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Crop Profile for Sweet Corn in Canada, 2012

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Canada

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Preface

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

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

For detailed information on growing 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.

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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Corn (*Zea mays*) is a member of the grass (Poaceae) family and it has been grown as a farm crop for more than 800 years. The crop is generally considered 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. Field corn is mainly used as animal feed or for industrial uses while sweet corn, with its higher sugar content, is used for human consumption. This sweet trait resulted from a mutation in the starchy gene (*su*) which is commonly found in field corn. The two other major modifiers that affect corn's sweetness, include the sugary-extender gene *(se)* and the shrunken or supersweet gene *(sh2)*.

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 little fresh sweet corn is exported to other countries.

Sweet corn is one of the major field grown vegetable crops in Canada, with a farm gate value of $72 million in 2012, placing it third in crop value behind carrots and tomatoes. Annual Canadian sweet corn production ranges between 200,000 to 240,000 metric tonnes. Sweet corn is grown on over 20,000 hectares of land, making it the most extensively planted vegetable in Canada, grown in all provinces.

Crop Production

Industry Overview

Sweet corn seed comes in three types, each with many different varieties. Normal sugary (*su*) corn is the standard sweet corn grown for the processing market. Sugary enhanced (*se*) corn is grown for its increased sugar levels and slower conversion of sugars to starch after harvest. This makes the kernels tender with a strong "corn" flavour. Supersweet or shrunken-2 (*sh2*) will produce kernels that contain two to three times the sugars of the normal sugary (*su*) varieties. The corn texture is crisp and not milky. The added benefit to supersweet or shrunken corn is that the fresh market shelf life is extended because the kernels can retain their moisture and sweetness longer.

Harvested sweet corn is purchased by consumers in four markets, fresh, baby corn (often frozen), frozen and canned. While sweet corn is commonly seen in late summer and early fall as a fresh product in grocery stores and country markets, only about 25% of the sweet corn grown in Canada is used to this end. Baby corn, which is hand harvested 2 days after the silks appear, makes up a small portion of sweet corn sales. The majority of sweet corn is used for processing as a frozen or canned product. Sweet corn has a variety of uses. Sweet corn is made into breakfast cereal, bread, snack foods and corn syrup. It is also used to make bourbon or whisky. Corn could also be used as a source of ethanol for fuel. In addition, corn can be used to make plastic and fabrics. In agriculture, corn is used as fish bait and in livestock feed.

Table 1. General production information

Canadian production (2012)[1]	212,728 metric tonnes 21,919 hectares
Farm gate value (2012)[1]	$72 million
Sweet corn available for consumption in Canada 2012[2]	3.58 kg/person (fresh)[2]
	1.3 kg/person (canned and frozen)[3]
Exports (2012)[2]	$21 million (fresh and frozen)
	16,698 metric tonnes (fresh and frozen)
Imports (2012)[2]	$57 million (fresh and frozen)
	66,839 metric tonnes (fresh and frozen)

[1]Source: Statistics Canada, Table 001-0013 - Area, production and farm gate value of vegetables, annual CANSIM (database) (accessed February 26, 2014)

[2]Source: Agriculture and Agri-Food Canada. Statistical Overview of the Canadian Vegetable Industry 2012. AAFC No. 12162E-PDF

[3]Source: Statistics Canada

Production Regions

Sweet corn is produced in all regions of Canada, with the majority of production coming from Ontario (9,995 ha or 46% of the national acreage) and Quebec (8,460 ha or 39% of the national acreage). The provinces of British Columbia (1,143 ha or 5% of the national acreage) and Alberta (1,619 ha or 7%) also contribute a significant amount of production to the Canadian total (Table 2).

Table 2. Distribution of sweet corn production in Canada (2012)[1]

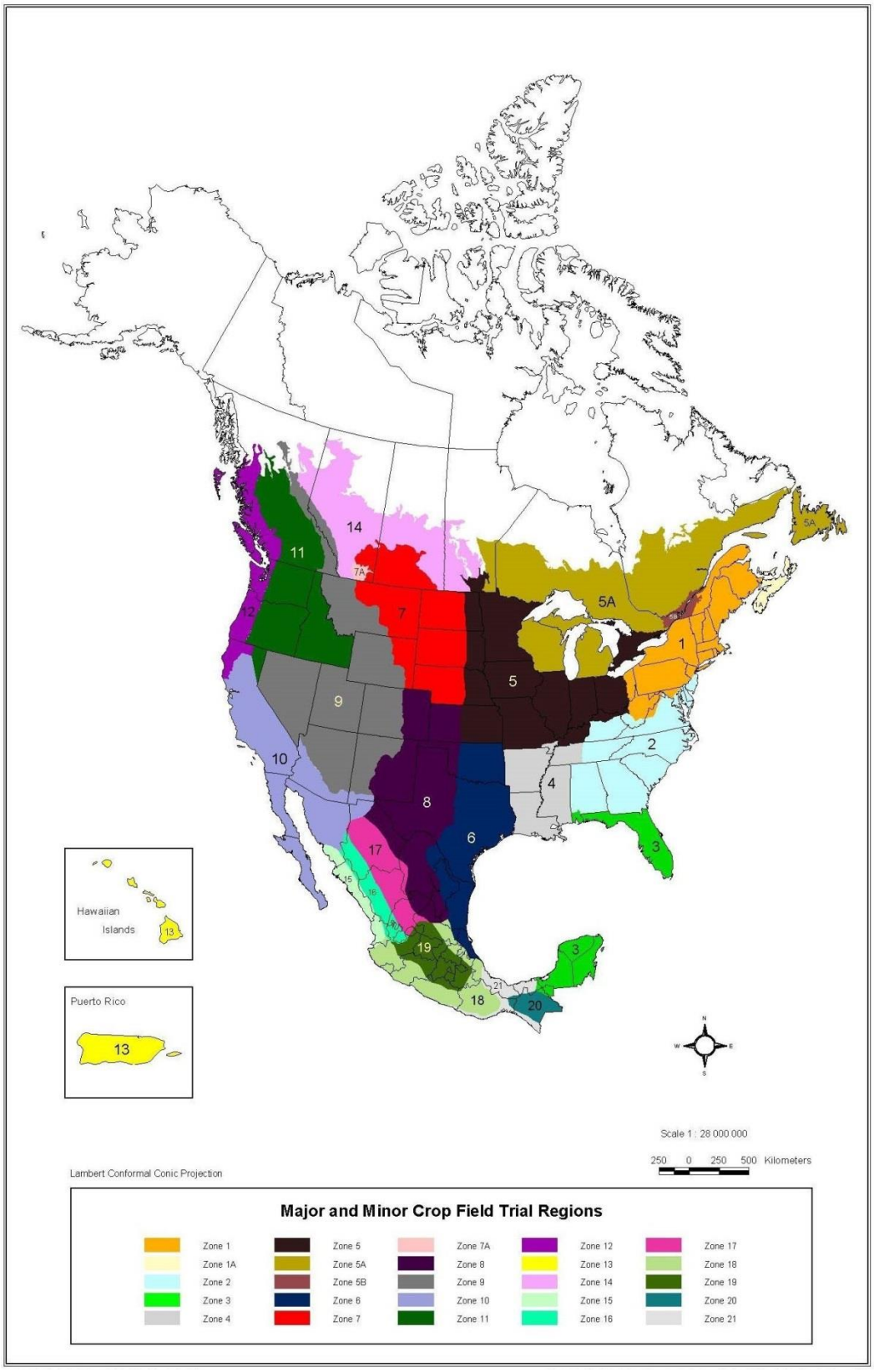
Production Regions	Seeded area (hectares)	Percent national production
British Columbia	1,143	5%
Alberta	1,619	7%
Saskatchewan	32	<1%
Manitoba	300	1%
Ontario	9,995	46%
Quebec	8,460	39%
New Brunswick	142	1%
Nova Scotia	202	1%
Prince Edward Island	22	<1%
Newfoundland and Labrador	3	<1%
Canada	21,919	100%

[1]Source: Statistics Canada, Table 001-0013 - Area, production and farm gate value of vegetables, annual CANSIM (database) (accessed February 26, 2014).

North American Major and Minor Field Trial Regions

Major and minor crop field trial regions (figure1) were developed following stakeholder consultation and are used by the Pest Management Regulatory Agency (PMRA) in Canada and the United States (US) Environmental Protection Agency to identify the regions where residue chemistry crop field trials are required to support the registration of new pesticide uses. The regions are based on a number of parameters, including soil type and climate but they do not correspond to plant hardiness zones. For additional information, please consult the PMRA Regulatory Directive 2010-05 "*Revisions to the Residue Chemistry Crop Field Trial Requirements"* (www.hc-sc.gc.ca/cps-spc/pubs/pest/_pol-guide/dir2010-05/index-eng.php).

Figure 1. Common zone map: North American major and minor field trial regions



[1]Produced for: *Asociación Mexicana de la Industria Fitosanitaria, A.C.*
[2]Produced by: Spatial Analysis and Geomatics Applications, Agriculture Division, Statistics Canada, February 2001.

