Crop Profile for Sweet Corn in Canada, 2018

Prepared by:
Pest Management Program
Agriculture and Agri-Food Canada

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Preface

National crop profiles are developed by the Pest Management Program of Agriculture and Agri-Food Canada (AAFC). The national crop profiles provide baseline information on crop production and pest management practices and document the pest management needs and issues faced by growers. This information is developed through extensive consultation with stakeholders.

Information on pest issues and management practices is provided for information purposes only. For detailed information on growing sweet corn, 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 sweet corn, the reader is referred to provincial crop production guides and Health Canada's Pesticide label database.

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.

For inquiries regarding the contents of the profile, please contact:

Crop Profiles Coordinator
Pest Management Centre
Agriculture and Agri-Food Canada
Building 57, 960 Carling Ave
Ottawa, ON, Canada K1A 0C6

aafc.pmcinfo-clainfo.aac@canada.ca

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Corn (*Zea mays*) is a member of the grass (*Poaceae*) family. It has been grown as a farm crop for more than 800 years. The crop is thought to have originated from a grassy weed commonly found in Central and South America. Plant selection by native farmers resulted in changes in the genetic makeup of the species over time. Immigrant European farmers who grew corn in the United States and adjacent areas of southern Canada continued this process. Two types of corn emerged from this genetic selection, field corn and sweet corn.

Today, field corn is mainly used as animal feed or for industrial uses while traditional sweet corn varieties, and those with higher sugar content, are used for human consumption. The sweet trait resulted from a mutation in the starchy gene (*su*). Two new genes contribute to the sweetness of corn, they are the sugary enhanced gene (*se*), and the supersweet gene (*sh2*). Some varieties are called 'triplesweet' as they have a mixture of the two sweet genes (75% *se* and 25% *sh2*). Modern sweet corn varieties have combinations of the *su, se* and *sh2* genes and other genes governing flavour, resulting in varieties with differing levels of sweetness.

Sweet corn is consumed both as a fresh vegetable and processed product. When used as a fresh crop, sweet corn must be refrigerated immediately and moved to market quickly in order to retain its sweet quality, which means fresh sweet corn is rarely exported to other countries.

Crop Production

Industry Overview

Harvested sweet corn is purchased by consumers in four markets: fresh, baby corn (often frozen), frozen and canned. While sweet corn is commonly available in late summer and early fall as a fresh product the majority of production is used for processing as a frozen or canned product. Baby corn, which is hand harvested two days after the silks appear, makes up a small portion of sweet corn sales. Sweet corn is also made into breakfast cereals, breads, snack foods and corn syrup and can be used to make bourbon or whisky.

Sweet corn is one of the major field grown vegetable crops in Canada, with a farm gate value of $76.2 million and 187, 819 metric tonnes produced in 2018. Sweet corn is grown in all provinces and in 2018 with 17,551 ha planted, it was the most extensively planted vegetable in Canada.

Table 1. General production information in 2018

Canadian Marketed Production[1]	Sweet corn
	187,819 metric tonnes Planted: 17,551 hectares
Total farm value[1]	$76.2 million
Sweet corn consumption in Canada[2]	Fresh: 2.84 kg/ person Canned: 1.99 kg/person Frozen: 1.41 kg/person
Exports[3]	$27.4 million
Imports[3]	$10.7 million

[1]Statistics Canada. Table 32-10-0365-01 (formerly CANSIM 001-0013) - Area, production and farm gate value of vegetables (database accessed 2020-06-26).
[2]Statistics Canada. Table 32-10-0054-01 (formerly CANSIM 002-0011) - Food available in Canada (database accessed: 2020-06-26).
[3]Statistics Canada. Canada International Merchandise Trade Database (accessed 2020-06-26): HS # 071040 - Sweet corn, frozen, uncooked, steamed, boiled in water.

Production Regions

Sweet corn is grown in all regions of Canada, with the majority of 2018 production occurring in Ontario (8,003 ha; 46% of the national acreage) and Quebec (6,981 ha; 40%). Significant production of sweet corn also occurs in British Columbia (1,012 ha; 6%) and Alberta (1,005 ha; 6%), see Table 2.

Table 2. Distribution of sweet corn production by province, 2018

Production Regions	Area planted[1] (hectares) and percentage	Marketed production[1] (metric tonnes) and percentage	Total farm value[2] ($)
	Sweet corn		
British Columbia	1,012 ha (6%)	6,577 m.t. (4%)	$8.5 million
Alberta	1,005 ha (6%)	13,027 m. t. (7%)	$4.2 million

Table 2. Distribution of sweet corn production by province, 2018 (continued)

Production Regions	Area planted[1] (hectares) and percentage	Marketed production[1] (metric tonnes) and percentage	Total farm value[2] ($)
	Sweet corn		
Ontario	8,003 ha (46%)	101,076 m. t. (54%)	$36.7 million
Quebec	6,981 ha (40%)	64,201 m. t. (34%)	$23.3 million
Canada	**17,551 ha**	**187,819 m. t.**	**$76.2 million**

[1]Source: Statistics Canada. Table 32-10-0365-01 (formerly CANSIM 001-0013) - Area, production and farm gate value of vegetables (database accessed: 2020-06-26).

Cultural Practices

Sweet corn can be grown on most soil types but the crop does best on well-drained soils or soils that are effectively tile drained. Sandy soils warm faster in spring and are more suitable for early plantings, whereas clay and loamy soils, which hold more water, are more suitable for late season production. By avoiding growing sweet corn in rotation after field corn possible insect and disease carryover in the soil can be reduced. For corn production, soil pH is maintained between 5.8 and 6.8. Most corn requires supplemental nitrogen, either through biological amendments, such as manure or from synthetic fertilizers or from a combination of both. Generally, nitrogen applications can be timed to match the needs of the growing corn by using a combination of quick release and slow release nitrogen at planting. As well, a portion of the nitrogen can be applied at the time of planting, and the remainder side-dressed or top-dressed when the corn stalk is about a foot in height (approximately 30.5 cm) or has six to seven leaves.

To successfully grow sweet corn seed needs to be selected based on the maturity of local soil and adaptability to local soil and climatic conditions. Sweet corn is planted throughout the spring and early summer to ensure a constant supply throughout the summer and early fall. As an example, in Ontario, plantings are separated by approximatively 80 degree-days with growers planting different varieties for the early season and late season. Seeding depths are adjusted based on the soil temperature and texture, and may be anywhere from 2 to 7 cm. Soil temperature should be at least 13°C at planting or there may be delayed emergence and increased susceptibility of the crop to early-season pests.

Pollination is extremely important in the production of sweet corn. For optimum performance, a variety is grown in isolation from other varieties with incompatible genotypes.

Pollen from field corn or the pollination of *sh2* varieties by *su* and *se* types will result in excessive starches.

The number of days from planting to maturity varies among corn varieties; most sweet corn varieties are ready for harvest about 18 to 21 days after the 50 percent silk stage, or about 16 to18 days after full silk. Immediately following harvest, the field heat should be removed from the cobs by dipping them in cool water (hydro-cooling) in order to maximize shelf-life.

The use of cover crops is an important tool in sustainable field vegetable production, with many cover crops recognized to provide benefits in reducing the pressure of nematodes, weeds and other pests, as well as improving soil structure and optimizing nutrient cycling. A tool to assist sweet corn growers in choosing an appropriate cover crop based on seeding dates and harvest time is available (http://decision-tool.incovercrops.ca/) (only in English).

