

Damage: Downy mildew is a water mold that initially produces a purple-grey, velvet-like mold lesions with black spores on upper leaf surfaces. As the disease progresses, these lesions on the leaves turn pale-green, yellow, and then the leaves collapse and die. Other symptoms may include a destroyed hypocotyl and a spongy neck. Infected plants are often invaded by secondary pathogens such as soft rot bacteria and purple blotch. The bulbs of infected plants are smaller than those of healthy plants and do not dry properly. Green onions infected by downy mildew are unmarketable.

Life cycle: The pathogen overwinters as mycelium on bulbs and other tissues, and as sexually produced oospores in diseased foliage discarded in fields. In the spring, new plants become infected by spores produced on culls and volunteer plants. Spores germinate at night and spread considerable distances by wind during the day. Spores may also be spread by rain. The incubation period of downy mildew is between 10 and 16 days. Infection can develop when foliage remains wet for two to six hours at 3 to 14 °C. If the pathogen is exposed to the right conditions, such as cool (< 22 °C), humid weather, and prolonged leaf wetness, the disease can become widespread and be very destructive. Several cycles of sporulation and infection can occur, and three or four of these cycles can destroy an onion crop over a period of 30 to 45 days.

Pest Management

Cultural Controls: The cleaning of equipment after use and the removal of cull piles from the field will minimize the spread of disease. Planting fields adjacent to allium fields with unrelated plants and controlling alternative weed hosts in and around fields is beneficial in reducing pathogen inoculum. A crop rotation out of Allium species of two to four years will reduce the overwintering oospore population in the soil. Fields that provide good air movement and drainage help in minimizing disease incidence. Weed control during the season will increase air circulation and shorten the time dew stays on foliage, making conditions less favourable for disease development. The DOWNCAST forecasting model is available to growers in some areas to help predict disease outbreaks and the need for protective fungicide treatments. Field scouting can provide accurate assessment of disease levels. Additional management practices for downy mildew are listed in *Tables 6 and 7*.

Resistant Cultivars: Some tolerant cultivars are available, including *Powell*, *Highlander*, and *Southport White Globe* green bunching variety. *Norstar* is highly tolerant.

Issues for Downy Mildew

1. There is a need for the registration of fungicides with curative effects for use in situations where the optimum spray window has been missed.
2. The stick (spore collector) assessment is a useful tool for pathogen identification; however, there is an urgent need for a coordinated, national approach to the transport logistics of these sample sticks. Current processes are complicated, time consuming, and expensive.
3. There is a need for the development of conventional and non-conventional products, including biopesticides, for the management of downy mildew.

Purple Blotch (*Alternaria porri*)

Pest Information

Damage: Purple blotch is a fungal disease affecting onion and garlic. It causes brown oval lesions with purplish centres, up to 3 cm in diameter on the leaves. Symptoms begin as water-soaked lesions that usually have a white center. With time, dark brown to black concentric rings form throughout the lesions. As the disease progresses, leaves become weakened and plants are easily blown over. Leaves may become girdled, and then collapse and die. If the fungus invades the bulb, the disease can cause bulb rot in storage.

Life Cycle: The fungus overwinters as mycelium in leaf debris and cull piles, but can also be seedborne on onion. During periods of high humidity in the spring, conidia are produced in infected crop residues and spread to new tissues by wind or splashing rain. Free moisture is required on the leaves for infection to occur. Cycles of infection can occur throughout the growing season when conditions are favourable. The pathogen often infects leaves damaged by other diseases, insects (onion thrips) or environmental stresses. The disease is most prevalent during warm (18 to 30 °C), wet growing seasons.

Pest Management

Cultural Controls: Removing crop residue and cull piles in the field and in storage sheds will reduce the incidence and severity of infection. A three to four year crop rotation with crops such as potato, carrot and lettuce will minimize pest populations. Fields that allow good air circulation and drainage will help minimize infections. Harvesting crops during dry weather and ensuring proper curing will prevent disease introduction into storage. Additional management practices for purple blotch are listed in *Tables 6 and 7*.

Resistant Cultivars: None available.

Issues for Purple Blotch

1. There is a need for non-conventional pesticides, including biopesticides for use in organic production systems, especially in organic leek production.

Stemphylium Leaf Blight (*Stemphylium vesicarium*)

Pest Information

Damage: Stemphylium leaf blight is an important fungal disease of the onion crop, but can also infect garlic and leeks. Symptoms often start as small yellow to tan, water-soaked lesions that develop into elongated leaf spotsthat turn dark olive brown to black when spores develop. Older leaves are more susceptible to infection than younger leaves. Symptoms are traditionally observed after the plant has reached the three- to four-leaf stage. As the disease progresses, leaves begin to die back from the tip resulting in early lodging, which can reduce bulb size and yield. Infected crops can become more susceptible to other pathogens.

Life Cycle: The pathogen overwinters on infected crop residue and begins releasing spores in the spring. Spores are mainly spread by wind, but can also be spread by splashing from rainfall or irrigation. Warm temperatures (18 to 26 ºC) and long periods of leaf wetness (six hours or more) are conducive to disease development. Leaf spot symptoms occur about six days after initial infection. The fungus is often found on leaves previously damaged by other diseases (e.g., purple blotch, downy mildew), insects (e.g., onion thrips), herbicides, and environmental stresses.

Pest Management

Cultural Controls: Controlling other diseases and insect pests on onion and avoiding herbicide injury will reduce the potential for leaf blight development. Providing proper nutrients throughout the growing season to mitigate the effects of environmental stresses will help the plants be more resilient to infections. Following a crop rotation of three years with non-host crops such as carrot, celery, lettuce and eliminating crop debris and cull piles from the field will also help to reduce disease development. Reducing the duration of leaf wetness by increasing plant spacing and air circulation, as well as timing irrigation practices for the morning will also help minimize the development of the disease. Regular field scouting is the current approach used to assess disease levels as no reliable forecasting model exists for Stemphylium leaf blight. Practicing fungicide rotation to minimize the potential for pathogen resistance development is important as several *S. vesicarium* isolates insensitive to some fungicides have been reported in New York.

Resistant Cultivars: None available.

Issues for Stemphylium Leaf Blight

1. Fungicides to control Stemphylium leaf blight are urgently needed as currently registered fungicides do not provide complete control of this disease.
2. The prevalence of Stemphylium leaf blight continues to increase in Quebec. It is important to continue to monitor this disease in the years to come. Predictive models adapted to the culture must be established.

Rust *(Puccinia allii (syn. Puccinia porri))*

Pest Information

Damage: This fungal pathogen primarily affects leek, but can also affect onion, garlic and chives. Rust is characterized by rust coloured pustules on both sides of leaf surfaces. Initially the leaves and stems harbour small circular white spots. As the disease progresses, spots become elongated, and orange spore pustules start to emerge through the epidermis, releasing clouds of dusty spores. Later in the season, brown to black spores are formed in the lesions and heavy attacks can cause the leaves to shrivel and die prematurely. Yields, bulb quality and storage ability can be significantly affected by the disease.

Life Cycle: The fungus overwinters in crop residues, volunteer crops and infected weeds as urediospores or teliospores. In the spring, spores are released and land on other plants thereby causing infection. Infection is favoured when temperatures range from 12 to 21 ºC. Spore germination requires a relative humidity over 97 percent for at least four hours. Spores can be spread by wind and by splashing water. Disease development is favoured at high plant density and during environmental stresses.

Pest Management

Cultural Controls: Following a crop rotation of three years with non-host crops, and removing plant residue, cull piles, and allium weeds in the field, will help to reduce the spread of rust. Planting in fields with adequate drainage can also help reduce disease incidence, as over irrigation can promote the formation of spores that cause the disease. Watering in the morning will allow sufficient time during the day for foliage to dry off. Eliminating excess nitrogen applications may help to minimize infection.

Resistant Cultivars: None available.

Issues for Rust

1. There is a need for efficacious fungicides for the control of garlic rust.

Fusarium Basal Rot (*Fusarium oxysporum*)

Pest Information

Damage: Fusarium basal rot causes a pinkish-brown rot at the base of the bulb and roots. Occasionally a reddish discolouration may appear on bulb sheathes of severely infected garlic plants early in the season. Early symptoms include yellowing and tip dieback of leaves. As the disease progresses the basal plate and roots start to decay, secondary bacterial rots can invade the bulb, and the whole plant may collapse. During very hot and dry conditions, infected plants wilt and bulbs appear watery and brown. A white mold is sometimes observed growing on the basal plate and occasionally orange to salmon coloured spore masses develop around the rotted basal plate. Plant growth and disease symptoms may be non-symmetrical as the infection may develop on only one side of the basal plate. Bulbs that appear to be free of symptoms at harvest may in fact, may be infected and decay in storage.