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 for late season production, clay and loamy soils, which hold more water, are more suitable. Sweet corn should not be grown in rotation after field corn, because of possible insect and disease carryover in the soil. For corn production, soil pH should be maintained between 6.2 and 6.5. Most corn requires supplemental nitrogen, either through biological amendments, such as manure, from synthetic fertilizers or from a combination of both. Generally, nitrogen applications should be timed to match the needs of the growing corn. Usually a portion of the nitrogen is applied at the time of planting, with the remainder side-dressed or top-dressed when the corn is about a foot in height.

Seed selection is critical. A variety should be selected that has the proper maturity and that is well adapted to the soils and environmental conditions of the particular farm. Corn is generally planted in late April or early May, when soil temperature reaches at least 10° C, however sweet corn is planted throughout the spring and early summer to ensure a constant harvest supply throughout the summer and early fall. Almost all varieties of sweet corn grown in Canada are hybrids. When planting into warm soils, the seeding depth should be gauged so as to place the seed in moist soil. Seeds planted deeper than 7 cm will have difficulty emerging, especially on fine-textured clay or compacted soils where crusting is a problem. When corn is planted early in the season and soil temperatures are still low, seeds should be planted shallowly (2-3cm) where the soil is warmest. When planting early or when the soil is cold, the seeding rate should be 10% greater than the desired final stand, as some of the seeds will not emerge. When planting into warm soils, an adjustment of 5% is sufficient.

Sweet corn hybrids 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 proteins produced by the genes have been found to be safe for human consumption.

Pollination is extremely important in the production of sweet corn and for a variety to perform best, it should be grown in isolation from other varieties with incompatible genotypes. For example, pollen from field corn can make the sweet corn starchy. The pollination of *sh2* varieties by *su* and *se* types will also result in starchiness.

The number of days from planting to maturity varies among corn varieties, however, appropriate harvest dates are usually supplied by the seed companies. As a general guideline, most sweet corn varieties are ready for harvest about 18-21 days after 50% silk, or about 16-18 days after full silk.

Abiotic Factors Limiting Production

Herbicide Injury

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

Frost and Hail

Frost or 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 usually results in very little reduction in the final yield. During tassel and ear development, loss of all of the unfurled leaves by frost or hail may result in a 10 to 20% reduction in final yield. Complete leaf loss at this stage results in complete loss of yield. Loss of leaves from hail or other unfavourable conditions 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 being determined. Thus, nutrient or moisture deficiency and injury (hail or insects) at this stage may seriously reduce the number of kernels that develop. Moisture stress or nutrient deficiencies usually increase in intensity from the top to the bottom of the plant and so will delay silking more than tassel emergence and pollen shedding.

Low Temperature 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 temperature injury causes leaves to wilt, collapse, develop a water soaked appearance and die. Injured plants become defoliated with secondary shoots and leaves forming and yields are reduced. Low areas in fields with poor air drainage are prone to low temperature injury. The risk of low temperature injury is reduced as planting is delayed in the spring.

Diseases

Key issues

- Currently available fungicides and crop rotation often do not provide adequate control of common and head smut.
- The levels of resistance to common rust in sweet corn hybrids do not provide complete control.
- In Ontario, high flea beetle populations, which act as a vector of Stewart's wilt and make the disease a severe problem, are of concern.
- Some countries regulate against the Stewart's wilt pathogen, requiring that imported seed corn be free of the bacterium.

Table 3. Occurrence of diseases in sweet corn production in Canada[1,2]

Disease	British Columbia	Alberta	Ontario	Quebec
Common smut				
Head smut				
Seed rot and seedling blight				
Root rot				
Common rust				
Northern corn leaf blight				
Stewart's wilt				

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

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

Pest not present.
Data not reported.

[1]Source: Sweet corn stakeholders in reporting provinces.

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

Table 4. 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	resistant varieties					
	planting / harvest date adjustment					
	crop rotation					
	choice of planting site					
	optimizing fertilization					
	reducing mechanical damage or insect damage					
	thinning / pruning					
	use of disease-free seed, transplants					
Prevention	equipment sanitation					
	mowing / mulching / flaming					
	modification of plant density (row or plant spacing; seeding rate)					
	seeding / planting depth					
	water / irrigation management					
	end of season crop residue removal / management					
	pruning out / elimination of infected crop residues					
	tillage / cultivation					
	removal of other hosts (weeds / volunteers / wild plants)					
Monitoring	scouting - trapping					
	records to track diseases					
	soil analysis					
	weather monitoring for disease forecasting					
	use of portable electronic devices in the field to access pest identification /management information					
	use of precision agriculture technology (GPS, GIS) for data collection and field mapping of pests					

…continued

Table 4. 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
Decision making tools	economic threshold					
	weather / weather-based forecast / predictive model					
	recommendation from crop specialist					
	first appearance of pest or pest life stage					
	observed crop damage					
	crop stage					
Suppression	pesticide rotation for resistance management					
	soil amendments					
	biological pesticides					
	controlled atmosphere storage					
	targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)					

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).**

Table 5. Fungicides and biofungicides registered for disease management in sweet corn in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Seed treatments						
captan	phthalimide	Multi-site contact activity	Multi-site contact activity	M4	RE	*Penicillium* spp.
captan + thio-phanate-methyl + diazinon	phthalimide + thiophanate	Multi-site contact activity + B1: mitosis and cell division	multi-site contact activity + ß-tubuline assembly in mitosis	M4 + 1	RE + RE	Seedling blight, root rot, *Penicillium oxalicum*, *Penicillium* spp.
fludioxonil (seed treatment by commercial seed treaters only)	phenylpyrrole	E2: signal transduction	MAP/Histidine- Kinase in osmotic signal transduction (os-2, HOG1)	12	RE	Seed and soil-borne diseases caused by fusarium (including seedling disease due to *F. graminearum*), rhizoctonia, aspergillus and penicillium
fludioxonil + metalaxyl-M and S-isomer (seed treatment by commercial seed treaters only)	phenylpyrrole + acrylalanine	E2: signal transduction + A1: nucleic acid synthesis	MAP/Histidine- Kinase in osmotic signal transduction (os-2, HOG1) + RNA polymerase I	12 + 4	RE + RE	Seed and soil-borne fungi which cause seed decay, damping-off and seedling blights
penflufen	pyrazole carboxamide	C2. respiration	complex II: succinate-dehydro-genase	7	R	Seed rot/ pre-emergence damping-off caused by soil-borne *Rhizoctonia solani*

…continued

Table 5. Fungicides and biofungicides registered for disease management in sweet corn in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Seed treatments						
penflufen + prothioconazole +metalaxyl	pyrazole carboxamide + triazole + acylalanine	C2. Respiration + G1: sterol biosynthesis in membranes + A1: nucleic acid sysnthesis	complex II: succinate-dehydro-genase + C14-demethylase in sterol biosynthesis (erg11/cyp51) + RNA polymerase 1	4 + 3 + 4	R + R + R	Seedrot/ pre-emergence damping off caused by *Fusarium* spp., *Pythium* spp., *Rhizoctonia solan*i, *Cladosporium* spp. and *Aspergillus* spp; post emergence damping off caused by *Fusarium* spp.; suppresses seedrot/ pre-emergence damping-off caused by *Penicillium* spp.
sedaxane	pyrazole carboxamide	C2. respiration	complex II: succinate-dehydro-genase	7	R	Seed and soil-borne diseases
trifloxystrobin	oximino acetate	C3. respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	Seed decay/ pre-emergence damping off caused by *Fusarium* spp.
trifloxystrobin + metalaxyl	oximino acetate + acylalanine	C3. respiration + A1: nucleic acid synthesis	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene) + RNA polymerase 1	11 + 4	R + R + R	Seed decay/ pre-emergence damping off caused by *Fusarium* spp.