Table 3. Sweet corn production and pest management schedule in Canada

Time of Year	Activity	Action
May	Plant care	Seeding in medium-heavy, well drained, loamy soil with organic matter when soil temperature reaches a minimum of 13ºC
	Soil care	Pre-plant fertilizer applications and cultivation, with and without mulch (in conventional till systems only)
	Disease management	Planting in warm soil, using disease tolerant or resistant varieties
	Insect and mite management	Shallow planting in warm soil for earlier crop emergence
	Weed management	Cultivation and elimination of weeds (in conventional till systems only); application of pre-plant or post-emergence herbicides
June	Plant care	Seeding done at time intervals. Irrigation, if necessary
	Soil care	Use of mulch for moisture retention, if necessary
	Disease management	Monitoring and spraying, if necessary
	Insect and mite management	Monitoring and spraying, if necessary
	Weed management	Cultivation and eliminating weeds from within as well as the perimeter of the field
July	Plant care	Seeding done at time intervals; first harvest complete in some growing regions
	Soil care	None
	Disease management	Monitoring and spraying, if necessary
	Insect and mite management	Monitoring and spraying, if necessary
	Weed management	Application of post-emergence herbicides, if necessary and mechanical cultivation and/or cover crop destruction

…continued

Table 3. Sweet corn production and pest management schedule in Canada (continued)

Time of Year	Activity	Action
August	Plant care	Harvest continues; irrigation, if needed
	Soil care	None
	Disease management	Monitoring and spraying, if necessary
	Insect and mite management	Monitoring and spraying, if necessary
	Weed management	Limited activity; application of post-emergence herbicides in some growing regions
September	Plant care	Harvest continues in some growing regions
	Soil care	None
	Disease management	Monitoring and spraying, if necessary
	Insect and mite management	Monitoring and spraying, if necessary
	Weed management	Limited activity
October	Plant care	Harvesting completed
	Soil care	Plowing under of residues and cover crops in some growing regions
	Disease management	Monitoring and spraying, if necessary
	Insect and mite management	Monitoring and spraying, if necessary
	Weed management	Limited activity

Abiotic Factors Limiting Production

Herbicide Injury

Injury can occur from herbicide applications during the growing season, particularly on sensitive varieties, as a result of herbicide carryover from the previous season or drift from a nearby field. Environmental conditions and application timing also have an effect on the incidence of herbicide injury. Typical symptoms include chlorosis or yellowing of leaves and distorted growth of foliage. Herbicide injury can range from slight stunting of plants to complete kill.

Low Temperature and Frost Injury

Low temperature injury can occur early or late in the growing season when temperatures are around the freezing point. Symptoms of injury include irregularly shaped or oddly curled leaves with chlorotic areas. Young leaves turn a light brown to yellow. This injury may be confused with herbicide injury. Plants can recover after mild low temperature injury, as new leaves form. Lethal low temperatures cause leaves to wilt, collapse, develop a water-soaked appearance and die. Injured plants become defoliated with secondary shoots and leaves forming. Yields are reduced. Low areas in fields are prone to low temperature injury. The risk of low temperature injury is reduced if planting is delayed in the spring.

Hail Injury

Hail may destroy the exposed leaves but will not damage the growing point if it is below the soil surface. In these cases, the hail damage usually results in very little reduction in the final yield. During tassel and ear development, loss of all of the unfurled leaves due to hail may result in a 10 to 20 percent reduction in final yield. Complete leaf loss at this stage results in complete loss of yield. Loss of leaves from hail at grain filling results in unfilled kernels, usually at the tip of the ear.

Nutrient or Moisture Deficiency

At flowering, the number of kernels that develop silks is determined. Nutrient or moisture deficiency (and injury from hail or insects) at this stage may seriously reduce the number of kernels that develop.

Diseases

Key issues

- There is a need for improved cultural approaches and chemical control measures against damping-off in sweet corn.
- There is a need for sweet corn varieties with improved resistance to rust, in particular late maturing varieties.

Table 4. Occurrence of diseases in sweet corn production in Canada[1,2]

Disease	British Columbia	Alberta	Ontario	Quebec
Seed rot/ seedling blight	White	Red	Yellow	White
Anthracnose leaf blight	White	Black	Yellow	Black
Common rust	Grey	White	Orange	Yellow
Northern corn leaf blight	Grey	White	Orange	White
Gray leaf spot	Grey	Black	Yellow	White
Stewart's wilt	Grey	Black	Orange	Black
Common smut	Grey	White	Orange	Yellow
Head smut	White	White	Yellow	Yellow
Root rot	Orange	Orange	White	Black
Ear rot	Grey	White	Yellow	White
Nematodes	Grey	White	Yellow	White
Root lesion nematode	Grey	Grey	Yellow	White
Root knot nematode	Grey	Grey	Yellow	White

Red	Widespread yearly occurrence with high pest pressure.
Orange	Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest
Yellow	Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pest pressure.
White	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.
Blue	Pest is present and of concern, however little is known of its distribution, frequency and pressure.
Black	Pest not present.
Grey	Data not reported.

[1]Source: Sweet corn stakeholders in reporting provinces (British Columbia, Alberta, Ontario and Quebec); the data reflect the 2018, 2017 and 2016 production years.
[2]Refer to Appendix 1 for a detailed explanation of colour coding of occurrence data.

Table 5. Adoption of disease management practices in sweet corn production in Canada[1]

Practice / Pest		Common smut	Seed rot and seedling blight	Common rust	Northern corn leaf blight	Stewart's wilt
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 and to minimize stress					
	Minimizing wounding and insect damage to limit infection sites					
	Use of disease-free propagative materials (seed, cuttings or transplants)					
Prevention	Equipment sanitation					
	Canopy management (thinning, pruning, row or plant spacing, etc.)					
	Manipulating seeding / planting depth					
	Irrigation management (timing, duration, amount) to minimize disease infection periods and manage plant growth					
	Management of soil moisture (improvements in drainage, use of raised beds, hilling, mounds, etc.)					
	End of season or pre-planting crop residue removal / management					

… continued

Table 5. Adoption of disease management practices in sweet corn production in Canada[1] (continued)

Practice / Pest		Common smut	Seed rot and seedling blight	Common rust	Northern corn leaf blight	Stewart's wilt
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					
	Use of biopesticides (microbial and non-conventional pesticides)					

… continued

Table 5. Adoption of disease management practices in sweet corn production in Canada[1] (continued)

Practice / Pest		Common smut	Seed rot and seedling blight	Common rust	Northern corn leaf blight	Stewart's wilt
Suppression	Controlled atmosphere storage					
	Targeted pesticide applications (banding, spot treatments, use of variable rate sprayers, etc.)					
	Selection of pesticides that are soft on beneficial insects, pollinators and other non-target organisms					
New practices (by province)	Use of cover crops (Quebec)					

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.

Information regarding the practice for this pest is unknown.

[1]**Source: Sweet corn stakeholders in reporting provinces (Ontario and Quebec); the data reflect the 2018, 2017 and 2016 production years.**

Seed Rot and Seedling Blight (*Pythium* spp., *Fusarium* spp., *Penicillium* spp., *Aspergillus* spp. and *Rhizoctonia* spp.)

Pest Information

Damage: Symptoms of seed rot and seedling blight include rotting of seed prior to germination, slow and uneven emergence in the spring, and the failure of the seedlings to emerge from the soil. Seedlings affected by seed rot and seedling blight are prone to stunting and wilting. During cool, wet springs, the diseases can cause extensive crop losses. Symptoms differ depending on the causal agent: *Pythium* spp. damage is characterised by dark, water-soaked lesions on seed, seedling and roots; *Fusarium* spp. infections result in white, purple or pink lesions; *Rhizoctonia* spp, cause sunken, elongated reddish-brown lesions on hypocotyls and roots and *Diplodia* spp. cause greyish-white lesions on roots. *Penicillium* spp., *Fusarium* spp. and *Aspergillus* spp. may be associated with stored seed, and can cause spoilage or initiate disease when the seed is planted in subsequent years.