Life Cycle: Fusarium oxysporum is a persistent fungus that can overwinter as dormant spores in the soil or on plant residue. Spores can spread by water, wind and the movement of contaminated soil and infect onion or garlic bulbs at any stage of plant growth. Warm soil temperatures (optimum 29 ºC) and high soil moisture promote disease development. The fungus commonly enters plant tissues through damage caused by insects (e.g., onion maggot), nematodes (e.g., bulb and stem nematode) or other pathogens. The fungus is not usually an issue in cool growing seasons (soil temperatures below 15 ºC), even in heavily contaminated fields.

Pest Management

Cultural Controls: Avoidance of fields with a history of basal rot and following a three to four year crop rotation with non-allium crops will limit the spread of the disease. Using disease-free transplants will help prevent the introduction of the organism in the field. A hot water treatment of garlic cloves prior to planting can reduce infection rates. Curing in the field and discarding all damaged, bruised or infected bulbs prior to storing will reduce the development of the disease in storage. Well-ventilated storage facilities kept at 0 °C and at 60 to 70 percent relative humidity will slow the progression of the disease. Additional management practices for Fusarium basal rot are listed in *Tables 6 and 7*.

Resistant Cultivars: A number of early yellow, red Spanish and white varieties have tolerance to Fusarium basal rot.

Issues for Fusarium Basal Rot

1. There is a need for new conventional and non-conventional fungicides, including biofungicides for the control of Fusarium basal rot.
2. There is a need to understand the different species and pathovars of Fusarium.
3. Research to learn more about preventive measures such as green manure fumigants is needed.

Pink Root (*Phoma terrestris*)

Pest Information

Damage: Pink root infections cause a discolouration of roots with infected roots turning dark pink to purple. *Phoma terrestris* tends to affect mature plants as it requires warmer soil temperatures; however, if soil temperatures in the spring warm up enough, young plants can be infected. Infected roots wilt and eventually die while new roots on infected plants die quickly. Early above ground symptoms include wilted leaf tips. As the disease progresses there is tip dieback and stunted plant and bulb growth. This pathogen is also known to infect corn, potato, cucumber, peppers and tomato.

Life Cycle: Phoma terrestris is an opportunistic fungus that can overwinter and survive for years as dormant spores in the soil or on plant residue. Warm soil temperatures (24 to 30 ºC) and poorly drained fields favour disease development. When host plants are available, *P. terrestris* migrates to the host plant roots, releasing enzymes that provide an entrance for the pathogen. This fungus is not usually an issue in cool growing seasons (soil temperatures between 16 to 20 ºC) even in heavily contaminated fields.

Pest Management

Cultural Controls: A three to five year crop rotation with non-host crops will greatly reduce pathogen prevalence. Ensure regular intervals between irrigation as significant yield losses can occur under dry weather conditions. Plant resistant varieties of onions.

Resistant Cultivars: A number of early yellow, red Spanish and white varieties have tolerance to pink root. Early Japanese varieties appear to be very susceptible to pink root.

Issues for Pink Root

1. Pink root is prominent in onion fields in Ontario. There is a need for the registration of control products for pink root management and development of cultivars with resistance to the pathogen.

White Rot (*Sclerotium cepivorum*)

Pest Information

Damage: Sclerotium cepivorum is a regulated pest in Canada. The pest is a very destructive disease of onion, garlic and leek, causing watery rot and disintegration of infected bulbs. Garlic is most susceptible to the disease, followed by onion and leek. Initial symptoms include the yellowing of leaf tips, followed by dieback and death of the leaves. White mycelium grows around the base of the bulb and masses of tiny black sclerotia are formed. Eventually the entire plant is killed. Occasionally, white rot develops late in the growing season with symptoms on dry onion only observed once bulbs are in storage.

Life Cycle: Only members of the Allium genus are attacked by this pathogen. The disease is favoured by cool, damp conditions (10 to 24 °C) and typically develops in patches in the field. The fungus can survive as sclerotia in the soil for several years and germinate when roots of allium crops are in proximity. Infection is facilitated through wounds on roots and bulbs caused by feeding insects or other pathogens. The disease can spread by mycelial growth when plants are in close proximity to each other, by windblown spores, by equipment, by animals and by irrigation water. The fungus can be introduced into new areas through infected seed and transplants.

Pest Management

Cultural Controls: Thorough sanitation will minimize the spread of the disease. Sanitation practices may include the use of disease-free seed and transplants, the cleaning of machinery and containers, the use of clean irrigation water and the removal of infected plant material from the field. A hot water treatment of garlic cloves prior to planting can reduce infection rates. In small scale production, practices such as field solarisation and flooding during the spring can be used to encourage the decay of sclerotia. Long term crop rotation with unrelated crops can help maintain low fungus populations in the field. Minimizing the movement of contaminated soil will also reduce the spread of the disease to uncontaminated fields.

Resistant Cultivars: None available.

Issues for White Rot

1. There is a need for pest control products for the management of white rot.

Onion Smut (*Urocystis cepulae;* syn. *U. magica*)

Pest Information

Damage: Onion smut is a very serious fungal disease, primarily affecting onion seedlings. The disease is characterized by black streaks and blisters on the leaves and developing bulbs. Seedlings are often killed before the third and fourth leaves are produced. Plants that survive infection often produce little to no bulb; bulbs that do form may be distorted and will be covered with black streaks and lesions. Infected leaves may become twisted and bent. Bacterial soft rot commonly invades onions previously infected by onion smut.

Life Cycle: The fungus is very persistent, and can survive in the soil as spores (teliospores) for up to 15 years. Infection by spores occurs shortly after seed germination until the emergence of the first true leaf, a period of about 15 days. The pathogen infects the flag leaf (cotyledon) as it emerges from the soil. A cool wet spring increases the incidence of infection by slowing the growth of the seedlings, resulting in a longer period that the flag leaf is in contact with the soil. Spores can develop in the leaf blisters, which can split and release the spores into the soil. Spores can also be spread by wind, surface drainage water, on equipment, and by the movement of contaminated soil and infected plant parts. Bulbs of infected plants act as inoculum sources, passing on the disease to other bulbs in storage.

Pest Management

Cultural Controls: To reduce the period of seedling susceptibility to infection, seeds can be planted shallowly (< ½ cm) and the planting date may be delayed until soil temperatures rise, to promote rapid emergence. Planting uncontaminated onion sets and transplants, and cleaning equipment between fields can help minimize the spread of the disease to new areas.

Resistant Cultivars: None available.

Issues for Onion Smut

1. There is a need for the development of cultivars with resistance to onion smut.
2. There is a need for the development of new seed treatments and in-furrow treatments for the prevention and control of onion smut.

Aster Yellows (Aster Yellows Phytoplasma)

Pest Information

Damage: Aster yellows is a widespread disease that affects a large number of wild and cultivated plants, including carrot, lettuce, celery, onion, spinach and ornamental crops. The disease generally causes more damage to onion seed crops than to onion bulb crops. The disease causes a yellowing of the leaves, which starts at the base of the young leaves and spreads towards the top. The leaves then flatten and become marked with yellow and green streaks. Plants are usually stunted, resulting in reduced bulb size and yield. In infected plants grown for seed, flower stems become abnormally elongated, and have malformed, sterile floral clusters.

Life Cycle: The aster yellows phytoplasma can overwinter in adult leafhoppers, cereals, weeds and ornamentals, and spreads naturally by leafhoppers. While approximately 20 insect species can transmit the disease, the aster leafhopper (*Macrosteles quadrilineatus*) is reported to be the principal leafhopper vector. Leafhoppers acquire the pathogen from an infected host plant during feeding. The pathogen incubates within the leafhopper for 10 days before it can be transmitted to new plants. The leafhopper can remain active and continue to spread the disease for more than 100 days after acquiring the pathogen. The spread of the disease may be increased by rainfall as this makes plants more succulent and attractive to leafhoppers.