…continued

Table 5. Fungicides and biofungicides registered for disease management in sweet corn in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Foliar treatments						
azoxystrobin	methoxy-acrylate	C3. respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	Rust, (*Puccinia sorghi*), northern corn leaf blight (*Setosphaeria turcicum*), southern corn leaf blight (*Cochliobolus heterostrophus*), eye spot (*Aureobasidium zeae*), grey leafspot (*Cercospora zeae-maydis*)
chlorothalonil	chloronitrile (phthalonitrile)	Multi-site contact activity	Multi-site contact activity	M5	RE	Common rust
fluoxastrobin	dihydro-dioxazine	C3. respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	Common rust (*Puccinia sorghi*), southern corn leaf blight *(Cochliobolus heterostrophus)*, grey leaf spot (*Cercospora zeae-maydis*)
fluxapyroxad	pyrazole-4-carboxamide	C2. respiration	complex II: succinate-dehydro-genase	7	R	Grey leaf spot (*Cercospora zeae-maydis*), eyespot (*Aureobasidium zeae*)
fluxapyroxad + pyraclostrobin	pyrazole-4-carboxamide + methoxy-carbamate	C2. respiration + C3 respiration	complex II: succinate-dehydro-genase + C14-demethylase in sterol biosynthesis (erg11/cyp51)	11	R + R + R	Common rust, grey leaf spot (*Cercospora zeae-maydis*), eyespot (*Aureobasidium zeae*)

…continued

Table 5. Fungicides and biofungicides registered for disease management in sweet corn in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-valuation Status[3]	Targeted Pests[1]
Foliar treatments						
ipconazole	triazole	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	Seed, seedling an soil-borne diseases caused by *Aspergillus* spp, *Cladosporium* spp., *Fusarium* spp., *Penicillium* spp., *Rhizoctonia solani* and *Rhizopus* spp.
mancozeb	dithio-carbamate and relatives	Multi-site contact activity	Multi-site contact activity	M3	RE	Root rot, seedling blight
metalaxyl	acylalanine	A1: nucleic acids synthesis	RNA polymerase I	4	R	Pythium damping-off,
penthiopyrad	pyrazole carboxamide	C2. respiration	complex II: succinate-dehydro-genase	7	R	Common rust (*Puccinia sorghi*), suppression of grey leaf spot (*Cercospora zeae-maydis*)
picoxystrobin	methoxy-acrylate	C3. respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	Northern corn leaf blight *(Setosphaeria turcica, Exserohilum turcicum*)
propiconazole	triazole	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	Rusts, northern corn leaf blight, southern corn leaf blight, helminthosporium leaf spot, eye spot, grey leafspot

…continued

Table 5. Fungicides and biofungicides registered for disease management in sweet corn in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Foliar treatments						
propiconazole + trifloxstrobin	triazole + oximino acetate	G1: sterol biosynthesis in membranes + C.repiration	C14- demethylase in sterol biosynthesis (erg11/cyp51) + complex III: cytochrome bc1 (ubiquinlo oxidase) at Qo site (cyt b gene)	3 + 11	R + R + R	Rust (*Puccinia sorghi* and *Puccinia polysora*), eye spot (*Aureobasidium zeae*, alt. *Kabatiella zeae*), northern corn leaf blight (*Setosphaeria turcica*, anamorph alt. *Exserohilum turcicum*)
prothioconazole	triazole	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	Rusts *(Puccinia sorghi, Puccinia polysora*), eye spot (*Aureobasidium zeae* or *Kabatiella zeae*), northern corn leaf blight (*Setosphaeria turcica*), grey leaf spot (*Cercospora zeae-maydis*), suppression of fusarium and gibberella ear rots (*Fusarium* spp. and *Gibberella* spp.), suppression of stalk rot pathogens *Fusarium* spp., *Gibberella* spp. and *Colletotrichum* spp.
pyraclostrobin	methoxy-carbamate	C3. respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	Seed rot caused by *Rhizoctonia solani*

…continued

Table 5. Fungicides and biofungicides registered for disease management in sweet corn in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Foliar treatments						
tebuconazole	triazole	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	Soilborne and seedborne head smut (*Sphacelotheca reiliana*)
thiram	dithio-carbamate and relatives	Multi-site contact activity	v	M3	RE	Seed decay, seedling blight and damping-off
triticonazole	triazole	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	Seed rot and seedling blight caused by *Rhizoctonia solan*i and *Fusarium* spp; post-emergent damping-off caused by Fusarium spp.; heat smut (*Sporisorium reiliana*)

[1]Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of January 3, 2014. The product label is the final authority on pesticide use and should be consulted for application information. Not all end use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

[2]Source: Fungicide Resistance Action Committee. *FRAC Code List 2013: Fungicides sorted by mode of action (including FRAC code numbering)* (www.frac.info/) (accessed January 2014).

[3]PMRA re-evaluation status: R - full registration, RE (yellow) - under re-evaluation , RES (yellow) - under special review as published in PMRA Re-evaluation note *REV2013-06, Special Review Initiation of 23 Active Ingredients*, RES* (yellow) - under re-evaluation and special review, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA as of November 15, 2013.

Seed Rot and Seedling Blight (*Pythium* spp., *Fusarium* spp., *Diplodia* 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. During poor planting seasons (cool, wet soil conditions), seed rot and seedling blight can cause extensive crop losses.

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.

Pest Management

Cultural Controls: Corn should not be planted in fields with poor drainage. Injury-free seed should be planted in warm, moist soil with fertilizer correctly placed, avoiding seedling stress. Crop rotations with non-cereal crops can help reduce pathogen populations in the soil.

Resistant Cultivars: None available.

Chemical Controls: Seed treatment fungicides are registered for the control of seed rot and seedling blights.

Issues for Seed Rot and Seedling Blight

None identified.

Northern Corn Leaf Blight (*Exserohilum turcicum)*

Pest information

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

Life Cycle: E. turcicum overwinters as mycelium and conidia in corn debris in southwestern Ontario and southern Quebec. In the spring, conidia are also wind-blown long distances northward from the United States to corn fields where they cause infection and lesion development. Conidia produced in the lesions may re-infect corn thus producing secondary cycles of the disease. Northern corn leaf blight is more severe during extended wet, cool and humid weather. Heavy dews favour disease development.

Pest Management

Cultural Controls: Reducing crop residues by tillage helps reduce the amount of inoculum present in the spring. Disease incidence may also be reduced early in the season by crop rotation with unrelated crops.

Resistant Cultivars: Cultivars with resistance are available.

Chemical Controls: Refer to table 5. "Fungicides and biofungicides registered for disease management in sweet corn in Canada" for fungicides registered for the control of northern corn leaf blight.

Issues for Northern Corn Leaf Blight

None identified.

Common rust (*Puccinia sorghi*)

Pest Information

Damage: Damage varies from year to year, with the most severe problems resulting from early infections. The fungus causes chlorotic flecks on the leaf surface, husks, leaf sheaths and stalks which eventually give rise to reddish – brown pustules in which urediniospores develop. Entire leaves can die when infection is severe. Severe leaf damage can result in yield losses and delayed maturity.

Life Cycle: The fungus produces four different spore types, but only brick-red urediniospores are important in Canada's northern climate. 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 faced with 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 clean ploughing have no impact on the development of rust, since it does not survive in crop residue. Early planting allows the crop to escape severe infection, since spores blown in from the United States arrive too late to cause severe damage.

Resistant Cultivars: Most hybrids are resistant to rust, however some inbreds are quite susceptible.

Chemical Controls: Refer to Table 5 "Fungicides and biofungicides registered for disease management in sweet corn in Canada" for fungicides registered for the control of common rust.

Issues for Common Rust

1. The levels of resistance to common rust in sweet corn hybrids do not provide complete control.

Common smut (*Ustilago maydis*)

Pest Information

Damage: Smut causes the development of growths on tassels, nodes, and ears of the growing corn plant, rendering the infected ears unmarketable. Growths on ears appear as galls covered by a white membrane that can be up to 10 cm in diameter. The disease is found in most corn growing regions of Canada, being more common in warm, moderately dry areas. The pathogen can affect field corn, seed corn and sweet corn.

Life Cycle: The pathogen overwinters as teliospores in soil, crop residues or in contaminated seed. Teliospores give rise to sporidia which initiate new infections in susceptible corn. 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 25 and 34 °C. Spores are spread locally by wind and can spread from field to field on contaminated farm equipment.

Pest Management

Cultural Controls: Mechanical injury to plants should be avoided and soil fertility should be balanced. Phosphate fertilization tends to decrease disease incidence. Herbicide injury promotes infection. Providing the crop with ideal growing conditions is the best way to reduce smut problems. Fields should be monitored often, especially if insect or weather damage has occurred. Infected plants should be pulled and removed from the field in plastic bags to prevent further spread of the disease.

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

Chemical Controls: There are no seed treatments or foliar fungicides available that provide effective control.

Issues for Smut

1. Fungicides and crop rotation are often not effective for control of the disease.

Head smut (*Sporisorium holci-sorghi*)

Pest Information

Damage: Tassels and ears become covered by compact masses of black spores covered by a greyish membrane (sori). The membrane readily ruptures to release a powdery mass of dark spores. Affected ears do not produce kernels.

Life Cycle: The fungus persists for many years in the 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.

Pest Management

Cultural Controls: The incidence of head smut can be reduced through sanitation.
Resistant Cultivars: Resistant varieties of corn are available.
Chemical Controls: Seed treatments are available.

Issues for head smut

1. Fungicides and crop rotation are often not effective for control of the disease.

Stalk Rot (*Fusarium spp., Colletotrichum graminicola, Diplodia sp.* and *Gibberella zeae*)

Pest Information

Damage: Stalk rot causes premature death and/or lodging. Symptoms tend to develop later in the season when the ears are starting to fill. The disease is more of a problem in field corn, where premature plant death results in poor yields and low test weight grain. However supersweet cultivars with the sh2 gene are very susceptible to stalk rot pathogens.