Life Cycle: The pathogens causing seed rots and seedling blights are commonly found in all soils and often on seeds. Disease occurs primarily in poorly drained soils during periods of cold, wet weather, when soil temperatures are below 15 °C. *Penicillium* spp. and *Fusarium* spp. are frequently found on the seed and are often prevalent on 'supersweet' corn cultivars where seeds appear shrunken and cracked, which favours colonization by penicillium. *Fusarium* spp. and *Diplodia* spp. are also present in corn residue. Seed and root rotting pathogens typically overwinter in soils and/ or plant debris, and are able to persist for several years.

Pest Management

Cultural Controls: Planting injury-free seed in well drained fields in warm soil can help to reduce the impact of these pathogens. Crop rotations with non-cereal crops can help reduce pathogen populations in the soil. Additional management practices for seed rots and seedling blight are listed in *Table 5*.

Resistant Cultivars: None available.

Issues for Seed Rot and Seedling Blight

1. There is a need for improved cultural approaches and chemical control measures against seed rot and seedling blight in sweet corn.

Anthracnose Leaf Blight (*Colletotrichum graminicola*)

Pest Information

Damage: Symptoms caused by *Colletotrichum graminicola* appear as oval lesions with brown centres and purple-brown borders that first develop on lower leaves, progressing to upper leaves. Lesions may join to form streaks along midribs or leaf margins. The injury resembles frost damage and can eventually kill the plant.

Life Cycle: The pathogen overwinters as mycelium within seed and corn residue. This disease is prevalent during warm, wet years when conidia are spread by splashing rain or wind, and infect leaves and stalks.

Pest Management

Cultural Controls: Avoid planting susceptible sweet corn varieties in no-till or reduced till fields because the *C. graminicola* overwinters in crop residue. A rotation of two to three years will help reduce overwintering inoculum.

Resistant Cultivars: None identified.

Issues for Anthracnose Leaf Blight

None identified.

Common Rust (*Puccinia sorghi*)

Pest Information

Damage: Puccinia sorghi causes chlorotic flecks on leaves, husks, leaf sheaths and stalks, which eventually give rise to reddish-brown pustules. Entire leaves can die when infection is severe. Severe leaf damage can result in delayed maturity and yield losses.

Life Cycle: The fungus produces several different spore types, but only the brick-red urediniospores are important in Canada. The pathogen overwinters on corn in the southern United States. Urediniospores are carried northward by wind and infect corn crops in Canada in the spring. Once established in the crop, new infections occur approximately every 14 days. Thus, later plantings of sweet corn can be exposed to high spore populations as a result of infection of early planted crops. Rust is favoured by wet seasons with high humidity and warm temperatures.

Pest Management

Cultural Controls: Cultural practices, such as crop rotation and cultivation have no impact on the development of rust, since it does not survive in crop residue. Crops can be planted early to escape severe infection, since spores blown in from the United States arrive too late to cause severe damage. Additional management practices for common rust are listed in *Table 5.*

Resistant Cultivars: Some varieties are resistant to rust.

Issues for Common Rust

1. There is a need for sweet corn varieties with improved resistance to rust, in particular late maturing varieties.

Northern Corn Leaf Blight (*Exserohilum turcicum)*

Pest information

Damage: Northern corn leaf blight causes large, grey-green, elliptical lesions on the lower leaves. Lesions may coalesce and kill the entire leaf. Spores produced in the lesions often appear as concentric rings, giving the spot a target-like appearance. The disease is more problematic on corn that has a longer growing season.

Life Cycle: The pathogen overwinters in corn debris. In the spring, conidia may also be wind-blown long distances northward from the United States to corn fields where they cause infection and lesion development. Conidia produced in the lesions are spread by splashing rain and can re-infect the crop thus producing additional cycles of the disease. Northern corn leaf blight is more severe during extended wet, cool and humid weather. Heavy dews also favour disease development.

Pest Management

Cultural Controls: Tillage helps reduce crop residues and the amount of inoculum present in the spring. Crop rotation with non-host crops may also reduce disease incidence early in the season. Additional management practices for northern corn leaf blight are listed in *Table 5.*

Resistant Cultivars: Cultivars with resistance are available.

Issues for Northern Corn Leaf Blight

None identified.

Gray Leaf Spot (*Cercospora spp.*)

Pest Information

Damage: Gray leaf spot is a foliar disease that is strongly influenced by weather. Warm and humid conditions through late July and August favour development. Leaf spots associated with this disease are small pinpoint lesions surrounded by yellow halos. As lesions mature, they elongate into narrow and rectangular brown to grey spots along leaf veins and can progress to leaf sheath and husk. Late season corn varieties may show more infection than earlier types and result in heavier yield loss. Infection occurring two weeks before and after tasseling will cause the most damage.

Life Cycle: The fungus survives the winter on infected corn residues in the field, as well spores can be spread by wind from infected fields. In the spring, rain causes spores to splash on young corn leaves and infection spreads when warm temperatures (24 to 30 ^{o}C) and humid conditions (over 90 percent relative humidity) persist over a prolonged period. The spread of the disease appears to move upward on the plant.

Pest Management

Cultural Controls: Avoid planting susceptible sweet corn varieties in no-till or reduced till fields where more corn residues are present on the soil surface. Early corn varieties and early plantings may also suffer less damage. Include rotation in your planting schedule. For an infected field, a one to two-year rotation away from corn with fall tillage is a good practice.

Resistant Cultivars: Some moderate resistance to gray leaf spot exists in sweet corn varieties.

Issues for Gray Leaf Spot

None identified.

Stewart's Wilt (*Pantoea stewartii*)

Pest Information

Damage: Plants infected as seedlings usually wither and die. Plants which survive infection are stunted, have abnormal ears and often have bleached or dead tassels. Other symptoms caused by this bacterium are long, pale green streaks on leaves generally following leaf veins, sometimes leading to senescence of the leaf. Commercial varieties are often infected, but significant yield reductions are rare. Corn plants become more resistant to this disease as they mature.

Life Cycle: Several insects are capable of transmitting the bacterium, but the corn flea beetle (*Chaetocnema pulicaria*) is the primary vector. The bacterium survives in the gut of overwintering flea beetles, and is transmitted to the new crop when flea beetles begin feeding. Warm winter temperatures result in a high survival rate of insects and therefore a higher incidence of disease in the spring.

Pest Management

Cultural Controls: Avoiding high levels of nitrogen and phosphorus can help reduce disease incidence, while high levels of calcium and potassium may decrease disease severity. Controlling the flea beetle and managing weeds to remove alternate hosts of the beetle will help to reduce transmission of the disease. Plowing under crop debris and crop rotation may also help reduce this disease. Additional management practices for Stewart's wilt are listed in *Table 5*.

Resistant Cultivars: Resistant varieties are available.

Issues for Stewart's Wilt

None identified.

Common Smut (*Ustilago maydis*)

Pest Information

Damage: Common smut can affect all plant parts above ground, causing growths on tassels, nodes, and ears of the growing corn plant, and render the infected ears unmarketable. Growths on the ears will develop into dark masses of spores covered by a white or greyish membrane. The pathogen may kill young plants. Large galls can cause plants to be barren and stunted.