Pest Management

Cultural Controls: The control of biennial and perennial weeds on headlands, along roadways and fences, in ditch banks, and in adjacent fields will help reduce the spread of the disease as they can serve as overwintering hosts for aster yellows phytoplasma. Early planting will promote the establishment of plants before infection can become a concern. The control of leafhopper populations in the crop and on weeds as early in the season as possible will also minimize the potential for phytoplasma infection. Several species of parasitoid wasps are able to attack the aster leafhopper.

Resistant Cultivars: None available.

Issues for Aster Yellows

1. The prevalence of aster yellows in a crop is a function of the number of leafhoppers and the proportion of that population that are carrying the phytoplasma. There is a need to develop economic thresholds, based on the proportion of leafhoppers carrying the aster yellows phytoplasma to determine when leafhopper control needs to be implemented.
2. There is a need for a quick, effective field test to determine if leafhoppers are carrying the aster yellows phytoplasma.

Iris Yellow Spot Virus (IYSV)

Pest Information

Damage: The IYSV has a relatively restricted host range that includes Allium crops, some ornamental species and a few weed species. Damage is characterized by straw coloured, diamond- and spindle-shaped lesions on leaves. In the early stages of infection, lesions appear as oval, concentric rings. On second year crops (onions from sets, garlic), active lesions may have a yellow halo surrounding a green island of leaf tissue. Infected leaves eventually fall over during the latter part of the growing season. The IYSV does not always kill its host; however, the virus can reduce plant vigour, disturb photosynthesis and reduce bulb size. Infection at early stages of crop growth usually results in yield losses. Infection at later stages of development can still cause significant losses due to reduced quality.

Life Cycle: The IYSV is a tospovirus that is transmitted by onion thrips. It does not appear to be seed-borne or seed-transmitted in onion. It likely overwinters in volunteer onions or weeds found among or around crops, where larval thrips acquire the virus while feeding. Thrips can transmit the virus from the second larval instar through adults, persistently for the remainder of its lifetime. Thrips are favoured under hot, dry weather conditions and they are present throughout the growing season. The IYSV is not distributed uniformly throughout the host plant. The highest titers are typically found in the inner leaves where thrips tend to congregate and feed. The IYSV can also accumulate in some onion bulbs.

Pest Management

Cultural Controls: Removing volunteer plants and weeds will help reduce disease inoculum. Following a three year crop rotation with unrelated crops will reduce the build-up of thrips populations. Carefully inspecting transplants for IYSV and thrips will minimize their introduction into the field. Isolating onion bulb and seed crops geographically from one another will also help to prevent the spread of the disease. Planting early maturing varieties or harvesting transplants early will aid in preventing potential yield loss from IYSV.

Resistant Cultivars: None available.

Issues for Iris Yellow Spot Virus

1. Iris yellow spot virus is present in Ontario and allium plant material should be tested for the virus.

Nematodes: Stem and Bulb Nematode *(Ditylenchus dipsaci)* and Root Lesion Nematode *(Pratylenchus penetrans)*

Pest Information

Damage: Allium crops susceptible to invasion by nematodes include chives, leek, onion, and garlic, with the latter being particularly affected by damage caused by stem and bulb nematode. Stem and bulb nematode is a regulated pest in Canada and several other countries. Plants can become infected during or shortly after germination. Seedling bases become swollen, and leaves appear twisted, malformed and may bear slightly raised pimple-like spots. Severely infected plants eventually turn yellow and die. Plants that do not die are stunted and have badly deformed bulbs that are prone to secondary infections by fungi and bacteria, and sometimes to invasion by maggots. Bulbs can be discoloured, spongy and bloated and may split when dried. Severely infected garlic bulbs tend to be soft, shriveled, discoloured and lighter in weight. The damage can occur in the field and in storage if not kept at low temperatures and can lead to yield losses of up to 90 percent. If garlic plants become infected late in the summer or close to harvest, no noticeable damage to the mature bulbs and cloves will occur, which may lead to their selection and replanting in the fall, and consequently to nematode infection the following season. Root lesion nematodes feed on the roots of allium crops causing stunting and wilting of foliage and bulbs. Feeding sites also provide entrance sites for pathogenic soil bacteria and fungi that can grow rapidly in the lesion and accelerate decomposition of root tissues.

Life Cycle: These nematodes have a very extensive host range of more than 450 species. They can spread by contaminated irrigation water, soil, equipment and by infected plants and seed. In garlic, stem and bulb nematode enter the host through the roots or wounds on bulbs. In onions, they move down inside the leaf sheath until they reach the bulb and feed between onion scales. They may also migrate up the stem and infect young leaves. Root lesion nematodes migrate through the soil, infecting roots. All life stages of nematodes can penetrate roots and cause damage. They can become dormant at advanced juvenile stages and survive in the soil for many years, even under extreme conditions.

Pest Management

Cultural Controls: The most effective management of nematodes is an integrated approach that focuses on preventing soil populations from reaching damaging threshold levels and planting clean nematode-free seed. Soil samples taken before planting or after harvest can be analysed for species identification and nematode enumeration. The economic thresholds for stem and bulb nematode and root lesion nematode in allium crops is 100 nematodes per kilogram of soil and 1000 nematodes per kilogram of soil, respectively. Carefully inspecting seed, sets, bulbs and transplants before planting for signs of nematode contamination will help prevent the introduction in disease-free fields. Hot water treatment (49 °C for 20 minutes) and meristem tip culture are efficient methods for eliminating nematodes in seed cloves. Rogueing out plants with obvious symptoms will help reduce the potential of the nematodes moving to neighbouring plants. Following at least a three year crop rotation with non-host crops, while also avoiding legumes, and removing cull piles will help reduce numbers of infective juveniles. Proper sanitation of equipment will help prevent the spread of nematodes. Planting allium crops during cooler temperatures may limit damage to new seedlings as nematodes are usually not very active at cooler temperatures. Adequate weed management can be beneficial, as several weeds can act as maintenance hosts for nematodes. Summer fallow, flooding, various organic amendments, and a number of biological products are reported to reduce nematode populations. Planting a cover crop such as oriental mustard before planting garlic can help suppress nematodes in the soil.

Resistant Cultivars: None available.

Issues for Nematodes

1. In Ontario, the stem and bulb nematode is primarily an issue in garlic. Conventional and non-conventional nematicide registration, and bio-nematicide development for onion and leek, or other allium crops, would be important tools to have in the event of an outbreak.
2. Research on general management strategies of nematodes (e.g., effectiveness of green manures, prevention strategies) is needed.

Bacterial Diseases (Slippery Skin (Burkholderia gladioli; syn. *Pseudomonas gladioli*), Sour Skin (*Burkholderia cepacia*), Soft Rot (*Pectobacterium carotovorum* subsp. *carotovorum*))

Pest Information

Damage: Bacterial diseases may initially show symptoms on the leaves, characterized by wilting, yellowing and dieback. Later, bacterial diseases will cause bulbs to become watery and eventually to breakdown into an odorous sticky material, making them unmarketable. Slippery skin mostly affects onions. Onions may appear sound on the surface, but the inner rotted portions slide out through the neck when squeezed. Sour skin only affects onions. Symptoms include tan or brown rotted leaves, soft rot near the neck, and diseased scales separating from healthy scales. Secondary organisms such as yeasts are often associated with this disease and may be responsible for the acrid, vinegar-like odor from which the name “sour skin” was derived. Soft rot can affect most cultivated Allium species. Bulbs may have symptoms ranging from rot near the neck, spongy or water-soaked scales to a complete bulb breakdown.

Life Cycle: These pathogens can survive in the soil and on allium crop residues. Rain and irrigation transfer the bacteria to the plant where they can enter through natural openings or wounds made by insects, diseases, damaging winds, pounding rain or hail. Once the bacteria infect the leaves, they multiply inside the tissues and move downward into the bulb killing the tissue as they advance. Disease development is favoured under high humidity and hot (> 30 °C) temperatures, although even at cool to moderate temperatures bacteria are still capable of multiplying, but symptoms develop slowly and may not be detected until the bulbs have been in storage for some time. Once in storage, diseased bulbs may deteriorate, impacting quality.