Life Cycle: Stalk rot pathogens may enter roots, at nodes or through insect wounds on the stem. High nitrogen and low potassium fertility, as well as high plant densities favour rot. Loss of leaf area through disease, hail or insect damage can increase the susceptibility of plants to infection. Dry conditions early in the season with warm, wet weather for 2-3 weeks after silking can also increase susceptibility to stalk rot.

Pest Management

Cultural Controls: Soil fertility should be balanced, avoiding high levels of nitrogen and low levels of potassium. Decreasing plant density and following a crop rotation out of cereals for several years can reduce disease incidence. Control of stalk boring insects helps reduce the chances of infection. Scout fields early in the growing season and remove infected plants from the fields, if possible.

Resistant Cultivars: Resistant hybrids and varieties are available.
Chemical Controls: None available.

Issues for Stalk Rot

None identified.

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

Pest Information

Damage: Root rot reduces the growth of the corn plant. Affected roots eventually turn black and necrotic. Above ground symptoms may include wilting, stunting and yellowing of leaves, but these symptoms are not always apparent. The impact of root rot is unpredictable in seasons with extended cool wet periods.

Life Cycle: Soilborne fungi invade plant roots. Early season root rots occur in soils where oxygen is deficient due to poor drainage or compaction. Root rot fungi are found in water, muck or heavy soils in association with dead organic matter or in the roots of susceptible plants.

Pest Management

Cultural Controls: Corn should not be planted in fields with poor drainage or heavily structured soils, such as muck soils. Good cultural practices can help to prevent problems with the disease.

Resistant Cultivars: None available.

Chemical Controls: Treating seeds with a registered seed treatment can help reduce early season infection.

Issues for Root Rot

None identified.

Stewart's Wilt (*Erwinia stewartii*)

Pest Information

Damage: This bacterial disease affects seed, field and sweet corn. Plants infected as seedlings usually wither and die, while plants which survive are stunted, have abnormal ears and often have bleached or dead tassels. Commercial hybrids 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 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: High levels of nitrogen and phosphorus can increase disease incidence and severity, while high levels of calcium and potassium may decrease disease severity. Controlling weeds, especially grasses, removes alternate hosts of the main vector, the flea beetle. Control of the flea beetle is important to reduce transmission of the disease.

Resistant Cultivars: Resistant hybrids are available and should be used in areas where warm winters favour the survival of flea beetles.

Chemical Controls: Insecticide applications can be effective to reduce flea beetle populations, but their use may not be economical for sweet corn.

Issues for Stewart's Wilt

1. In Ontario, high flea beetle populations, which can make the disease a severe problem, are of concern.
2. Some countries regulate against this pathogen, requiring that imported seed corn be free of the bacterium.

Insects and Mites

Key issues

- Rootworm is becoming more important. Work needs to be done to monitor levels of the new variant of corn rootworm that lays its eggs in soybean crops making rotation an ineffective means of insect avoidance.
- The corn earworm is a growing concern that must be monitored. More control products are needed especially organic products such as Entrust which is approved in the US. There is concern that this pest is developing resistance to insecticides.
- The registration of new products is urgently required for the control of European corn borer.
- There is concern that the brown marmorated stinkbug, a new invasive insect, may begin damaging crops. More work is required to develop control measures before this pest begins to attack corn crops.
- There is concern about the difficulties in detecting black cutworm infestations before significant damage occurs.
- There is a need to register additional products for armyworm control; alternatives to insecticides are required for the control of armyworm.
- There is concern about the loss of pirimicarb (Pirimor) for aphid control, since this chemical is "soft" on predators. An alternative, reduced risk aphicide is required. Currently there is only one registered chemical for aphid control, therefore growers cannot rotate modes of action to delay resistance.
- There is a need for the registration of chemicals for the control of European crane fly.
- A better understanding of the impact of aphid feeding, monitoring methods and action thresholds are required for aphid control.

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

Insect	British Columbia	Alberta	Ontario	Quebec
Seed corn maggot				
Flea beetles				
Corn flea beetle				
Corn rootworms				
Northern corn rootworm				
Western corn rootworm				
Aphids				
Corn leaf aphid				
Bird cherry-oat aphid				
European corn borer				
Corn earworm				
Fall armyworm				
Brown marmorated stinkbug				
True armyworm				
Western bean cutworm				
Cutworms				
Black cutworm				
Dark-sided cutworm				
Glassy cutworm				
Sandhill cutworm				
Wireworm				
White grubs				
Sap beetles				
Slugs				

Widespread yearly occurrence with high pest pressure.

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

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

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

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

Pest not present.

Data not reported.

[1]Source: Sweet corn stakeholders in reporting provinces.

[2]Please 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	Flea beetles	Corn rootworms	Corn leaf aphid	European corn borer	Cutworms
Avoidance	resistant varieties						
	planting / harvest date adjustment						
	crop rotation						
	choice of planting site						
	optimizing fertilization						
	reducing mechanical damage						
	thinning / pruning						
	trap crops / perimeter spraying						
	physical barriers						
Prevention	equipment sanitation						
	mowing / mulching / flaming						
	modification of plant density (row or plant spacing; seeding rate)						
	seeding depth						
	water / irrigation management						
	end of season crop residue removal / management						
	pruning out / removal of infested material						
	tillage / cultivation						
	removal of other hosts (weeds / volunteers / wild plants)						
Monitoring	scouting - trapping						
	records to track pests						
	soil analysis						
	use of portable electronic devices in the field to access pest identification /management information						
	use of precision agriculture technology (GPS, GIS) for data collection and field mapping of pests						
	grading out infected produce						

…continued

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

Practice / Pest		Seed corn maggot	Flea beetles	Corn rootworms	Corn leaf aphid	European corn borer	Cutworms
Decision making tools	economic threshold						
	weather / weather-based forecast / predictive model (eg. degree day modelling)						
	recommendation from crop specialist						
	first appearance of pest or pest life stage						
	observed crop damage						
	crop stage						
Suppression	pesticide rotation for resistance management						
	soil amendments						
	biological pesticides						
	arthropod biological control agents						
	beneficial organisms and habitat management						
	ground cover / physical barriers						
	pheromones (eg. mating disruption)						
	sterile mating technique						
	trapping						
	targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)						

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).**

Table 8. Insecticides and bioinsecticides registered for the management of insect pests in sweet corn production in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted Pests[1]
Seed treatment					
clothianidin	Neonicotinoid	Nicotinic acetylcholine receptor (nAChR) agonist	4A	RE	Corn rootworm (including northern, western), corn flea beetle, black cutworm, seedcorn maggot, wireworm, white grub (larvae of European chafer, may/June beetle, Japanese beetle)
diazinon, captan, thiophanate-methyl	Organophosphate	Acetylcholinesterase inhibitor		RES*	Root maggots
imidacloprid	Neonicotinoid	Nicotinic acetylcholine receptor (nAChR) agonist	4A	RE	Wireworms, corn flea beetle (vector of Stewart's wilt)
thiamethoxam	Neonicotinoid	Nicotinic acetylcholine receptor (nAChR) agonist	4A	RE	Wireworms, European chafer, seed corn maggot, corn rootworm (western and northern), corn flea beetles (vectors of Stewart's wilt)
Soil application					
tefluthrin	Pyrethroid, pyrethrin	Sodium channel modulator		RES*	Corn rootworm, black cutworm, wireworms, seedcorn magot

…continued

Table 8. Insecticides and bioinsecticides registered for the management of insect pests in sweet corn production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted Pests[1]
Foliar application					
acephate	Organophosphate	Acetylcholinesterase inhibitor	1B	RES*	European corn borer
acetamiprid	Neonicotinoid	Nicotinic acetylcholine receptor (nAChR) agonist	4A	R	Aphids
Bacillus thuringiensis subsp. *kurstaki*	*Bacillus thuringiensis* or *Bacillus sphaericus* and the insecticidal proteins they produce	Microbial disruptors of insect midgut membrane	11	R	European corn borer
carbaryl	Carbamate	Acetylcholinesterase inhibitor	1A	RES*	Corn earworm, European corn borer, fall armyworm, northern corn rootworm (adult)
chlorpyrifos	Organophosphate	Acetylcholinesterase inhibitor		RE	Northern corn rootworm, western corn rootworm, cutworm (suppression)
chlorantraniliprole	Diamide	Ryanodine receptor modulator	26	R	Black cutworm, armyworm, fall armyworm, beet armyworm, variegated cutworm, corn earworm/ tomato fruitworm, European corn borer, western bean cutworm,
cypermethrin	Pyrethroid, pyrethrin	Sodium channel modulator	3A	RE	European corn borer

…continued

Table 8. Insecticides and bioinsecticides registered for the management of insect pests in sweet corn production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted Pests[1]
Foliar application					
deltamethrin	Pyrethroid, pyrethrin	Sodium channel modulator		RE	Western bean cutworm, European corn borer, corn earworm
lambda-cyhalothrin	Pyrethroid, pyrethrin	Sodium channel modulator	3A	RE	Cutworms, fall armyworm, armyworm, European corn borer, corn earworm
methomyl	Carbamate	Acetylcholinesterase inhibitor	1A	RE	Corn earworm, European corn borer, aphid
methoxyfenozide	Diacylhydrazine	Ecdysone receptor agonist	18	R	European corn borer
novaluron	Benzoylurea	Inhibitor of chitin biosynthesis, type 0	15	R	Corn earworm
permethrin	Pyrethroid, pyrethrin	Sodium channel modulator	3A	RE	European corn borer, corn earworm, fall armyworm, corn sap beetle
spinosad	Spinosyn	Nicotinic acetylcholine receptor (nAChR) allosteric activator	5	R	European corn borer

…continued

Table 8. Insecticides and bioinsecticides registered for the management of insect pests in sweet corn production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted Pests[1]
Foliar application					
spirotetramat	Tetronic and tetramic acid derivative	Inhibitors of acetyl CoA carboxylase		R	Aphids

[1]Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of January 3, 2014. The product label is the final authority on pesticide use and should be consulted for application information. Not all end use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

[2] Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (April 2012)* (www.irac-online.org) (accessed January 2014).