Life Cycle: The pathogen overwinters as teliospores in soil, crop residues or in contaminated seed, where it can survive for several years. Teliospores give rise to sporidia which cause new infections in susceptible corn in the spring. Intercellular growth of the fungus stimulates the production of galls. The galls rupture at maturity, releasing teliospores. The disease is common when conditions are dry and temperatures are between 26 and 34 °C. Spores are spread locally by wind and can spread from field to field on contaminated farm equipment. Injuries caused by hail, insects or other means are often entry sites for smut infection.

Pest Management

Cultural Controls: Avoiding mechanical or herbicide injury to plants and maintaining balanced soil fertility may help reduce the incidence of this disease. Regular monitoring, especially if insect or weather damage has occurred, and removing infected plants from the field may prevent further spread of the disease. Long crop rotations involving non-host crops may help reduce disease severity. Additional management practices for common smut are listed in *Table 5.*

Resistant Cultivars: Most corn varieties have some resistance to common smut.

Issues for Common Smut

1. There is a need for improved cultural approaches, improved varietal resistance and chemical controls for common smut in sweet corn.

Head Smut (*Sporisorium reilianum*)

Pest Information

Damage: Tassels and ears become covered with compact masses of black spores which are encased in a greyish membrane, structures called sori. The membrane will readily rupture to release the powdery dark spores. Affected ears are misshapen, do not produce kernels and may be aborted. Plants may also become significantly dwarfed. Yield is reduced as a result of head smut infections.

Life Cycle: The fungus can persist up to 10 years in soil and on seed as teliospores. Germinating teliospores infect seedlings and establish a systemic infection. Sori are produced on developing ears and tassels and give rise to new teliospores. The fungus is favoured by dry conditions and temperatures between 21 and 28°C. The disease is spread locally by wind, on contaminated machinery and in contaminated manure.

Pest Management

Cultural Controls: The incidence of head smut can be reduced through a long crop rotation and by preventing spore dissemination on contaminated seed, manure, and farm equipment. Avoiding nitrogen deficient-soils may also reduce incidence of head smut.
Resistant Cultivars: Resistant varieties of corn are available.

Issues for Head Smut

1. There is a need for improved cultural approaches, improved varietal resistance and pest control products for head smut in sweet corn.

Root Rots (*Fusarium* spp., *Pythium* spp.)

Pest Information

Damage: Fusarium and Pythium species can cause root rot on sweet corn. Symptoms of root rots can appear as early as the 6-leaf stage developing as brown lesions of the roots. Severe root rot may be apparent at the silking stage. Pythium root rot may show darker infected roots compare to Fusarium root rot and aboveground plants may appear yellow and stunted; however, the two fungi are often found together as a complex.
Life Cycle: These soil borne pathogens can survive in plant residues, hosts, such as grassy species, and in the soil. Root rot organisms can attack dead or dying plant tissue and can assist in the rotting of corn residues.

Pest Management

Cultural Controls: Crop rotation appears to reduce the occurrence of fusarium root rot while improving soil drainage is the only way to manage pythium root rot.
Resistant Cultivars: None identified.

Issues for Root Rot

None identified.

Ear Rot (*Fusarium* spp. and various fungi)

Pest Information

Damage: Ear rot caused by *Fusarium* spp. is the most common ear disease. Early symptoms include a cottony mold on single or multiple kernels appearing between silking and maturity. White streaks around kernels are also a common symptom. Infected kernels can be clustered or scattered on the ear. Although the impact of ear rot on yield is generally considered minimal, there are several species of Fusarium that produce mycotoxins, poisonous by-products, which are toxic to humans and livestock. Examples include deoxynivalenol mycotoxin and fumonisins. Supersweet varieties are particularly susceptible to Fusarium ear rot infections.

Life Cycle: The fungi overwinter in soil and on crop debris. Some ear rot is favored by warm, rainy weather following silk emergence while other ear rots develop under relatively dry conditions. Infested debris is considered to be the main source of overwintering spores.

Pest Management

Cultural Controls: Corn stalks and other debris should be plowed under to reduce the inoculum load in crop fields. Sweet corn should not be grown in rotation with or seeded into stubble of field corn or susceptible small grains, such as wheat and barley, or planted in or adjacent to fields having surface debris on which spores of the pathogens may be produced.

Resistant Cultivars: Varieties of corn with ear rot resistance ratings are available.

Issues for Ear Rot

None identified.

Nematodes: Root Lesion Nematode (*Pratylenchus* spp.) and Northern Root Knot Nematode (*Meloidogyne* spp.)

Pest Information

Damage: Root lesion nematodes feed on the roots of sweet corn causing yellowing, stunting and wilting of foliage. Feeding sites also provide entrance sites for pathogenic soil bacteria and fungi which can grow rapidly in the lesion and accelerate decomposition of root tissues. The root-knot nematode damage on corn appears very similar to symptoms of nutrient deficiencies, soil compaction or low soil pH. Plants appear stunted or water stressed and roots are stunted, “knotted’ or galled. Nematode damage appears in scattered areas across the field. Yield losses can be significant.

Life Cycle: Root lesion nematodes migrate through the soil, infecting roots. Eggs are laid in soil or root tissues and upon hatching, juvenile nematodes feed on plant cells killing plant tissues. Depending on moisture, host and soil temperature, the life cycle from egg to adult can take between 40 to 90 days with an optimum temperature ranging from 15 to 25 ^{o}C. As they mature, northern root knot nematodes move through the roots and establish other feeding sites in the vascular tissue. Feeding results in gall formation, branching roots and other root distortions. When mature, females lay eggs on the surfaces of galls. Infective second-stage juveniles develop in about two weeks to re-infect new roots and form new galls.

Pest Management

Cultural Controls: Elimination of infested crop residue, rotation with non-host crops and fallowing between crops may be effective in reducing nematodes in sweet corn fields. Soil from fields suspected to be infested can be tested for nematodes to enable growers to avoid planting in fields where these are a problem.

Resistant Cultivars: None available.

Issues for Nematodes

None identified.

Insects and Mites

Key issues

- There is a need for the development of new seed treatment options for seed corn maggot and wireworm. The new control products are needed due to the potential restriction in the use of neonicotinoids and the need for new control options that are safe for beneficial and non-target organisms.
- The registration of new control products with different modes of action is required for the control and resistance management of European corn borer and corn earworm.
- There is concern that the brown marmorated stinkbug may become a pest of sweet corn. Work is required to develop management approaches should brown marmorated stink bug become a problem.
- Monitoring to better understand the increase in populations of rootworms (including western corn rootworm), corn earworm, and western bean cutworm is required.
- Corn earworm monitoring, particularly of migrating populations is needed to help understand and manage the development of resistance to *Bacillus thuringiensis* (Bt) corn.

Table 6. Occurrence of insect pests in Canadian sweet corn production[1,2]

Insect and mite	British Columbia	Alberta	Ontario	Quebec
Seed corn maggot				
Flea beetles				
Corn flea beetle				
Redheaded flea beetle				
Corn rootworms				
Northern corn rootworm				
Western corn rootworm				
Aphids				
Corn leaf aphid				
Oat-birdcherry aphid				
Brown marmorated stinkbug				
European corn borer				
Corn earworm				
Fall armyworm				
True armyworm				
Cutworms				
Black cutworm				
Dark-sided cutworm				
Variegated cutworm				
Wireworms				
White grubs				
European chafer				
June beetle				
Japanese beetle				
Sap beetles				

…continued

Table 6. Occurrence of insect pests in Canadian sweet corn production[1,2] (continued)

Insect and mite	British Columbia	Alberta	Ontario	Quebec
Two spotted spider mite				

Widespread yearly occurrence with high pest pressure.
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.
Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high 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: Sweet corn stakeholders in reporting provinces (British Columbia, Alberta, Ontario and Quebec); the data reflect the 2018, 2017 and 2016 production years.