Pest Management

Cultural Controls: Since bacteria can enter the crop through wounds, minimizing insect damage, bruising and mechanical injury will reduce the potential for disease development. Following a three year crop rotation with non-host crops and eliminating cull piles in the field will help keep pathogen populations in the soil low. Planting in well-drained soils and using adequate row spacing will help keep local humidity low, which will reduce infection. Using a moderate fertilizer program especially after bulb initiation will help reduce disease development and losses. Harvesting when the crop is fully mature, properly curing, and carefully inspecting the crop before putting into storage will help prevent the spread of the disease in storage. Maintaining adequate temperature and moisture conditions in storage, as well as monitoring storage facilities often for signs of bacterial diseases will also help minimize the spread of the disease.

Resistant Cultivars: None available.

Issues for Bacterial Diseases

1. Innovative and cultural alternatives need to be developed for the management of bacterial diseases of allium crops, in both the field and storage.
2. Harvest and storage conditions that can reduce or prevent the survival of bacterial diseases need to be identified.
3. There is a need to identify the source of inoculum of bacterial diseases.

Botrytis Neck Rot (*Botrytis* spp.)

Pest Information

Damage: Botrytis neck rot is an important storage disease of dry onions and can also occur on garlic, leeks, shallots and chives. The three main species involved in neck rot disease are *Botrytis allii*, *B. aclada* and *B. byssoidea*. Onions are often infected through the neck when the tops are cut prior to storage or through bruises. Symptoms of the disease begin with softening of the affected neck scale tissue that takes on a sunken, cooked appearance. A definite margin becomes visible between healthy and diseased tissue. As the disease progresses, the tissue becomes grey and a grey mold may also develop. As the pathogen spreads throughout the bulb, mycelia begin to appear. The onion becomes blackened and mummified, making it unmarketable. The mycelium can spread to other bulbs in storage. Additional losses can result from secondary infections by bacterial soft rot. The disease is not much of a concern for green onion and shallot since they are not stored for a significant length of time.

Life Cycle: Sclerotia overwinter in the soil and on culled onions and may survive for several years. In the spring, conidia are produced that are carried by wind to the allium crop. The spores infect young plants, and it may take a significant amount of time for symptoms to appear. The disease is more prevalent in cool, wet conditions ranging from 15 to 20 °C and under these conditions, continual spore germination can occur. The fungus can also be seed-borne.

Pest Management

Cultural Controls: Proper field sanitation including removing cull plants and cull piles from the field is beneficial for preventing neck rot outbreaks. Following a three year crop rotation with crops unrelated to Alliums, such as carrot, corn or celery will help diminish pathogen populations. Using well-drained soils and planting crops early, with adequate row spacing will help maintain low humidity and encourage early emergence, which will discourage infection. Harvesting during dry conditions, when the crop is fully mature, and properly curing the crop will minimize potential for disease damage in storage. While in storage, the progression of the disease can be slowed at 0 °C and at 60 to 70 percent relative humidity.

Resistant Cultivars: Highlander is tolerant; *Norstar* is highly tolerant.

Issues for Botrytis Neck Rot

1. Field research to determine whether fungicides registered for Botrytis leaf blight (*Botrytis squamosa*) are also effective against neck rot (*Botrytis* spp.) is needed.
2. Further research is needed on the biology of the pathogen and epidemiology of the disease, as well as the timing of treatment, in order to develop an effective management strategy for neck rot.

Insects and Mites

Key Issues

- There is the need for additional insecticides for control and resistance management of onion maggot and seedcorn maggot.

- While thrips populations have been average over the past three years, it’s important to note that in some years, populations can be high and difficult to control with currently available insecticides. New insecticides for effective management of thrips remains a key issue.

Table 8. Occurrence of insect pests in dry onion in Canada[1,2]

Insects and mites	Ontario	Quebec
Onion maggot, seed corn maggot		
Onion thrips		
Black cutworm		
Dark-sided cutworm		
Leafminers		
Aster leafhopper		
Leek moth		
Wireworms		
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 pest 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 pressure.		

[1]Source: Onion stakeholders in reporting provinces (Ontario and Quebec); the data reflect the 2019, 2020 and 2021 production years.
[2]Refer to Appendix 1 for a detailed explanation of colour coding of occurrence data.

Table 9. Occurrence of insect pests in leek in Canada[1,2]

Insects and mites	Ontario	Quebec
Onion maggot, seed corn maggot		
Onion thrips		
Black cutworm		
Dark-sided cutworm		
Leafminers		
Aster leafhopper		
Leek moth		
Wireworms		
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 pest 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 pressure.		
Pest not present.		

[1]Source: Leek stakeholders in reporting provinces (Ontario and Quebec); the data reflect the 2019, 2020 and 2021 production years.
[2]Refer to Appendix 1 for a detailed explanation of colour coding of occurrence data.

Table 10. Adoption of insect management practices in dry onion crop production in Canada[1]

Practice / Pest		Onion maggot/ Seedcorn maggot	Onion thrips	Cutworms	Aster leafhopper	Leek moth
Avoidance	Varietal selection / use of resistant or tolerant varieties					
	Planting / harvest date adjustment					
	Rotation with non-host crops					
	Choice of planting site					
	Optimizing fertilization for balanced growth					
	Minimizing wounding to reduce attractiveness to pests					
	Reducing pest populations at field perimeters					
	Use of physical barriers (e.g., mulches, netting, floating row covers)					
	Use of pest-free propagative materials (seeds, cuttings or transplants)					
Prevention	Equipment sanitation					
	Canopy management (e.g., thinning, pruning, row or plant spacing)					
	Manipulating seeding / planting depth					
	Irrigation management (timing, duration, amount) to manage plant growth					
	Management of soil moisture (e.g., improvements to drainage, use of raised beds, hilling, mounds)					
	End of season or pre-planting crop residue removal / management					
	Pruning out / removal of infested material throughout the growing season					
	Tillage / cultivation to expose soil insect pests					
	Removal of other hosts (weeds / wild plants / volunteer crops) in field and vicinity					

…continued

Table 10. Adoption of insect management practices in dry onion crop production in Canada[1] (continued)

Practice / Pest		Onion maggot/ Seedcorn maggot	Onion thrips	Cutworms	Aster leafhopper	Leek moth
Monitoring	Scouting / trapping	green	green	green	green	green
	Maintaining records to track pests	green	green	green	green	green
	Soil analysis for pests	red	red	red	red	red
	Weather monitoring for degree day modelling	green	red	red	green	green
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of pests	green	green	green	green	green
Decision making tools	Economic threshold	green	green	green	green	
	Use of predictive model for management decisions	green	green	red	green	green
	Crop specialist recommendation or advisory bulletin	green	green	green	green	green
	Decision to treat based on observed presence of pest at susceptible stage of life cycle	green	green	green	green	green
	Use of portable electronic devices in the field to access pest identification / management information	green	green	green	green	green
Suppression	Use of diverse pesticide modes of action for resistance management	green	green	green		green
	Soil amendments and green manuring involving soil incorporation as biofumigants, to reduce pest populations	red		red	red	red
	Use of non-conventional pest control products (e.g., biopesticides)	red	green	green		green
	Release of arthropod biological control agents	red	red	red	red	red

…continued

Table 10. Adoption of insect management practices in dry onion crop production in Canada[1] (continued)

	Practice / Pest	Onion maggot/ Seedcorn maggot	Onion thrips	Cutworms	Aster leafhopper	Leek moth
Suppression	Preservation or development of habitat to conserve or augment natural controls (e.g., preserve natural areas and hedgerows, adjust crop swathing height)	Green	Green	Green	Green	Green
	Mating disruption through the use of pheromones	Red	Red	Red	Red	Red
	Mating disruption through the release of sterile insects	Green	Red	Red	Red	Red
	Trapping	Green	Red	Green	Red	Green
	Targeted pesticide applications (e.g., banding, spot treatments, use of variable rate sprayers)	Green	Green	Green		Green
	Selection of pesticides that are soft on beneficial insects, pollinators and other non-target organisms	Green	Green	Green		Green

Green: This practice is used to manage this pest by at least some growers in the province.

Red: This practice is not used by growers in the province to manage this pest.

White (empty): This practice is not applicable for the management of this pest

[1]Source: Dry onion stakeholders in reporting provinces (Ontario and Quebec); the data reflect the 2019, 2020 and 2021 production years.