[3]PMRA re-evaluation status: R - full registration, RE (yellow) - under re-evaluation , RES (yellow) - under special review as published in PMRA Re-evaluation note *REV2013-06, Special Review Initiation of 23 Active Ingredients*, RES* (yellow) - under re-evaluation and special review, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA as of November 15, 2013.

Seed Corn Maggot (*Delia platura*)

Pest Information

Damage: The seed corn maggot is a pest of corn, beans, peas, cucumbers, melons, potatoes and other vegetables. Newly hatched maggots feed inside the seed, where they destroy the germ or allow the entrance of soil organisms that cause rot. Damage results in poor stands. The most severe damage usually occurs to spring crops planted too deep into cool, wet, high organic content soil.

Life Cycle: Seed corn maggots over-winter as pupa 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 may be completed in 3 weeks resulting in many generations per year.

Pest Management

Cultural Controls: Heavily manured or over-cropped land should be ploughed early in the fall so that it is less attractive to egg laying adults the following spring. Shallow planting will help reduce damage. Planting in the spring should be delayed until the soil is warm enough for rapid germination.

Resistant Cultivars: None available.

Chemical Controls: Seed treatments are available for the control of seed corn maggot (refer to Table 8 "Insecticides and bioinsecticides registered for the management of insect pests in sweet corn production in Canada").

Issues for Seed Corn Maggot

None identified.

Black Cutworm (*Agrotis ipsilon*)

Pest Information

Damage: Although sporadic, cutworms can cause major damage to corn crops. 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 2 to 5 leaf stage.

Life Cycle: Adults migrate into Canada in early spring and lay eggs on weeds or crop debris. Egg laying may coincide with the planting of the crop. Larvae of the cutworm develop through seven instars. Mature larvae pupate in the soil and a second and sometimes third generation occurs by the end of the growing season.

Pest Management

Cultural Controls: Weeds should be removed from the field edge, as this is where adult moths lay their eggs. Crops should not be planted in low lying, wet areas or in rotation following

sod. Crops should be kept away from pasture land. Replanting can be done once feeding has stopped. The pest has many natural enemies, including ground beetles and birds.

Resistant Cultivars: None available.

Chemical Controls: Insecticide treatments are the most reliable method of control once the pest is detected in sufficient numbers. Insecticides should be applied at night when the pest is actively feeding. Refer to Table 8: "Insecticides and bioinsecticides registered for the management of insect pests in sweet corn production in Canada".

Issues for Black Cutworm (Issues for cutworms generally)

1. There is concern over the difficulty in detecting larvae early before damage becomes obvious. The larvae rapidly become tolerant to insecticides as they mature and become more difficult to control.

Corn leaf aphid (*Rhopalosiphum maidis*)

Pest Information

Damage: The aphid feeds on the tassels, cobs and upper leaves of plants. Feeding can weaken the plant and lead to reduced pollination and poor kernel fill. The aphid also secretes honey dew, which supports the development of black sooty moulds. Generally, the corn leaf aphid is controlled to reduce cosmetic damage to the cob from sooty moulds.

Life Cycle: The corn leaf aphid does not overwinter in Canada, but blows in from the United States each season. As the aphid can reproduce without mating and bear live young, populations can increase very quickly, especially during hot, dry weather.

Pest Management

Cultural Controls: Avoiding the use of broad-spectrum insecticides, which can wipe out natural predators, can help control aphid numbers in sweet corn. Practices which encourage lady beetle populations can be of benefit in keeping aphids under control.

Resistant Cultivars: None available.

Chemical Controls: When necessary, insecticides may be applied to effectively control aphids in sweet corn.

Issues for Aphids

1. There is concern about the loss of Pirimor (pirimicarb) for aphid control, since this chemical was "soft" on predators. An alternative, reduced risk aphicide is required.
2. Currently there is only one registered chemical for aphid control therefore growers cannot rotate modes of action to delay resistance.
3. A better understanding of the impact of aphid feeding, monitoring methods and action thresholds is required for aphid control.

Flea Beetle (*Chaetocnema pulicaria*)

Pest Information

Damage: Adult flea beetles chew small holes in leaves. Heavy feeding on young plants can result in plant death. Larvae feed on corn roots. Flea beetles are a vector of Stewart's wilt and losses can result from this disease, even when damage from the beetle itself is not significant.

Life Cycle: Flea beetles overwinter in the soil in grassy areas. In the spring, eggs are laid at the base of small corn plants or grass seedlings. Upon hatching the larvae feed on host plant roots. Adults emerge following pupation and are present from mid-summer until frost.

Pest Management

Cultural Controls: Burial of crop residue in the fall will help to remove habitat for the flea beetles, and will reduce spring populations. Populations of flea beetles are also reduced by cold winter temperatures.

Resistant cultivars: None available.

Chemical Controls: Granular insecticides targeting corn rootworm provide some early season control.

Issues for Flea beetles

None identified.

European Corn Borer (*Ostrinia nubilalis*)

Pest Information

Damage: European corn borer (ECB) larvae feed initially on leaves and then bore into stems after the second instar. Maturing larvae tunnel through all parts of stalks and ears, and cause early breakage of tassels and stalks and poor ear development. In sweet corn, infestations of larvae in ears are the major concern, since not only are infested ears unsuited for sale as fresh-market produce, but small larvae may remain in kernels of sweet corn used for processing. Where two generations of ECB are known to occur, the second generation larvae cause the greatest damage.

Life Cycle: The European corn borer exists as strains with one, two and 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 20-30 days until they mature. Cool, rainy weather during June and July reduces infestations because it restricts egg laying and washes the tiny, hatching borers off plants.

Pest Management

Cultural Controls: Potatoes and beans should not be used in rotation with corn. Ploughing in the fall and disking in the spring can eliminate a large portion of the overwintering larvae. Shredding plant debris after harvest, but before ploughing the field, is an economical and effective way to destroy borers in stalks and stubble. Weeds should be controlled in the field so that adults are attracted away from the field for rest and mating. Microbial insecticides containing *Bacillus thuringiensis* (Bt), are available for the control of the European corn borer. Predators, such as pirate bugs and lady beetle adults and larvae eat corn borer eggs, but have proved to be of little value in reducing borer populations, particularly when weather conditions favour the reproduction of the pest. The release of tiny wasps (*Trichogramma* sp.) into the field several times during the season may help, as the wasps parasitize corn borer eggs and prevent them from hatching.

Resistant Cultivars: Resistant cultivars and early crop maturity can help suppress the pest. Transgenic Bt hybrids effectively kill the pest. When Bt hybrids are used, non-Bt corn refuge areas must be planted nearby to reduce the chance of resistance to Bt arising in the pest population.

Chemical Controls: The need for insecticide treatment depends on the severity of infestation and the value of the crop. Application timing has to be very precise for treatments to be effective, since larvae are present on the exterior of the plant for relatively brief periods.

Issues for European Corn Borer

1. The registration of new products is urgently required for the control of European corn borer.

Corn Earworm (*Heliothis zea*)

Pest Information

Damage: The corn earworm feeds on the kernels of sweet corn in the top third of the cob.

Life Cycle: Corn earworm moths fly into Canada each spring from the southern United States, where they overwinter as pupae. Infestations are difficult to predict and the protective husks on the cobs make the insect difficult to detect or control. The moths may arrive any time from early to late summer. Adults lay pale green eggs singly on fresh silk and occasionally on the husks of developing ears. Each female can produce as many as 1000 eggs that hatch in two to ten days, depending on temperature. Young caterpillars feed on the silks and eventually work their way down to the kernels. Larvae pupate after feeding for 2- 4 weeks although sweet corn is often harvested before pupation occurs. Other host plants include tomato, beans, cabbage, tobacco, field corn, sweet potatoes, cotton and soybean.

Pest Management

Cultural Controls: Infestations can be avoided with early planting. Harvesting the crop before mid-August helps reduce the chances of having earworm damage. Low levels of natural

control result from cannibalism by larvae, parasites of eggs and larvae and from a number of predaceous insects and birds.