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

Table 7. Adoption of insect pest management practices in sweet corn production in Canada[1]

Practice / Pest		Seed corn maggot	Corn rootworm	Corn leaf aphid	European corn borer	Wireworm
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 (eg. mulches, netting, floating row covers)					
	Use of pest-free propagative materials (seeds, cuttings or transplants)					
Prevention	Equipment sanitation					
	Canopy management (thinning, pruning, row or plant spacing, etc.)					
	Manipulating seeding / planting depth					
	Irrigation management (timing, duration, amount) to manage plant growth					
	Management of soil moisture (improvements to drainage, use of raised beds, hilling, mounds, etc.)					
	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 7. Adoption of insect pest management practices in sweet corn production in Canada[1] (continued)

Practice / Pest		Seed corn maggot	Corn rootworm	Corn leaf aphid	European corn borer	Wireworm
Monitoring	Scouting / trapping	green	green	green	green	green
	Maintaining records to track pests	green	green	green	green	green
	Soil analysis for pests	green	green		green	green
	Weather monitoring for degree day modelling	red	red	red	green	red
	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	green
	Use of predictive model for management decisions	red	red	red	green	red
	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	red	green	green	green	red
	Soil amendments and green manuring involving soil incorporation as biofumigants, to reduce pest populations	red	red		red	red
	Use of biopesticides (microbial and non-conventional pesticides)	red	red	red	green	red
	Release of arthropod biological control agents	red	red	green	green	red

…continued

Table 7. Adoption of insect pest management practices in sweet corn production in Canada[1] (continued)

Practice / Pest		Seed corn maggot	Corn rootworm	Corn leaf aphid	European corn borer	Wireworm
Suppression	Preservation or development of habitat to conserve or augment natural controls (e.g. preserve natural areas and hedgerows, adjust crop swathing height, etc.)					
	Mating disruption through the use of pheromones					
	Mating disruption throught the release of sterile insects					
	Trapping					
	Targeted pesticide applications (banding, spot treatments, use of variable rate sprayers, etc.)					
	Selection of pesticides that are soft on beneficial insects, pollinators and other non-target organisms					
This practice is used to management 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						
Information regarding the practice for this pest is unknown.						

[1]Source: Sweet corn stakeholders in reporting provinces (Ontario and Quebec); the data reflect the 2018, 2017 and 2016 production years.

Seedcorn Maggot (*Delia platura*)

Pest Information

Damage: Newly hatched maggots feed inside the seed, where they destroy the germ. Feeding injury also provides entry sites for soil organisms that cause rot. Damage results in poor stands. The most severe damage usually occurs to spring crops planted too deeply into cool, wet, high organic-content soil.

Life Cycle: Seed corn maggots overwinter as pupae in the soil. Adult flies emerge in the spring and lay eggs in moist soil where there is an abundance of decaying plant material. Larvae feed on germinating seed. The entire life cycle can be completed in three weeks resulting in multiple generations per year.

Pest Management

Cultural Controls: Since this insect is attracted to soil humus, ploughing heavily manured land early in the fall to make it less attractive to egg laying adults the following spring may reduce pest populations. Delaying planting until the soil is warm enough for rapid germination, and shallow planting can help reduce damage. Natural enemies of seedcorn maggot including rove and carabid beetles, nematodes and entomopathogens may reduce populations of this insect. Additional management practices for seedcorn maggot are listed in *Table 7*.

Resistant Cultivars: None available.

Issues for Seedcorn Maggot

1. Neonicotinoid seed treatments are the main insecticide control for seed corn maggot. Therefore there is a need for the development of new seed treatment options due to the potential restriction in the use of neonicotinoids, and the need for new control options that are safe for beneficial and non-target organisms.

Flea Beetles: Corn Flea Beetle (*Chaetocnema pulicaria*) and Redheaded Flea Beetle (*Systena frontalis*)

Pest Information

Damage: Corn flea beetle hosts include sweet corn and many grasses. In the spring, larvae of the corn flea beetle feed on corn roots and may cause stand reduction. Adult flea beetles chew small holes in the cotyledons and young leaves. Heavy feeding will skeletonize young plants which can result in plant death. Flea beetles are a vector of *Pantoea stewartii*, the bacteria responsible for Stewart’s wilt. The bacteria survive in the beetle’s gut and are transmitted to sweet corn plants during feeding. Stewart’s wilt can cause losses even when damage from the beetle itself is not significant.

Life Cycle: Flea beetles overwinter in the soil in grassy areas and emerge in early spring to lay eggs at the base of small corn plants or grass seedlings. Upon hatching the larvae feed on host plant roots. Next generation adults emerge following pupation and are present from mid-summer until frost. Flea beetle populations are reduced by cold winter temperatures.

Pest Management

Cultural Controls: Burial of crop residue in the fall will help to remove habitat for flea beetles, which will help reduce spring populations.

Resistant cultivars: None available.

Issues for Flea beetles

1. There is the need for the development of new seed treatments (non-Group 4 insecticides) for corn flea beetle for both control and resistance management.

Corn Rootworms: Northern Corn Rootworm (*Diabrotica barberi*) and Western Corn Rootworm (*Diabrotia virgifera*)

Pest Information

Damage: Northern and western corn rootworms feed on corn silks and on the pollen of corn and other plants. When beetles are numerous, pollination may be affected to the point that ears bear only scattered kernels or none at all, causing economic damage especially to late planted or late-maturing cultivars. In severe infestations, feeding on foliage will result in long silver streaks on the lower epidermis. Larvae feed on roots, reducing plant vigor and predisposing plants to lodging and stem curvature. Feeding sites may become entry points for stalk rot, ear rot and fusarium root rot pathogens.

Life Cycle: Both species of rootworm overwinter as eggs that hatch between May and June. Newly hatched larvae feed for three to four weeks on small corn roots, then tunnel into larger roots, eventually leaving roots to pupate in the soil. Adults emerge early July, gather on corn to feed on the silks, leaf tissue, tassels and pollen and mate and lay eggs in the soil near corn plants late in the summer and early fall.

Pest Management

Cultural Controls: Non-host crops grown in rotation with corn may help reduce corn rootworm populations. Practices that favour corn growth and the use of deep-rooted corn varieties will help reduce the damage caused by this pest. Early planting allows silks to develop before peak adult feeding. There are some ground beetle and mite species found in soils that feed root-worm eggs, larvae and pupae, although these natural enemies are generally not effective at reducing numbers. Additional management practices for corn rootworms are listed in *Table 7.*

Resistant Cultivars: Resistant cultivars are available

Issues for Corn Rootworm

1. Northern and western corn rootworm populations are increasing. Continued monitoring is required to better understand the distribution of these pests.
2. There is a need for the registration of additional control products for corn rootworm, which are compatible with the use of *Trichogramma* sp. for the management of European corn borer.

Aphids: Corn Leaf Aphid (*Rhopalosiphum maidis*) and Oat-birdcherry aphid (*Rhopalosiphumpadi*)

Pest Information

Damage: Aphids feed on the tassels, ears and upper leaves of corn plants. Feeding can weaken and dwarf the plant and lead to desiccation of leaves, reduced pollination, and poor kernel fill causing reduced yield. Feeding aphids also secrete honey dew on tassels and silks, which supports the development of black sooty moulds reducing marketability of ears.