Table 11. **Adoption of insect management practices in leek crop production in Canada[1]**

Practice / Pest		Onion maggot/ Seedcorn maggot	Onion thrips	Cutworms	Aster leafhopper	Leek moth
Avoidance	Varietal selection / use of resistant or tolerant varieties					
	Planting / harvest date adjustment					
	Rotation with non-host crops					
	Choice of planting site					
	Optimizing fertilization for balanced growth					
	Minimizing wounding to reduce attractiveness to pests					
	Reducing pest populations at field perimeters					
	Use of physical barriers (e.g., mulches, netting, floating row covers)					
	Use of pest-free propagative materials (seeds, cuttings or transplants)					
Prevention	Equipment sanitation					
	Canopy management (e.g., thinning, pruning, row or plant spacing)					
	Manipulating seeding / planting depth					
	Irrigation management (timing, duration, amount) to manage plant growth					
	Management of soil moisture (e.g., improvements to drainage, use of raised beds, hilling, mounds)					
	End of season or pre-planting crop residue removal / management					
	Pruning out / removal of infested material throughout the growing season					

…continued

Table 11.. Adoption of insect management practices in leek crop production in Canada[1] (continued)

Practice / Pest		Onion maggot/ Seedcorn maggot	Onion thrips	Cutworms	Aster leafhopper	Leek moth
Prevention	Tillage / cultivation to expose soil insect pests					
	Removal of other hosts (weeds / wild plants / volunteer crops) in field and vicinity					
Monitoring	Scouting / trapping					
	Maintaining records to track pests					
	Soil analysis for pests					
	Weather monitoring for degree day modelling					
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of pests					
Decision making tools	Economic threshold					
	Use of predictive model for management decisions					
	Crop specialist recommendation or advisory bulletin					
	Decision to treat based on observed presence of pest at susceptible stage of life cycle					
	Use of portable electronic devices in the field to access pest identification / management information					
Suppression	Use of diverse pesticide modes of action for resistance management					
	Soil amendments and green manuring involving soil incorporation as biofumigants, to reduce pest populations					

…continued

Table 11.. Adoption of insect management practices in leek crop production in Canada[1] (continued)

Practice / Pest		Onion maggot/ Seedcorn maggot	Onion thrips	Cutworms	Aster leafhopper	Leek moth
Suppression	Use of non-conventional pest control products (e.g., biopesticides)	[red]	[red]	[red]	[white]	[green]
	Release of arthropod biological control agents	[red]	[red]	[red]	[red]	[green]
	Preservation or development of habitat to conserve or augment natural controls (e.g., preserve natural areas and hedgerows, adjust crop swathing height)	[green]	[green]	[green]	[green]	[green]
	Mating disruption through the use of pheromones	[red]	[red]	[red]	[red]	[red]
	Mating disruption through the release of sterile insects	[green]	[red]	[red]	[red]	[red]
	Trapping	[green]	[red]	[green]	[green]	[green]
	Targeted pesticide applications (e.g., banding, spot treatments, use of variable rate sprayers)	[green]	[green]	[green]	[white]	[red]
	Selection of pesticides that are soft on beneficial insects, pollinators and other non-target organisms	[green]	[green]	[green]	[red]	[green]

This practice is used to manage this pest by at least some growers in the province. [green]
This practice is not used by growers in the province to manage this pest. [red]
This practice is not applicable for the management of this pest [white]

[1]Source: Leek crop stakeholders in reporting provinces (Ontario and Quebec); the data reflect the 2019, 2020 and 2021 production years.

Onion Maggot (*Delia antiqua*) and Seedcorn Maggot (*D. platura*)

Pest Information

Damage: The onion maggot is the most damaging insect pest of onion in Canada. The most serious damage occurs in early spring by first generation larvae that feed on the roots of plants. One larva can destroy 20 to 30 seedlings. Above-ground damage symptoms depend on the growth stage when the plant is attacked. An attack in early growth stages (e.g., emergence) will cause the plant to wilt and disappear. An attack at the two- to three-leaf stage will cause wilting, leaves to turn pale green or yellow and stem rotting. Onion plants attacked mid-season are usually not killed; however, plants may have misshapen bulbs that are often infected by fungal or bacterial pathogens. Annual losses to commercial onion crops average about 2 to 5 percent across Canada, despite heavy use of insecticides. However, in the absence of insecticidal treatments, average yearly losses to onion maggot would be in the order of 40 to 45 percent in commercial fields. The seedcorn maggot attacks newly planted seeds, often leaving empty seed shells and preventing germination. Seedlings that do emerge are often spindly and die before maturation. Occasionally, seedcorn maggots tunnel within seedling stems and germinating seeds.

Life Cycle: Onion maggot pupae overwinter in the soil. Adult flies emerge in the spring when the temperature rises above 4 °C. Emergence usually begins when 300 degree-days above 4 °C have accumulated after March 1. Adults disperse randomly, often remaining within a few hundred metres of their emergence sites. After five to seven days, adults mate in or near onion fields. Three to four days following mating, the females lay eggs in the soil adjacent to onion seedlings. After hatching, young larvae feed on onion roots for about two to three weeks and then pupate. There can be up to three generations of onion maggots per year depending on the region. Seedcorn maggot are polyphagous insects; pupae overwinter in the soil and adults emerge earlier than the onion maggot and have two generations in the onion growing regions of Canada.

Pest Management

Cultural Controls: The removal of diseased and weakened onions and cull piles from the field, as well as avoiding animal or green manure incorporation prior to onion seeding are beneficial practices to control maggot populations, as these are preferred egg-laying and feeding spots of the pests. Other preventative measures for the seedcorn maggot may include late planting, shallow planting, higher seeding rates, and planting into a well-prepared seedbed. Following a three year crop rotation with unrelated crops and planting allium crops at least one kilometre away from previous plantings will help to keep maggot populations low. The release of sterile insects is currently being used in Quebec and has been shown to reduce onion maggot populations. Refer to the Pest Management Centre's Sustainable Crop Protection factsheet on Sterile Insect Technology: A Different Way to Manage Onion Maggot for more information. The use of sticky traps and visual scouting to monitor maggot populations and determine the need and timing of insecticide treatments is also beneficial. A degree-day prediction model for onion maggot emergence is available for Quebec producers. Because damaged onion bulbs are the major food source for late-summer onion maggot larvae, which in turn become the overwintering pupae, it is very helpful to minimize mechanical injury to onions at this time. Several parasitoids, predators and diseases of these two pests have been identified and it may be beneficial to grow plants that harbor the natural enemies and to apply insecticides that are not harmful to these species. Trap crops, such as the green onion variety *Green Banner*, planted along the perimeter of onion fields may help lure onion maggots out of the field. Additional management practices for maggots are listed in *Tables 10 and 11*.

Resistant Cultivars: None available.

Issues for Onion Maggot / Seed Corn Maggot

1. Resistance management is an ongoing concern due to resistance to granular, in-furrow treatments applied at seeding. There is a need for new, effective control products with different modes of action for resistance management.
2. There is the need for the registration of additional products for onion maggot and seedcorn maggot control.
3. Promotion of sterile fly technology for management of onion maggot throughout the province is needed. As well, monitoring of natural onion fly pressure should be promoted.

Onion Thrips (*Thrips tabaci*)

Pest Information

Damage: Damage is caused by both nymph and adult feeding. Onion thrips have piercing mouthparts with which they suck juice from the leaves of plants. Feeding results in silver streaks on the foliage that coalesce to form white patches. The leaves of severely affected plants die back from the tip and become wilted and distorted. Heavy thrips feeding can result in earlier ripening, undersized bulbs, yield reductions and plant death. Feeding damage also predisposes plants to foliar diseases. Infestations are often reduced by a drenching rain. Feeding by thrips often makes green onions and shallots unmarketable due to the unsightly patches generated on the leaves.

Life Cycle: Onion thrips are highly polyphagous, feeding on many different vegetable, forage and weed hosts. The insect overwinters as an adult or a nymph in a variety of crops and weeds. Infestations often begin at field borders and gradually spread in the direction of the prevailing wind through the rest of the crop. Thrips may also be wind-blown from neighbouring fields. Females are able to reproduce asexually (without mating). In the spring, eggs are oviposited on allium leaves and/or other host plants. The eggs hatch in five to 10 days. Nymphs cluster at the base of the plant in the leaves that are close together. As they mature, nymphs move over the leaves to feed and then drop to the soil to pupate. There are several generations per year, depending on temperature. Thrips are most active during hot and dry weather. If temperatures remain above 32 °C, a complete life cycle can occur in 12 days. They can also transmit several plant pathogens, including viruses and the causal agent of powdery mildew.