Resistant Cultivars: None, although the transgenic Bt varieties can provide partial control.

Chemical Controls: Sprays must be applied every 3-7 days while silks are still fresh.

Issues for Corn Earworm

1. There is concern that this pest is developing resistance to insecticides.
2. The corn earworm is a growing concern that must be monitored. More control products are needed, especially organic products such as Entrust which is approved in the United States.

Armyworm (*Mythimna unipuncta*)

Pest Information

Damage: Armyworm larvae feed on foliage of young corn plants often leaving only the stalks and leaf mid-veins. If the growing point is not affected, the corn plants may recover.

Life Cycle: Armyworms overwinter in the south as partially grown larvae in grasses or small grain fields. Adult moths are carried northward into Canada on storm fronts in the spring. Eggs are laid in leaves or leaf sheaths and larvae are present from late spring to early summer. When feeding is complete, larvae pupate just below the surface of the soil. There may be two to three generations per year.

Pest Management

Cultural Controls: The control of grassy weeds in and around fields is very important. Planting should be done as early as possible to minimize the impact of the pest. The pest is often kept in check by naturally occurring beneficial organisms however scouting should be done to determine whether further controls are necessary.

Resistant Cultivars: None available.

Chemical Controls: Controls are most effective when larvae are small. Sprays used to control corn borer usually also control the armyworm.

Issues for Armyworm

1. There is concern that when infestations are severe, insecticides are the only effective means of control.
2. More products are required for the control of armyworm.
3. Alternatives to insecticides are required for the control of armyworm.

Brown Marmorated Stink Bug (BMSB) (*Halyomorpha halys*)

Pest Information

Damage: Although the BMSB has not yet been identified as a pest in crops in Canada, it has caused significant crop injury in other jurisdictions where it is established in agricultural crops. This insect has a broad host range including tree fruit, berries, grapes, ornamentals, grain crops, tomatoes, peppers and sweet corn. Injury is caused by feeding of adults and nymphs. The insect injects saliva with digestive enzymes into the plant and ingests the liquefied plant material. Each feeding puncture results in crop injury. In corn, feeding results in a shrivelling of developing kernels and can introduce moulds.

Life Cycle: The insect spreads through natural means and also as a "hitchhiker" in cargo and vehicles. It has been intercepted in many provinces over the years and in 2012 an established population was identified in the Hamilton, Ontario area. It readily moves between host crops throughout the growing season. BMSB overwinter as adults. In the spring, adults mate and lay eggs on host plants. Both nymphs and adults feed on host plants. Adults are long-lived and females may lay several hundred eggs over an extended period of time. In the fall, the adults move back to protected overwintering sites. They have frequently entered structures in the fall where they are a nuisance pest.

Pest Management

Cultural Controls: Monitoring for the insect may be done through aggregation pheromones and by scouting. Although thresholds have not been established, small numbers of nymphs and adults can cause considerable damage in a growing season.

Resistant cultivars: None available.

Chemical Controls: Refer to Table 8: "Insecticides and bioinsecticides registered for the management of insect pests in sweet corn production in Canada."

Issues for brown marmorated stinkbug

1. There is concern that the pest may begin appearing in crops. More work is needed to develop management approaches before this pest begins to attack corn crops.

Corn Rootworm – Northern (*Diabrotia longicornis*) and Western (*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 and germination may be affected to the point that ears bear only scattered kernels or none at all.

Life Cycle: Both species of rootworm first appear in late July and are present until fall frost. They complete one generation per year. Rootworm eggs are laid in the soil near corn plants late in the summer and in early fall. The eggs hatch during early to mid-June of the following

year. Newly hatched larvae feed on corn roots and pupate in mid-July in the soil. Adults emerge from the soil in late-July to early August and feed primarily on the silks as well as on leaf tissue, tassels and pollen. After feeding and mating, females lay eggs in the soil in corn fields. Females may crawl down soil cracks and can lay eggs as deep as 12 inches below the soil surface.

Pest Management

Cultural Controls: When corn is grown in rotation with other crops, no other controls are necessary. Practices that help speed up corn growth will help reduce the effects of the pest. Early planting allows silks to develop before peak rootworm beetle feeding. There are a few ground beetle and mite species found in soils that feed on rootworm eggs, larvae and pupae, although these natural enemies are generally not effective at reducing numbers.

Resistant Cultivars: Corn hybrids containing *Bacillus thuringiensis* (Bt) are available and provide control against the corn rootworm. There are no commercially available non-genetically modified corn hybrids with resistance to the pest. Hybrids that have large root systems are more tolerant to corn rootworm damage. Deep rooted hybrids that are grown under good conditions may outgrow rootworm damage.

Chemical Controls: Refer to Table 8: "Insecticides registered for the management of insect pests in sweet corn production in Canada."

Issues for Corn Rootworm

1. Rootworm is becoming more important. Work needs to be done to monitor levels of the new variant of corn rootworm that lays its eggs in soybean crops making rotation an ineffective means of insect avoidance.

White grubs (Scarabaeidae) (European chafer (*Rhizotrogus majalis*), June beetle (*Phyllophaga* spp.) and Japanese beetle (*Popillia japonica*)

Pest Information

Damage: Corn is most susceptible to injury when in the seedling stage. White grubs feed on the roots of susceptible plants and cause stunting, wilting and death.

Life Cycle: European chafer has a one year life cycle. Adults lay eggs in soil in mid-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.

Pest Management

Cultural Controls: Fields should be monitored in the spring or fall prior to seeding corn. Corn should not be planted in fields with high populations of white grubs. Cultivation prior to planting will expose grubs to natural predators.

Resistant cultivars: None available.

Chemical Controls: Refer to Table 8: "Insecticides and bioinsecticides registered for the management of insect pests in sweet corn production in Canada."

Issues for white grubs

None identified.

Sap beetles (Nitidulidae)

Pest Information

Damage: Adult sap beetles are attracted to and feed on over-ripe and damaged fruit. In corn, adults feed on kernels damaged by other insect, 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 in which the larvae develop. 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.

Chemical Controls: Refer to Table 8: "Insecticides and bioinsecticides registered for the management of insect pests in sweet corn production in Canada."

Issues for sap beetles

None identified.

Slugs (various species)

Pest Information

Damage: Feeding by slugs results in ragged holes and skeletonization of leaves. Feeding impact is more severe on young plants. Slug damage is more prevalent in years with cool wet springs.

Life Cycle: Slugs overwinter as adults or eggs. Both immature and adult slugs feed on plant material. Slugs are very susceptible to desiccation and are more active during cool, moist weather.

Pest Management

Cultural Controls: Eliminate crop residues which provide protection for slugs. Tillage will help to expose slugs to dehydration and predators.

Resistant cultivars: None available.

Chemical Controls: Refer to Table 8: "Insecticides and bioinsecticides registered for the management of insect pests in sweet corn production in Canada."

Issues for slugs

None identified.

Wireworm (Family: Elateridae)

Pest Information

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

Life Cycle: Wireworms overwinter as larvae or adult beetles in the soil. Adults lay eggs in the spring near grass roots. The larval stage may require 2-5+ years to complete. Pupation occurs in the soil.

Pest Management

Cultural Controls: As wireworms are attracted to pasture and grassland, corn should not be planted in a field the year after breaking sod to avoid wireworm populations in the soil. Grass weeds need to be controlled in crops following pasture or sod. Cultivation will expose larvae to predators. Wireworm populations may be monitored in the fall or early spring using bait stations or by field inspection in the spring.

Resistant cultivars: None available.

Chemical Controls: Insecticide seed treatments are available to control wireworms.

Issues for Wireworm

None identified.

Weeds

Key Issues

- There is concern over the development of resistance to some families of chemical herbicides within weed populations.
- Resistance to group 2 herbicides is a concern with the observation of resistant eastern black nightshade (*Solanum ptcanthum*) and ragweed (*Ambrosia artemisiifolia*).
- There are no effective chemical controls for wild proso millet (*Panicum miliaceum*).

Table 9. Occurrence of weeds in Canadian sweet corn production[1,2]

Pest	British Columbia	Alberta	Ontario	Quebec
Annual broadleaf weeds				
Cocklebur				
Common ragweed				
Eastern black nightshade				
Lady's-thumb				
Lamb's quarters				
Purslane				
Redroot pigweed				
Spreading atriplex				
Velvetleaf				
Wild buckwheat				
Mustards (various species)				
Corn spurry				
Annual grasses				
Barnyard grass				
Crabgrasses				
Smooth crab grass				
Large crabgrass				
Fall panicum				
Foxtail				
Green foxtail				
Yellow foxtail				
Giant foxtail				
Proso millet				
Witch grass				
Perennial weeds				
Quackgrass				
Canada thistle				
Dandelion				
Field bindweed				
Field horsetail				
Mouse-eared chickweed				
Yellow nutsedge				

…continued

Table 9. Occurrence of weeds in Canadian sweet corn production[1,2] (continued)

Widespread yearly occurrence with high pest pressure.
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.
Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pressure.
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.
Pest is present and of concern, however little is known of its distribution, frequency and importance.
Pest not present.
Data not reported.