Life Cycle: The corn leaf aphid does not overwinter in Canada, but blows in from the United States during the growing season while the oat-birdcherry aphid overwinters on common choke-cherry in Canada. Aphids can reproduce without mating and bear live young, so populations can increase very quickly, especially during hot, dry weather. Infestations often begin deep in the leaf whorl.

Pest Management

Cultural Controls: Practices which encourage natural predator populations, such as avoiding the use of broad-spectrum insecticides, can be of benefit as these beneficial species can help in keeping aphid populations low. Early planting may help minimize the build-up of aphid populations and feeding damage. Additional management practices for corn leaf aphid are listed in *Table 7*.

Resistant Cultivars: None available.

Issues for Aphids

1. There is a need for the registration of additional insecticides for the management of aphids in sweet corn and for resistance management, particularly in regions where aphids pose problems annually.
2. Greater understanding of the feeding activities of aphids and improved monitoring methods and economic thresholds are required for improved management decisions.

Brown Marmorated Stink Bug (*Halyomorpha halys*)

Pest Information

Damage: The brown marmorated stink bug (BMSB) has a broad host range including tree fruit, berries, grapes, ornamentals, grain crops, tomatoes, peppers and sweet corn. Injury is caused by both adult and nymph feeding. The insect injects saliva containing digestive enzymes into the plant and ingests the liquefied plant material. Each feeding puncture results in crop injury. In corn, feeding results in shrivelling and discoloration of developing kernels and can provide entry sites for moulds.

Life Cycle: Brown marmorated stink bug spreads through natural means and also as a "hitchhiker" in cargo and vehicles. The insect overwinters as adults, emerging in the spring to feed for several weeks and then mate and lay eggs on host plants. Once the eggs hatch, there are five nymphal stages. Female BMSB can lay several hundred eggs over an extended period of time. This may result in overlapping generations.

Pest Management

Cultural Controls: Monitoring for the insect may be done through aggregation pheromones and scouting. Although thresholds have not been established, small numbers of nymphs and adults can cause considerable damage in a growing season. Late maturing varieties as well as later plantings may sustain less damage, as the pest may be more attracted to other host plants later in the season. Insect species which parasitize BMSB eggs may help reduce the population of this insect.

Resistant cultivars: None available.

Issues for Brown Marmorated Stink Bug

1. There is concern that the BMSB may become a pest of Canadian sweet corn. Research is required to develop management approaches for BMSB should this pest become a problem.
2. There is a need for the registration of insecticides for the control of BMSB so that growers have tools available should this pest become an economic pest of sweet corn.

European Corn Borer (*Ostrinia nubilalis*)

Pest Information

Damage: European corn borer (ECB) larvae feed on leaves, boring into stems after the second instar stage. As they mature, larvae tunnel through stalks and ears, and cause early breakage of tassels and stalks and poor ear development. Infestations of larvae in ears are the major concern in sweet corn, since infested ears are unsuited for sale as fresh-market produce as well as for the processing market. In areas where two generations of ECB are known to occur, the second-generation larvae cause the greatest damage.

Life Cycle: Strains of ECB exist in sweet corn growing regions that have one, two or a partial third generation. This insect overwinters as mature larvae in corn stubble and residues. Adult moths begin to emerge in late spring reaching a peak in early summer (mid-June). The moths lay eggs on the underside of leaves. After hatching, larvae develop through five larval instars, feeding for 20 to 30 days until they mature. Cool, rainy weather during June and July reduces infestations because it reduces egg-laying and washes the tiny, hatching borers off plants.

Pest Management

Cultural Controls: Avoiding other host plants such as potatoes and bean, in rotation with corn and managing weeds in the field may help reduce ECB populations. Shredding plant debris after harvest, ploughing in the fall and disking in the spring can eliminate a large portion of the overwintering larvae. Sweet corn varieties with pest resistance have been developed through biotechnology. Genes from the bacterium *Bacillus thuringiensis* (Bt) have been inserted into some varieties of sweet corn, giving the corn insecticidal properties. The release of tiny wasps (*Trichogramma* sp.) into the field several times during the season may also help reduce ECB populations, as the wasps parasitize corn borer eggs preventing egg hatch. Additional management practices for European corn borer are listed in *Table 7.*

Resistant Cultivars: Resistant varieties cultivars are available.

Issues for European Corn Borer

1. The registration of new products with different modes of action is required for the control of ECB and for resistance management.
2. *Trichogramma* application techniques need to be improved, especially for large acreage production

Corn Earworm (*Helicoverpa zea*)

Pest Information

Damage: The corn earworm feeds in the silks and kernels of sweet corn, in the top third of the ear. Silks are sometimes destroyed before pollination is complete. Moulds may invade the larval feeding sites. Damage caused by *H. zea* reduces marketability of ears.

Life Cycle: Corn earworm moths are carried into Canada each year on winds from the southern United States and Mexico. Infestations are difficult to predict and the protective husks on the ears make the insect difficult to detect or control. The moths may arrive any time from early to late summer. Adults lay eggs singly on fresh silk and occasionally on the husks of developing ears. Each female can produce as many as 1,000 eggs that hatch in two to 10 days, depending on temperature. Young caterpillars feed on the silks and eventually work their way down to the kernels. Larvae pupate after feeding for two to four weeks although sweet corn is often harvested before pupation occurs.

Pest Management

Cultural Controls: Infestations can be avoided by planting early maturing varieties. Harvesting the crop before mid-August helps reduce the risk of earworm damage. Low levels of natural control result from larval cannibalism, parasitism of eggs and larvae and from a number of predaceous insects and birds. Pheromone traps can be used to monitor the population of this insect as a management decision aid.

Resistant Cultivars: None identified.

Issues for Corn Earworm

1. The corn earworm is acquiring resistance to a number of insecticides including Bt corn. The development of resistance must be closely monitored. It is very important that growers follow proper pesticide rotations to slow the development of resistance and prolong the life of available pest management tools.
2. There is a need for the registration of new products with different modes of action, including non-conventional products, including biopesticides that can be used in organic production, to control corn earworm and to manage resistance. Bt application techniques need to be modified to be effective against the corn earworm.

Fall Armyworm (*Spodoptera frugiperda*)

Pest Information

Damage: The fall armyworm affects late season sweet corn crops, causing defoliation as it feeds on leaves. Tassels may also be damaged. Yield loss becomes more significant as larval feeding progresses to the ear shanks of more mature plants.

Life Cycle: Fall armyworms overwinter in the southern United States and northern Mexico and are carried north to Canada on wind currents in the spring. Eggs are laid in leaves or leaf sheaths and larvae are present from late spring to early summer, maturing within 20 days to pupate just below the soil surface. There is one generation per year as this insect dies with fall frost.

Pest Management:

Cultural Controls: The use of early maturing cultivars and monitoring leaf whorls in August and September to assess the stage of infestation and identify control methods if needed, can help minimize the impact of this insect.

Resistant Cultivars: None available.

Issues for Fall Armyworm

None identified.

True Armyworm (*Mythimna unipuncta*)

Pest Information

Damage: True armyworm larvae can cause severe plant defoliation. Feeding damage appears as large, ragged holes in leaves. Similar to fall armyworm, this pest commonly affects late-planted sweet corn.

Life Cycle: The true armyworm is native to the southern United States. It migrates north as an adult every year. Eggs are laid in clusters, and are often hidden, larvae hatch and begin feeding on plant foliage about three weeks later. Larvae are mostly active at night. During the day they hide in the whorl or at the basis of corn leaves and at the soil surface. In some sweet corn growing areas, there is the possibility of a second generation in late summer; however, there is no evidence at this time that true armyworms can overwinter in Canada.