Pest Management

Cultural Controls: Planting onions at least two kilometres away from other host crops, especially alfalfa and wheat, and eliminating weeds around the perimeter of the field in the spring will help reduce onion thrips populations entering the field. Following a two to three year crop rotation with non-host crops, eliminating volunteers, debris and cull piles, and using heavy irrigation can also help diminish thrips populations. Applying shredded straw early in the season may delay thrips infestations and significantly reduce their overall abundance without affecting crop yield. Thrips can be monitored with white sticky traps or by shaking sample plants over a white surface. A spray threshold for dry cooking onions, leeks and Spanish onions has been established at one thrips per leaf. There are several natural enemies of onion thrips such as minute pirate bugs, lacewings, predatory mites, ladybird beetles, and spiders. Additional management practices for onion thrips are listed in *Tables 10 and 11*.

Resistant Cultivars: Some onion varieties with a light green leaf colour, semi-glossy appearance and with a more open canopy seem to be less attractive to thrips; however there are no resistant cultivars.

Issues for Onion Thrips

1. An effective integrated management approach is needed to improve the control of onion thrips. Research on onion thrips as vectors of disease is needed. Monitoring to determine what, if any diseases may be vectored and spread by onion thrips is needed.

Cutworms: Black Cutworm (*Agrotis ipsilon*), Darksided Cutworm (*Euxoa messoria)*

Pest Information

Damage: Most cutworm larvae feed on foliage and clip the stems of young plants at or below the soil line. The black cutworm can also feed on the roots and underground stems of clipped plants. Most of their damage is found at the field edge or in weedy fields. The most serious feeding injury results from early spring feeding by first generation cutworms. One cutworm can kill several plants.

Life Cycle: Most black cutworm moths are carried northward on winds from the United States in the early spring. Darksided cutworms are distributed throughout the United States and the southern parts of Canada and may overwinter in host weeds. Cutworms are more commonly found in low lying areas of the field where there is standing moisture. Eggs are laid on grasses and weeds, or under debris in cultivated fields. Following hatching, larvae can move into the crop to feed. Feeding occurs at night. At maturity, the larvae tunnel into the soil and pupate. Moths emerge through the larval tunnels. There is only one generation of darksided cutworm, but two generations of black cutworm may occur in Canada.

Pest Management

Cultural Controls: Cultivation to destroy weeds and other vegetation 10 days before planting and maintaining weed-free field and field perimeter throughout the growing season may reduce the number of cutworm larvae. Cutworm larvae have several natural enemies such as predators (e.g., birds, beetles, and ants), parasitoids, and pathogens. Following practices that conserve natural enemy populations, such as minimizing unnecessary sprays, can help reduce the severity of cutworm outbreaks. Proper drainage and following a two to three year crop rotation with unrelated host crops may also minimize the number of cutworms in the field. Adult populations can be monitored with black light traps and/or sex pheromones. Additional management practices for cutworms are listed in *Tables 10 and 11*.

Resistant Cultivars: None available.

Issues for Cutworms

1. Phase out of some effective pest control products has increased the need for new insecticides for cutworm management, particularly when pest pressure is high.

Leafminer (*Liriomyza* spp.)

Pest Information

Damage: Leafminer larvae feed on leaves making leaf punctures that appear as small white speckles on the upper side of the leaf. Leaf punctures are also created during oviposition, but are usually smaller and more uniformly round. Larger larvae may feed inside the hollow leaves of onions or garlic. Mines are created by larvae tunnelling within the leaf tissues. Depending on the species, mines can be serpentine, tightly coiled, irregular shaped or straight, and increase in width as the larvae mature. Young plants are particularly susceptible to leafminer damage, which may cause considerable delay in plant development, wilting and/or death. Damaged plants have reduced photosynthesis, which leads to reduced plant metabolism and vigour. Mines and punctures caused by leafminers can facilitate secondary infections by fungi and bacteria. On green bunching onions, aesthetic damage caused by leafminers can reduce the value of the crop and may even render it unmarketable. Damage to dry onions and garlic is usually of little concern unless populations become excessive and prematurely kill foliage.

Life Cycle: In Canada, there are four main species of leafminers that attack Allium crops (*Liriomyza sativae, L. huidobrensis, L. trifolii, and L. brassicae*). They are polyphagous, able to colonize a wide range of plants and are very similar in appearance and behaviour. Many species of leafminers are able to overwinter in Canada; however, it is unclear if *L. huidobrensis* can overwinter outside of greenhouses. Leafminers can be wind-blown into crops from surrounding vegetation/fields. Female flies insert their eggs just beneath the leaf surface, eggs hatch in four to seven days at 24 °C. Larvae feed between the leaf surfaces until maturity (four to six days) and then drop to the soil to pupate. Generally, adults emerge seven to fourteen days after pupation at temperatures between 20 and 30 °C and live for 15 to 30 days. However, pupation may be adversely affected by high humidity and drought. Mating takes place from 24 hours after adult emergence. Female flies puncture the leaves of the host plants causing wounds that serve as sites for feeding or oviposition.

Pest Management

Cultural Controls: Following a two to three year crop rotation with crops that cannot harbor leafminers, and planting allium crops away from lettuce, celery, and spinach will help minimize infestations. Destroying remains of broadleaf weeds and senescent crops is beneficial as these can harbor reproductive leafminers. Leafminers have several natural enemies including parasitoids, predatory insects and pathogens. Increasing the action of these through habitat management can help maintain low leafminer populations. Parasitic wasps are especially useful at reducing leafminer numbers. The use of *L. sativae* and *L. trifolii* sterile insects has been shown to successfully reduce pest populations in other jurisdictions and is likely applicable to all *Liriomyza* spp. Yellow sticky traps can be used to monitor and to suppress adult populations.

Resistant Cultivars: None available.

Issues for Leafminer

None identified.

Aster Leafhopper (*Macrosteles fascifrons*)

Pest Information

Damage: Adult leafhoppers occasionally feed on onion but generally do not cause noticeable direct injury. They are a concern because they can acquire and transmit the aster yellows disease through their feeding activity. The first generation of leafhoppers usually causes the most crop damage. Refer to *aster yellows* in the disease section for more information on damage caused by this disease.

Life Cycle: Leafhoppers feed on a broad range of plants. While cereals and grasses are their preferred hosts, leafhoppers also feed on many broadleaf weeds. In Ontario, there are two to five generations per year. They overwinter as eggs in the leaf tissue of winter cereals and grasses or are blown northward from overwintering sites in the United States. Leafhoppers are relatively poor fliers and tend to only take flight when temperatures exceed 15 °C. Eggs are laid on the underside of leaves. Following hatch, nymphs feed on host plants and develop into adults in two to three weeks. Leafhoppers can become infected with the aster yellows pathogen by feeding on infected host plants. Once infected, it takes about 10 days for the leafhopper to become capable of transmitting the disease to new plants. A leafhopper can remain active and continue to spread the disease for more than 100 days after acquiring the pathogen.

Pest Management

Cultural Controls: Removing weeds within and on the perimeter of fields will help control leafhopper numbers, as several weeds are hosts. Seeding crops at an earlier date may diminish their attractiveness to migrating leafhoppers and conversely, excessive irrigation can make plants more succulent and increase the attraction of leafhoppers. Several species of parasitoid wasps attack the aster leafhopper. Efforts to conserve beneficial insect populations may help to control leafhopper populations. Pest populations can be monitored through the use of yellow sticky traps or with sweep net monitoring. Additional management practices for aster leafhopper are listed in *Tables 10 and 11*.

Resistant Cultivars: None available.

Issues for Aster Leafhopper

1. There is a need for the development of economic thresholds, based on leafhopper numbers and the proportion that are carrying Aster yellows, to determine when leafhopper controls need to be implemented in allium crops.
2. There is a need for a quick, effective field test to determine if leafhoppers are carrying the Aster yellows phytoplasma.

Leek moth (*Acrolepiopsis assectella*)

Pest Information

Damage: The leek moth is an invasive alien species of European origin that attacks several Allium species, with a preference for leeks, garlic, onions and chives. Larval tunnelling and feeding can cause significant injury on leaf tissue and occasionally on bulbs. This pest can cause a series of pinholes on the inner leaves of leeks and garlic, and create translucent "windows" on the surface of onion and chive leaves as a result of internal feeding. Occasionally, larvae attack reproductive parts of the host plant, but usually avoid the flowers. Affected plants may appear distorted and are more susceptible to plant pathogens. Damage is often more prevalent near the field perimeters.