[1]Source: Sweet corn stakeholders in reporting provinces.

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

Table 10. Adoption of weed management practices in sweet corn production in Canada[1]

Practice / Pest		Annual grasses	Annual broadleaf weeds	Perennial grasses	Perennial broadleaf weeds
Avoidance	planting / harvest date adjustment				
	crop rotation				
	choice of planting site				
	optimizing fertilization				
	use of weed-free seed				
Prevention	equipment sanitation				
	mowing / mulching / flaming				
	modification of plant density (row or plant spacing; seeding)				
	seeding / planting depth				
	water / irrigation management				
	weed management in non-crop lands				
	weed management in non-crop years				
	tillage / cultivation				
Monitoring	scouting - field inspection				
	field mapping of weeds / record of resistant weeds				
	soil analysis				
	use of portable electronic devices in the field to access pest identification /management information				
	use of precision agriculture technology (GPS, GIS) for data collection and field mapping of pests				
Decision making tools	economic threshold				
	weather / weather-based forecast / predictive model				
	recommendation from crop specialist				
	first appearance of weed or weed growth stage				
	observed crop damage				
	crop stage				

…continued

Table 10. Adoption of weed management practices in sweet corn production in Canada[1] (continued)

Practice / Pest		Annual grasses	Annual broadleaf weeds	Perennial grasses	Perennial broadleaf weeds
Suppression	pesticide rotation for resistance management				
	soil amendments				
	biological pesticides				
	arthropod biological control agents				
	habitat / environment management				
	ground cover / physical barriers				
	mechanical weed control				
	targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)				
Crop specific practices	Herbicide banding				
	Cover crops				
New practices (by province)	Fall green manure (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).**

Table 11. Herbicides and bioherbicides registered for the control of weeds in sweet corn production in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted pests[1]
2,4-D	Phenoxy-carboxylic-acid	Action like indole acetic acid (synthetic auxins)	4	RES	Annual and perennial weeds and for woody plant growth
atrazine	Triazine	Inhibition of photosynthesis at photosystem II	5	RES	Wormseed mustard, wild mustard, common purslane, ragweed, smartweed, lady's-thumb, wild buckwheat, lamb's-quarters, redroot pigweed, volunteer clover, wild oats
bentazon + atrazine	Benzothiadiazinone + triazine	Inhibition of photosynthesis at photosystem II + inhibition of photosynthesis at photosystem II	6 + 5	R + RES	Broadleaf weeds
bromoxynil	Nitrile	Inhibition of photosynthesis at photosystem II	6	RES	Seedlings up to 4 leaf stage: green smartweed, pale smartweed, lady's-thumb, wild mustard, kochia, cow cockle, Russian thistle, stinkweed, cocklebur, common ragweed, pigweed, velvetleaf, bluebur, American nightshade. Seedlings up to 8 leaf stage: wild buckwheat, tartary buckwheat, common buckwheat, common groundsel, lamb's-quarters

…continued

Table 11. Herbicides and bioherbicides registered for the control of weeds in sweet corn production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted pests[1]
carfentrazone-ethyl	Triazolinone	Inhibition of protoporphyrinogen oxidase (PPO)	14	R	Pre-plant burn-down of many weeds as specified on the label
dimethenamid-p	Chloroacetamide	Inhibition of cell division (Inhibition of VLCFAs)	15	R	Most annual grass weeds and certain broadleaf weeds: foxtail (green, yellow and giant), crabgrass (smooth, large), old witchgrass, barnyard grass, fall panicum, redroot pigweed, eastern black nightshade, yellow nutsedge
dimethenamid-p + atrazine	Chloroacetamide + triazine	Inhibition of cell division (Inhibition of VLCFAs) + inhibition of photosynthesis at photosystem II	15 + 5	R+ RES	Barnyard grass, common purslane, crabgrass (smooth, large), eastern black nightshade, fall panicum, foxtail (green, yellow, giant) lady's t-thumb, lamb's-quarters, old witchgrass, ragweed, redroot pigweed, smartweed, volunteer clover, wild buckwheat, wild mustard, wild oats, wormseed mustard, yellow nutsedge
glyphosate	Glycine	Inhibition of EPSP synthase	9	RE	Uses include : In cropping systems before planting all crops; in minimum tillage systems; post emergent in glyphosate tolerant corn, i.e. varieties with the Roundup ReadyTM gene; annual and perennial weeds, grasses and broadleaf weeds.

…continued

Table 11. Herbicides and bioherbicides registered for the control of weeds in sweet corn production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted pests[1]
linuron (for tank mix with atrazine and Dual II Magnum) (mélanger en réservoir)	Urea	Inhibition of photosynthesis at photosystem II	7	RES*	Tank mix to control annual weeds including; common chickweed, field pennycress, foxtail, goosefoot, knowtweed, lamb's-quarters, redroot pigweed, purslane, ragweed, shepherd's-purse, smartweed, annual sowthistle, wild buckwheat, witchgrass, wormseed-mustard
MCPA	Phenoxy-carboxylic-acid	Action like indole acetic acid (synthetic auxins)	4	R	Broadleaf weeds
mesotrione	Triketone	Bleaching:Inhibition of 4-hydroxyphenyl-pyruvate-dioxygenase (4-HPPD)	27	R	Lamb's-quarters, redroot pigweed, velvet leaf, wild mustard, common ragweed (suppression)
nicosulfuron	Sulfonylurea	Inhibition of acetolactate synthase ALS (acetohydroxyacid synthase AHAS)	2	R	Barnyard grass, fall panicum, green foxtail, old witchgrass, quackgrass, yellow foxtail

…continued

Table 11. Herbicides and bioherbicides registered for the control of weeds in sweet corn production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted pests[1]
saflufenacil	Aryl triazone		14	R	Broadleaf plantain, Canada fleabane, common ragweed, dandelion (suppression only), lady's thumb, giant ragweed, lamb's-quarters, perennial sow thistle, (top growth burn-down control), prickly lettuce (top growth only), redroot pigweed, shepherd's purse, stinkweed, wild buckwheat, wild mustard
saflufenacil + dimethenamid-p	Aryl triazone + chloroacetamide	Inhibition of cell division (Inhibition of VLCFAs)	14 + 15	R + R	Barnyard grass, common ragweed, crabgrass (smooth and large) eastern black nightshade, fall panicum, foxtail (green, yellow, giant), lamb's-quarters, redroot pigweed, yellow nutsedge, old witchgrass, velvetleaf, wild buckwheat, wild mustard
s-metolachlor	Chloroacetamide	Inhibition of cell division (Inhibition of VLCFAs)	15	R	American nightshade, eastern black nightshade, crabgrass (smooth, hairy), barnyard grass, redroot pigweed (suppression only), fall panicum, foxtail (green, yellow, giant), old witchgrass, yellow nutsedge

…continued

Table 11. Herbicides and bioherbicides registered for the control of weeds in sweet corn production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted pests[1]
S-metolachlor and R-enantiomer + atrazine + mesotrione	Chloroacetamide + triazine + triketone	Inhibition of cell division (Inhibition of VLCFAs) + inhibition of photosynthesis + bleaching: inhibition of 4-hydroxyphenyl-pyruvate-dioxygenase (4-HPPD)	15 + 5 + 27	R + RES + R	American nightshade, eastern black nightshade, common ragweed, lady's thumb, lamb's quarters, redroot pigweed, velvetleaf, wild buckwheat, wild mustard, barnyard grass, crabgrass (smooth, hairy), fall panicum, foxtail (green, yellow, giant), witchgrass
topramezone	benzoylpyrazole herbicide; oxazole herbicide	inhibiting carotenoid biosynthesis (HPPD inhibitor	27	R	Annual weeds; to be tank mixed with atrazine

[1]Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of January 8, 2014. The product label is the final authority on pesticide use and should be consulted for application information. Not all end use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

[2] Source: Herbicide Resistance Action Committee (HRAC). *Classification of Herbicides According to Site of Action* (www.hracglobal.com) (accessed January 2014). Herbicide resistance groups are based on the Weed Science Society of America classification system as reported by HRAC.(www.hracglobal.com).

[3]PMRA re-evaluation status: R - full registration, RE (yellow) - under re-evaluation , RES (yellow) - under special review as published in PMRA Re-evaluation note *REV2013-06, Special Review Initiation of 23 Active Ingredients*, RES* (yellow) - under re-evaluation and special review, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA as of November 15, 2013.

Annual Weeds

Pest Information

Damage: Weeds compete with the crop for light, water and nutrients. If not controlled, they can reduce sweet corn growth and yield. 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. They can be very difficult to eliminate from infested fields and they require control prior to seed-set due to their prolific seeding. In sweet corn, the critical stage for control of annual weeds is early in the growing season.