Pest Management:

Cultural Controls: The use of early maturing cultivars and monitoring leaf whorls for level of infestation in August and September to determine if control methods are needed can help minimize the impact of this insect.

Resistant Cultivars: None available.

Issues for True Armyworm

None identified.

Cutworms: Black Cutworm (*Agrotis ipsilon*), Dark-sided Cutworm (*Euxoa messoria*), Glassy Cutworm (*Crymodes devaster*), Sandhill Cutworm (*Euxoa detersa*), Western Bean Cutworm (*Striacosta albicosta*) and Variegated Cutworm (*Peridroma saucia*)

Pest Information

Damage: Although sporadic, cutworms can cause major damage to sweet corn. Cutworm larvae feed on foliage and cut stems of seedlings at or below the soil level. Damage is most severe on young plants at the two to five leaf stage.

Life Cycle: Depending on species, cutworms can overwinter as eggs, partially grown larvae or pupae in soil or may be blown up from overwintering sites in the United States. Cutworms can have one or more generations per year, with first generation feeding causing the most crop damage. Following egg hatch in spring, larvae feed on foliage, developing through six to seven instars prior to pupating in the soil and emerging as adults.

Pest Management

Cultural Controls: Controlling weeds in the field and surrounding areas will reduce egg-laying by cutworm moths. Avoiding planting crops following sod or in low lying, wet, grassy areas, may help reduce black cutworm numbers. Ploughing in the fall will reduce overwintering populations. Fields can be monitored for cutworms early in the season by visually checking for damage. Pheromone traps may be used to monitor the flights of male moths and establish the period of egg-laying. The pest has many natural enemies, including birds, braconid wasp parasites and predaceous ground beetles that may help keep cutworm numbers down.

Resistant Cultivars: None available.

Issues for Cutworms

1. Western bean cutworm populations are increasing and must be carefully monitored.

Wireworms (Various species)

Pest Information

Damage: Wireworms burrow into seeds, roots and underground stems of plants, causing poor seed germination and weakened and distorted plants that often die or are non-productive. Damaged plants occur in a random pattern in the field.

Life Cycle: This insect overwinters as larvae or adult beetles in the soil. Adults lay eggs in the spring near grass roots. The larval stage may persist from two to five years, followed by pupation in the soil and adult emergence. Larvae move through the soil to feed, and will migrate deep into soil in the fall before returning to feed on corn roots and other hosts the following spring.

Pest Management

Cultural Controls: As wireworms are attracted to pasture and grassland, avoiding planting corn in a field the year after breaking sod may help reduce wireworm damage to the corn crop. Cultivation to expose larvae to predators can help reduce populations. Wireworm populations may be monitored in the fall or early spring using bait stations or by field inspection in the spring, as an aid in field selection for wireworm susceptible crops like sweet corn. Additional management practices for wireworms are listed in *Table 7*.

Resistant cultivars: None available.

Issues for Wireworm

1. Neonicotinoid seed treatments are the main insecticide control for wireworm. Therefore there is a need for the development of new seed treatment options due to the potential restriction in the use of neonicotinoids, and the need for new control options that are safe for beneficial and non-target organisms.

2. Wireworm management is becoming more challenging with the loss of registered treatments, and the lack of registration of effective alternative treatments.

White grubs: European Chafer (*Rhizotrogus majalis*), June Beetle (*Phyllophaga* spp.) and Japanese Beetle (*Popillia japonica*)

Pest Information

Damage: Sweet corn is most susceptible to injury at the seedling stage. White grubs, including the European chafer and June beetle feed on the roots of susceptible plants and cause stunting, wilting and plant death. The Japanese beetle feeds on foliage and fruit of approximately 250 host plants and is a regulated pest in Canada.

Life Cycle: European chafer has a one-year life cycle. Adults lay eggs in soil in mid-to-late summer. Eggs hatch and the larvae (grubs) feed on plant roots in the fall, overwinter and feed again in spring. Pupation occurs in early summer. June beetles have a three-year life cycle. Adult June beetles lay eggs in the soil in late spring. After hatching the larvae remain in the soil to feed and overwinter. Pupation occurs in the third year and adults emerge the following spring. June beetle grubs are present in the soil throughout the growing season and are most common in soils following pasture, turf and other perennial crops. The Japanese beetle lays eggs in the soil. Larvae move to the soil surface to feed on fibrous roots for three to four weeks before pupating in late May to early June. Adults emerge in July and mate. In September, as the soil cools down, grubs at the third larval stage move deeper (25-30 cm) into the cultivated soil to overwinter. The Japanese beetle has one generation per year.

Pest Management

Cultural Controls: Fields can be monitored in the spring or fall prior to seeding corn. Avoiding planting corn in fields with high populations of white grubs may help reduce overall damage. Cultivation prior to planting will expose grubs to natural predators. Rotation with crops other than legumes or corn may help reduce the population of these insects.

Resistant cultivars: None available.

Issues for White Grubs

None identified.

Sap Beetles

Pest Information

Damage: Adult sap beetles are attracted to and feed on over-ripe and damaged fruit. In sweet corn, adults feed on kernels damaged by other insects, birds or raccoons.

Life Cycle: Sap beetles overwinter as adults under crop residue and in other protected sites. Eggs are laid in the spring in crop debris. Following pupation, adult beetles appear from early to mid-summer. There is one generation per year.

Pest Management

Cultural Controls: The elimination of crop residues from the field will reduce overwintering sites and food sources for larvae, and reduce the sap beetle population.

Resistant cultivars: None available.

Issues for Sap Beetles

None identified.

Two-Spotted Spider Mite (*Tetranychus urtichae*)

Pest Information

Damage: Two-spotted spider mites feed on leaves, removing plant cell contents. Attacked leaves become yellow and grey, reducing their photosynthetic capacity and resulting in symptoms similar to drought stress. Mites cover severely infested plants with silk threads that are used by the mites to move around the plants

Life Cycle: Two-spotted spider mite has four to six generations per year. Mated females overwinter under foliage cover; males die in the fall. Females become active mid-April to mid-May when temperatures reach 12 °C. Populations explode in in hot weather with a generation occurring in little as six days. In August, with shorter days, females enter a diapause phase, gradually stop eating and migrate under the vegetation canopy to seek cover for the winter.

Pest Management

Cultural Controls: Good weed management may reduce two-spotted spider mite populations. Reducing dust may also reduce populations as two-spotted spider mites may increase more quickly on leaves with dust deposits. Natural enemies of mites include some predatory mites and thrips. Care in choosing products and application rates that are least toxic to the predatory mites may favour control of two spotted spider mites.

Resistant cultivars: None available.

Issues for Two-Spotted Spider Mite

None identified.

Weeds

Key Issues

- There is concern over the development of resistance of weeds to some families of chemical herbicides.
- There is a need for the registration of herbicides in different chemical families for resistance management.

Table 8. Occurrence of weeds in Canadian sweet corn production[1,2]

Weeds	British Columbia	Alberta	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.				
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: Sweet corn stakeholders in reporting provinces (British Columbia, Alberta, Ontario and Quebec); the data reflect the 2018, 2017 and 2016 production years.