Life Cycle: The leek moth overwinters as adult moths or pupae in buildings, hedges and plant debris. Adults become active in the spring when temperatures reach 9.5 °C and mate shortly thereafter. Adults are nocturnal with flights and mating restricted to the hours of darkness. Following mating, eggs are laid on lower leaf surfaces. Following hatching, young larvae enter leaves and begin to feed. After several days, they move to the younger leaves in the centre of the plant to feed. Larvae will feed for several weeks before exiting the foliage to spin cocoons on the leaf surface. Adults emerge in about 12 days, depending on weather conditions. There can be up to three generations per season.

Pest Management

Cultural Controls: Sanitation practices including the removal of infested leaves and the elimination of crop debris following harvest may help to reduce the number of leek moth. Delaying planting, following a crop rotation with non-susceptible hosts and planting allium crops away from infested areas may also help to minimize leek moth populations. Activity of leek moths can be monitored by scouting for damage, by using pheromone traps and by using a degree day model for producers in Quebec. The timing for insecticide applications can be based on these monitoring tools. The use of lightweight floating row covers may reduce damage from first and second generation larvae. Injury from late season leek moth attack can be avoided by harvesting the crop early. Since 2010, the parasitoid *Diadromus pulchellus* has been continually released in eastern Canada as a biological control agent for the long-term reduction of leek moth populations. Additional management practices for leek moth are listed in *Tables 10 and 11*.

Resistant Cultivars: None available.

Issues for Leek Moth

1. The registration of new conventional and non-conventional insecticides, including bioipesticides, are needed for the management of leek moth in both conventional and organic production systems.

Wireworms (Family: Elateridae)

Pest Information

Damage: Wireworm larvae feed on seeds and roots of plants, causing poor germination and weakening plants, which often die or are non-productive. Feeding is most severe during cool wet springs due to the slow rate of germination and growth. Wireworms often cause damage to plants in a random pattern in the field and are often most damaging on coarse sandy-loam soils.

Life Cycle: All life stages of the wireworm can overwinter. Many grass species are hosts for the pest. Early in the spring, adult wireworms, also called click beetles, lay their eggs around the roots of grasses and cereals. The eggs hatch in about a week and depending on the species, larvae will live for three to five years in the ground feeding on roots and seeds. Wireworms move up and down the soil profile in response to changes in soil temperature and moisture. During the heat of the summer and in the winter months, wireworm larvae will migrate deep into the soil for protection. They require three or more years to complete their life cycle. Throughout the year, wireworms of all sizes and ages are present in the soil as there is always an overlapping of generations. Wireworms are typically more numerous in soil that has been in sod for several years; however, they are becoming an increasing problem in fields that have been in cultivation for a number of years.

Pest Management

Cultural Controls: The use of fields known to have heavy wireworm infestations or fields coming out of sod will likely lead to increased crop damage. Eliminating grassy weeds within fields during the growing season will help minimize wireworm infestation as grasses are known hosts for egg-laying females. Wireworm presence may be monitored in the fall or early spring using bait stations, by field inspection or sampling, or with pheromone lures that attract adult click beetles. Trap cropping with wheat or applying a trap and kill strategy may provide some protection from damage to the crop.

Resistant Cultivars: None available.

Issues for Wireworms

1. Monitoring of wireworm populations and research to prevent damage is critical, in addition to the development of new pest control products.
2. Cultural methods (e.g., crop rotation) need to be investigated for the management of wireworm in onions.

Weeds

Key Issues

- Allium crops are poor competitors with weeds and significant crop loss due to weeds is possible. In addition, allium crops are sensitive to herbicide injury. There is a need for the development of an effective integrated approach to weed management in allium crops.

- There is a need for the registration of herbicides that provide effective control of annual weeds, especially in organic (muck) soils.

Table 12. Occurrence of weeds in dry onion in Canada[1,2]

Weeds	Ontario	Quebec
Annual broadleaf weeds	(red)	(red)
Annual grasses	(orange)	(red)
Perennial broadleaf weeds	(orange)	(orange)
Perennial grasses	(orange)	(orange)
Widespread yearly occurrence with high pest pressure. (red)		
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure. (orange)		

[1]Source: Onion stakeholders in reporting provinces (Ontario and Quebec); the data reflect the 2019, 2020 and 2021 production years.

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

Table 13. Occurrence of weeds in leek in Canada[1,2]

Weeds	Ontario	Quebec
Annual broadleaf weeds		
Annual grasses		
Perennial broadleaf weeds		
Perennial grasses		
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.		

[1]Source: Leek stakeholders in reporting provinces (Ontario and Quebec); the data reflect the 2019, 2020 and 2021 production years.

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

Table 14. Adoption of weed management practices in dry onion crop production in Canada[1]

Practice / Pest		Annual broadleaf weeds	Annual grasses	Perennial broadleaf weeds	Perennial grasses
Avoidance	Varietal selection / use of competitive varieties				
	Planting / harvest date adjustment				
	Crop rotation				
	Choice of planting site				
	Optimizing fertilization for balanced crop growth and to minimize stress				
	Use of weed-free propagative materials (seed, cuttings or transplants)				
	No till or low disturbance seeding to minimize weed seed germination				
	Use of physical barriers (e.g., mulches)				
Prevention	Equipment sanitation				
	Canopy management (e.g., thinning, pruning, row or plant spacing)				
	Manipulating seeding / planting depth				
	Irrigation management (timing, duration, amount) to maximize crop growth				
	Management of soil moisture (e.g., improvements in drainage, use of raised beds, hilling, mounds)				
	Weed management in non-crop lands				
Monitoring	Scouting / field inspection				
	Maintaining records of weed incidence including herbicide resistant weeds				
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of weeds				

…continued

Table 14. Adoption of weed management practices in dry onion crop production in Canada[1] (continued)

Practice / Pest		Annual broadleaf weeds	Annual grasses	Perennial broadleaf weeds	Perennial grasses
Decision making tools	Economic threshold				
	Crop specialist recommendation or advisory bulletin				
	Decision to treat based on observed presence of weed at susceptible stage of development				
	Use of portable electronic devices in the field to access weed identification / management information				
Suppression	Use of diverse herbicide modes of action for resistance management				
	Soil amendments and green manuring involving soil incorporation as biofumigants to reduce weed populations				
	Use of non-conventional pesticides (e.g., biopesticides)				
	Release of arthropod biological control agents				
	Mechanical weed control (cultivation / tillage)				
	Manual weed control (e.g., hand pulling, hoeing, flaming)				
	Use of stale seedbed approach				
	Targeted pesticide applications (e.g., banding, spot treatments, use of variable rate sprayers)				
	Selection of herbicides that are soft on beneficial insects, pollinators and other non-target organisms				
This practice is used to manage this pest by at least some growers in the province.					
This practice is not used by growers in the province to manage this pest.					
This practice is not applicable for the management of this pest					

[1]Source: Dry onion crop stakeholders in reporting provinces (Ontario and Quebec); the data reflect the 2019, 2020 and 2021 production years.

Table 15. Adoption of weed management practices in leek crop production in Canada[1]

	Practice / Pest	Annual broadleaf weeds	Annual grasses	Perennial broadleaf weeds	Perennial grasses
Avoidance	Varietal selection / use of competitive varieties				
	Planting / harvest date adjustment				
	Crop rotation				
	Choice of planting site				
	Optimizing fertilization for balanced crop growth and to minimize stress				
	Use of weed-free propagative materials (seed, cuttings or transplants)				
	No till or low disturbance seeding to minimize weed seed germination				
	Use of physical barriers (e.g., mulches)				
Prevention	Equipment sanitation				
	Canopy management (e.g., thinning, pruning, row or plant spacing)				
	Manipulating seeding / planting depth				
	Irrigation management (timing, duration, amount) to maximize crop growth				
	Management of soil moisture (e.g., improvements in drainage, use of raised beds, hilling, mounds)				
	Weed management in non-crop lands				
Monitoring	Scouting / field inspection				
	Maintaining records of weed incidence including herbicide resistant weeds				
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of weeds				

continued

Table 15. Adoption of weed management practices in leek crop production in Canada[1] (continued)

Practice / Pest		Annual broadleaf weeds	Annual grasses	Perennial broadleaf weeds	Perennial grasses
Decision making tools	Economic threshold				
	Crop specialist recommendation or advisory bulletin				
	Decision to treat based on observed presence of weed at susceptible stage of development				
	Use of portable electronic devices in the field to access weed identification / management information				
Suppression	Use of diverse herbicide modes of action for resistance management				
	Soil amendments and green manuring involving soil incorporation as biofumigants to reduce weed populations				
	Use of non-conventional pesticides (e.g., biopesticides)				
	Release of arthropod biological control agents				
	Mechanical weed control (cultivation / tillage)				
	Manual weed control (e.g., hand pulling, hoeing, flaming)				
	Use of stale seedbed approach				
	Targeted pesticide applications (e.g., banding, spot treatments, use of variable rate sprayers)				
	Selection of herbicides that are soft on beneficial insects, pollinators and other non-target organisms				
This practice is used to manage this pest by at least some growers in the province.					
This practice is not used by growers in the province to manage this pest.					
This practice is not applicable for the management of this pest					

[1]Source: Leek crop stakeholders in reporting provinces (Ontario and Quebec); the data reflect the 2019, 2020 and 2021 production years.

Annual and perennial weeds

Pest Information

Damage: Alliums, especially onions, are poor competitors with weeds, which can lead to significant crop loss due to weed competition. The critical stage for the control of weeds is early in the growing season. Broadleaf weeds can reach heights similar to that of onions and compete with the crop for light, water and nutrients. Grasses also cause significant problems in onion production because of their fast growth and ability to compete for necessary resources. Grass weeds can be very difficult to eliminate from infested fields. During harvest, weeds can interfere with harvesting equipment.

Life Cycle: Annual weeds complete their life cycle in one year, going from seed germination through growth to new seed production. Winter annuals begin their growth in the fall, growing a rosette and producing their seeds early in the following year. Annual weeds are very adept at survival and dissemination through the production of large numbers of seeds. Most arable land is infested with annual weed seeds at all times and some weed seeds can remain viable in the soil for many years, germinating when conditions are suitable. Perennial weeds can live for many years and generally establish from various types of root systems, although many will also spread by seeds. Tillage practices can break up underground root systems and contribute to the spread of perennial weeds.

Pest Management

Cultural Controls: An integrated approach for weed control is very important. Roadsides, ditches, and fence lines commonly host problematic weeds. Weed elimination from these areas can be beneficial to limit the spread of weed seeds into the field. Refraining from using fields with unknown weed history may be prudent. The use of certified seed to ensure lowest possible weed seed contamination of seed will help minimize weed introduction into the field. Cleaning soil from equipment between fields will minimize the spread of weeds from one field to the next. The application of well-composted manure as opposed to fresh manure can also minimize the introduction of weeds into a field, as it contains very little viable weed seed. Following a crop rotation and using a cover crop such as cereals and brassicas will also help manage weed populations. Shallow tilling and hilling during the growing season can help control weeds growing between the rows. Grass weeds require control prior to seed-set due to their prolific seeding. Additional management practices for weeds are listed in *Tables 14 and 15*.

Resistant Cultivars: Varieties that have quick emergence and produce vigorous crop stands will shade out germinating weed seeds.

Issues for Annual Weeds

1. In some areas, annual weeds have developed resistance to herbicides. Therefore, there is a need for the development of alternative approaches for the management of weeds in allium crops.
2. Registered herbicides are not fully effective against annual weeds on either organic or mineral soils. Newer root herbicides with short pre-harvest intervals are needed to control annual weeds.
3. New control methods are needed for the problematic weeds including yellow nutsedge, galinsoga and chickweed.
4. The residual effects of various herbicides are unknown. More research is needed to determine the impact of residual herbicide applications on crop growth and plant back restrictions.
5. To address and prevent herbicide resistance, herbicides with new modes of action are needed for weed management in allium vegetables.

Resources

Integrated pest management / integrated crop management resources for production of Allium crops in Canada

British Columbia Ministry of Agriculture. Vegetables. Production Guides. https://www2.gov.bc.ca/gov/content/industry/agriservice-bc/production-guides/vegetables

Government of Saskatchewan. Agriculture, Natural Resources, and Industry. Crops and Irrigation – Onions. https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/crops-and-irrigation/horticultural-crops/vegetables/onion

IRIIS Phytoprotection. http://www.iriisphytoprotection.qc.ca/ (in French only)

Manitoba Agriculture. Vegetable Crops – Production Information on Vegetable Crops. https://www.gov.mb.ca/agriculture/crops/crop-management/vegetable-crops.html

Ontario Ministry of Agriculture, Food and Rural Affairs. CropIPM. Onions. http://www.omafra.gov.on.ca/IPM/english/onions/index.html

Ontario Ministry of Agriculture, Food and Rural Affairs. Ontario Crop Protection Hub. https://cropprotectionhub.omafra.gov.on.ca/

Ontario Ministry of Agriculture, Food and Rural Affairs. Crop Scouting: Resources for Vegetable Crop Scouts. https://www.ontario.ca/page/crop-scouting-resources-vegetable-crop-scouts

Perennia – Alliums. https://www.perennia.ca/portfolio-items/alliums/

Quebec Ministry of Agriculture, Fisheries and Food. https://www.mapaq.gouv.qc.ca/fr/Pages/Accueil.aspx (in French only)

Provincial Contacts

Province	Ministry	Crop Specialist	Minor Use Coordinator
Ontario	Ontario Ministry of Agriculture, Food and Rural Affairs www.omafra.gov.on.ca	Travis Cranmer travis.cranmer@ontario.ca	Joshua Mosiondz joshua.mosiondz@ontario.ca
Quebec	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (in French only) www.mapaq.gouv.qc.ca	Eve Abel eve.abel@mapaq.gouv.qc.ca	Mathieu Côté mathieu.cote@mapaq.gouv.qc.ca

Provincial and National Vegetable Grower Organizations

Association des producteurs maraîchers du Québec: https://apmquebec.com/ (in French only)

British Columbia Potato and Vegetable Growers Association: http://bcfresh.ca/associations/

Canadian Organic Growers: https://www.cog.ca/

Fruit and Vegetable Growers of Canada: https://fvgc.ca/

Ontario Fruit & Vegetable Growers Association: http://www.ofvga.org

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, 5, 8, 9, 12 and 13 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 rowspan="2">Colour Code</th></tr>
<tr><td rowspan="15">Present</td><td rowspan="13">Data available</td><th>Frequency</th><th>Distribution</th><th>Pest Pressure</th></tr>
<tr><td rowspan="6">Yearly - Pest is present 2 or more years out of 3 in a given region of the province.</td><td rowspan="3">Widespread - The pest population is generally distributed throughout crop growing regions of the province. In a given year, outbreaks may occur in any region.</td><td>High - If present, potential for spread and crop loss is high and controls must be implemented even for small populations.</td><td>Red</td></tr>
<tr><td>Moderate - If present, potential for spread and crop loss is moderate: pest situation must be monitored and controls may be implemented.</td><td>Orange</td></tr>
<tr><td>Low - If present, the pest causes low or negligible crop damage and controls need not be implemented.</td><td>Yellow</td></tr>
<tr><td rowspan="3">Localized - The pest is established as localized populations and is found only in scattered or limited areas of the province.</td><td>High - see above</td><td>Orange</td></tr>
<tr><td>Moderate - see above</td><td>White</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="6">Sporadic - Pest is present 1 year out of 3 in a given region of the province.</td><td rowspan="3">Widespread - as above</td><td>High - see above</td><td>Orange</td></tr>
<tr><td>Moderate - see above</td><td>Yellow</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="3">Localized - as above</td><td>High - see above</td><td>Yellow</td></tr>
<tr><td>Moderate - see above</td><td>White</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="2">Data not available</td><td colspan="3">Not of concern - The pest is present in commercial crop growing areas of the province but is causing no significant damage. Little is known about its population distribution and frequency in this province; however, it is not of concern.</td><td>White</td></tr>
<tr><td colspan="3">Is of concern - The pest is present in commercial crop growing areas of the province. Little is known about its population distribution and frequency of outbreaks in this province and due to its potential to cause economic damage, is of concern.</td><td>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>

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