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

Table 9. Adoption of weed management practices in sweet corn 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				
	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 (thinning, pruning, row or plant spacing, etc.)				
	Manipulating seeding / planting depth				
	Irrigation management (timing, duration, amount) to maximize crop growth				
	Management of soil moisture (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				
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				

…continued

Table 9. Adoption of weed management practices in sweet corn production in Canada[1] (continued)

Practice / Pest		Annual broadleaf weeds	Annual grasses	Perennial broadleaf weeds	Perennial grasses
Decision making tools	Decision to treat based on observed crop damage				
	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 biopesticides (microbial and non-conventional pesticides)				
	Release of arthropod biological control agents				
	Mechanical weed control (cultivation / tillage)				
	Manual weed control (hand pulling, hoeing, flaming)				
	Use of stale seedbed approach				
	Targeted pesticide applications (banding, spot treatments, use of variable rate sprayers, etc.)				
	Selection of herbicides that are soft on beneficial insects, pollinators and other non-target organisms				
Crop specific practices	Use of cover crops				
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.					
Information regarding the practice for this pest is unknown.					

[1]Source: Sweet corn stakeholders in reporting provinces (Ontario and Quebec); the data reflect the 2018, 2017 and 2016 production years.

All Weeds

Pest Information

Damage: Weeds compete with the crop for light, water and nutrients. Depending on the time of emergence of the weed relative to the crop and weed population density, weeds can reduce sweet corn growth and yield. The critical stage for damage is early in the growing season. Annual grasses cause significant problems in sweet corn production because of their fast growth. Grass weeds are very tolerant to extremes in moisture and temperature once established.

Life cycle: Annual grass and broadleaf weeds: Annual weeds complete their life cycle from seed germination through vegetative growth and flowering to seed production in one year, producing large numbers of seeds. Some weed seeds remain viable in the soil for many years, germinating when conditions are suitable. They can be very difficult to eliminate from infested fields and they require control prior to seed-set due to their prolific seeding

Perennial grass and broadleaf weeds: Perennials weeds live for many years. They spread through seeds, through the expansion of various types of root systems and by other vegetative means. Perennial grass weeds tend to have extensive creeping root systems, which frequently produce shoots that will then produce a new plant. Most perennial grass weed seeds will germinate within a year, but some may remain viable in the soil for twenty years or more.

Pest Management

Cultural Controls: Annual grass and broadleaf weeds: Measures to reduce difficult to control weeds can be implemented before planting. Planting cover crops such as winter cereals can suppress weed growth following crop harvest as well as minimize erosion over the winter. Rotating between broadleaf and grassy crops provides a chance to control broadleaf weeds in grassy crops and grassy weeds in broadleaf crops with selective herbicides. It is important to know the history of the weed infestation in a field prior to planting so that heavily infested fields can be avoided. The use of clean, certified seed reduces the introduction of new weed seeds. Cleaning equipment between fields will prevent the transport of weed seeds to other fields. Deploying harvesting techniques that minimize seed loss the year prior to growing the crop can lead to reduced populations of volunteer crops. Fall tillage prior to freeze-up may reduce the annual weed seed population but this practice can leave the soil prone to erosion. For some annual broadleaf weeds, mowing of field edges will reduce the weed seed set and minimize spread into the filed. Annual grasses can be very difficult to eliminate from infested fields and require control prior to seed-set due to their prolific seeding. Monitoring for annual weeds during the first two to three weeks after weed emergence will support informed decisions regarding post-emergent controls. Effective management programs involve the use of all available control strategies including preventative, cultural, mechanical, and chemical control methods.

Perennial grass and broadleaf weeds: Perennial weed management is difficult in sweet corn, particularly after the crop has been planted. Field scouting, done the season prior to planting, is important in the development of control strategies. Crop rotation can disrupt perennial weed life cycles by allowing a variety of control options and cultural practices that discourage normal weed growth. Minimizing tillage can reduce the spread of some weeds such as quackgrass, as tillage cuts up the rhizome triggering the development of more shoots.

Monitoring uncultivated field edges and roadsides and mowing weeds prior to flowering can help minimize spread into fields. The management of field-scale infestations requires a combination of control measures over several years, along with good fertility to improve crop competition. Careful record keeping on herbicide treatments is essential for the selection of herbicide groups, to minimize potential weed resistance problems and to prevent crop injury from herbicide carryover. Cleaning equipment between fields to prevent the transport of weed seeds can reduce dispersal of weeds seeds. Additional management practices for weeds are listed in *Table 9*.

Resistant Cultivars: None available.

Issues for all Weeds

Annual grass and broadleaf weeds:

1. There is a concern over the development of herbicide resistant annual weeds and the loss in efficacy of available herbicides.
2. Alternatives to atrazine are needed. New herbicide solutions should not have residual activity that may affect vegetable crops that often follow sweet corn in the rotation.

Perennial grass and broadleaf weeds:

1. There is concern over the development of resistance of perennial weeds to some families of chemical herbicides.
2. Available herbicides provide only limited control of perennial weeds in sweet corn. There a need for the development of an improved control strategy for perennial weeds including cultural approaches and the registration of new herbicides.

Vertebrate Pests

Deer, birds and raccoons can affect sweet corn production. The severity of feeding damage depends on the location of the field and local wildlife populations.

Raccoons can cause substantial damage to corn crops throughout the cropping year. Electric fencing, constructed of two strands of electric fence at heights of 5 cm and 12 cm, are usually effective against raccoons.

Electric fencing at a height of 75 cm can also deter deer.

Red winged black birds and crows are the bird pests which cause the most damage. Noisemakers will scare birds away. Avoiding planting corn near known bird nesting areas such as wetlands will reduce damage caused by birds.

Resources

Integrated Pest Management / Integrated Crop Management Resources for Production of Sweet Corn in Canada

British Columbia Ministry of Agriculture. Production Guide.– *Corn.* https://www2.gov.bc.ca/gov/content/industry/agriservice-bc/production-guides/vegetables/corn

Health Canada. Pesticides and Pest Management. http://www.hc-sc.gc.ca/cps-spc/pest/index-eng.php

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Ontario Ministry of Agriculture, Food and Rural Affairs. (2020). *Ontario Vegetable Crop Production Publications.* Vegetable Crop Protection Guide 2020-2021 (Publication 838) http://www.omafra.gov.on.ca/english/crops/vegpubs/vegpubs.htm

Sage Pesticides. http://www.sagepesticides.qc.ca/

Provincial Contacts

Province	Ministry	Crop Specialist	Minor Use Coordinator
British Columbia	British Columbia Ministry of Agriculture www.gov.bc.ca/al	Susan Smith susan.l.smith@gov.bc.ca	Caroline Bédard caroline.bédard@gov.bc.ca
Alberta	Alberta Agriculture and Forestry www.agric.gov.ab.ca/	Robert Spencer robert.spencer@gov.ab.ca	Gayah Sieusahai gayah.sieusahai@gov.ab.ca Ron Pidskalny Prairie Minor Use Consortium pidskaln@gmail.com
Ontario	Ontario Ministry of Agriculture, Food and Rural Affairs www.omafra.gov.on.ca	Andrew Wylie Andrew.c.wylie@ontario.ca	Jim Chaput jim.chaput@ontario.ca
Québec	Ministère de l’Agriculture, des Pêcheries et de l'Alimentation du Québec www.mapaq.gouv.qc.ca	Melissa Gagnon melissa.gagnon@ mapaq.gouv. qc.ca	Mathieu Coté mathieu.cote@ mapaq.gouv.qc.ca

Provincial and National Vegetable Grower Organizations

Association des producteurs maraîchers du Québec: https://apmquebec.com/en/index.sn/

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

Canadian Federation of Agriculture: https://www.cfa-fca.ca/

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

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

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

Appendix 1

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

Information on the occurrence of disease, insect and mite and weed pests in each province is provided in Tables 4, 7 and 10 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>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 our 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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