Life Cycle: Annual weeds complete their life cycle in one year, going from seed germination through vegetative growth to new seed production. Winter annuals begin their growth in the fall and produce a rosette; flowers and seeds are produced the following year. Annual weeds produce a huge number 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 favourable. Biennial weeds germinate in the spring, producing a rosette of leaves during the first summer. In the second summer, they develop a flower stalk and seeds.

Proso Millet - *Panicum miliaceum* : This weed has increased in importance as other weed species such as foxtail have been controlled. Wild proso millet moves in to the bare spots in fields and because it is a prolific seed producer, it can rapidly colonize fields. Adding to its success as a weed is its high level of natural herbicide resistance.

Barnyard Grass - *Echinochloa crusgalli*: Found nationwide, barnyard grass is an annual weed. It reproduces from year to year by seed, but can also propagate as roots when lower nodes contact the soil, creating large clumps. It thrives in moist areas and can be very competitive with many crops if left uncontrolled.

Green Foxtail - *Setaria viridis*: Green foxtail, also known as wild millet, is an annual weed, reproduces by seed and is a member of the grass (Poaceae) family. The weed can flourish after the soil has been disturbed.

Common Ragweed - *Ambrosia artemisiifolia*: Common ragweed is an annual weed that reproduces by seed. It grows in most areas and is a serious problem in many annual crops.

Corn Spurry - *Spergula arvensis*: Corn spurry, a seed producing annual weed, is common in light textured soils. It is rarely a serious problem.

Hairy Nightshade - *Solanum sarrachoides*: In British Columbia hairy nightshade is found at low to mid-elevations on dry sites on a variety of soils. It is commonly found on disturbed soils such as roadsides and cultivated fields. It is an annual that reproduces by seed. The plant produces a sticky substance that can clog agricultural equipment.

Hempnettle - *Galeopsis tetrahit*: Hempnettle is an annual weed that reproduces by seed. It is very common throughout most farming areas of the country.

Lady's Thumb - *Polygonum persicaria*.: Lady's thumb is an annual weed that reproduces by seed. It is found in almost all cultivated areas in Canada.

Lamb's-quarters -*Chenopodium album.*: Lambsquarters is an annual weed that reproduces by seed. It is found all across Canada in cultivated and waste areas.

Low Cudweed -*Gnaphalium uliginosum*: Low cudweed is an annual broadleaf weed that reproduces by seed. It occurs in cultivated and waste areas.

Wild Buckwheat - *Polygonum convolulus* : Wild buckwheat is an annual weed that reproduces by seed and is found nation-wide. Its distinctive seeds are commonly found in grain.

Wild Oats -*Avena fatua*: The wild oat is an annual grass weed that reproduces by seed. The weed is found throughout the country, but is more commonly a problem in western Canada. Wild oats prefer disturbed land and thrive under irrigated conditions.

Pest Management

Cultural Controls: Site selection is important and the weed history of a field should be known before planting. Measures to reduce difficult to control weeds should be implemented before planting. 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. Planting cover crops, such as winter cereals, can suppress weed growth following crop harvest as well as minimize erosion and nutrient uptake over the winter. Repeated tilling prior to planting and cultivation after planting, can help reduce the number of germinating weeds that survive. Weeds along road sides, ditches and fence lines should be controlled by mowing or planting perennial grasses. Equipment should be cleaned between fields to prevent the transport of weed seeds to other fields. Wind, water and animals can also transport weeds seeds from one field to another. Manure applications can also be a source of weed contamination for a field. Monitoring for annual weeds should be done during the first 2-3 weeks after weed emergence if post-emergent controls are to be applied. Effective management programs involve using all available control strategies including preventative, cultural, mechanical, and chemical control methods when available.

Resistant Cultivars: Sweet corn varieties that have quick emergence and produce vigorous crop stands shade out germinating weed seeds. Transgenic varieties, with herbicide resistance are commercially available, which allow broad spectrum herbicides to be applied to control a variety of weeds without damaging the corn plant.

Chemical Controls: Herbicides registered for weed control in sweet corn are listed in Table 11. Most annual weeds can be controlled with a soil applied pre-emergent residual herbicide. This can provide season long protection against germinating weeds and seedlings. Once the sweet corn emerges, there are further herbicide options for controlling broadleaf weeds in the crop. Using selective systemic herbicides can control grass that emerges after the crop plants.

Issues for Annual Weeds

1. There is concern over the development of herbicide resistant annual weeds, such as triazine-resistant lamb's quarters that now infests many fields across the country. Resistance to group 2 herbicides is a concern with the observation of resistant eastern black nightshade and ragweed (*Ambrosia artemisiifolia*).

Perennial weeds

Pest Information

Damage: Perennial weeds compete with the crop for light, water and nutrients. If not controlled, they can reduce sweet corn growth and yield. As with annual weeds, the critical stage for damage is early in the growing season.

Life Cycle: Perennial weeds can live for several to many years, and generally establish from various types of root systems, although many will also spread by seeds. Most perennial weed seeds germinate in the spring, with the plants growing throughout the summer. During this period they also expand their root systems, sending up new plants along the roots as well as expanding the size of existing plants. Tillage practices can break up the underground root systems and aid in the spread of perennial weeds.

Canada Thistle - *Cirsium arvense*: Canada thistle is a creeping perennial broadleaf weed that reproduces by rhizomes and seed. It is not a native species but is found throughout Canada. It is a very invasive species and is found in all habitats disturbed and undisturbed, with the exception of wetlands.

Field Mint - *Mentha arvensis*): Field Mint is a perennial broadleaf weed that reproduces mainly by rhizomes, but can also spread by seed. It is a native plant and thrives in moist areas.

Narrow-leaved Goldenrod - *Solidago graminifolia*: Narrow-leaved goldenrod is a perennial weed that spreads mainly by rhizomes, but can also reproduce by seed. It usually does not persist in cultivated fields, but can be very troublesome in new fields.

Quack Grass -Elytrigia *repens* : Quack Grass (also known as couch grass) is a common perennial grass weed that primarily reproduces by rhizomes, but can also spread by seed. It is a very persistent weed and grows in most areas of Canada.

Pest Management

Cultural Controls: See cultural controls section for annual weeds. Perennial weed management is difficult in sweet corn, especially after the crop has been planted. Field scouting done in the previous season is important for perennial weeds, so that it will be known what weeds to expect during the following year and strategies for their control can be put in place. If the weed history shows that it may be difficult to control a specific perennial weed, consider reducing the weed infestation to a manageable level in the field before planting the corn crop. Crop rotation can disrupt perennial weed life cycles by allowing a variety of control options and cultural practices that discourage normal weed growth. Equipment should be cleaned before moving from one field to the next to prevent the dissemination of weeds.

Resistant Cultivars: See resistant cultivars section for annual weeds (page 51).

Chemical Controls: See chemical controls section for annual weeds (page 51).

Issues for Perennial Weeds

1. There is concern over the use of traditional tillage practices and their effect on perennial weeds. Tillage spreads perennial weeds and can increase weed control problems. However, early tillage assists in soil warming and an early crop. The disadvantage of additional weed problems must be weighed against the economic advantage of having the first cobs on the market.
2. There is concern over the development of resistance to some families of chemical herbicides within weed populations.

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.

Racoons can cause substantial damage to corn crops throughout the cropping year. Most farmers construct two strands of electric fence at heights of 5 cm and 12 cm. If kept weed free, they are usually effective against racoons. Trapping can also be effective depending on the population of racoons in the area.

Electric fencing at a height of 75 cm can also deter deer. Other farmers use dogs to keep deer out of fields.

Red winged black birds and crows are the bird pests which cause the most damage. Noisemakers will scare birds away. Corn should not be planted near known bird nesting areas such as wetlands.

Resources

IPM/ICM resources for production of Sweet Corn in Canada

Websites

Agri-Reseau http://www.agrireseau.qc.ca

Ontario Crop IPM http://www.omafra.gov.on.ca/IPM/english/index.html

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

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

Publications

British Columbia Ministry of Agriculture crop publications
http://www.agf.gov.bc.ca/ahc/pahb/index.html

British Columbia Ministry of Agriculture. *Vegetable Production Guide 2012: Beneficial Management Practices for Commercial growers in British Columbia*
http://www.agf.gov.bc.ca/cropprot/prodguide.htm

Howard, R.J., J.A. Garland and W.L. Seaman. Ed. 1994. *Diseases and Pests of Vegetable Crops in Canada*. Canadian Phytopathological Society and Entomological Society of Canada. Ottawa, ON. 554pp.

Ontario Ministry of Agriculture and Food. 2004. *Publication 12 Sweet Corn Production Manual*.
http://www.omafra.gov.on.ca/english/crops/pub12/p12order.htm

Ontario Ministry of Agriculture, Food and Rural Affairs. 2012. *Publication 75, Guide to Weed Control 2012-13*. http://www.omafra.gov.on.ca/english/crops/pub75/pub75toc.htm

Ontario Ministry of Agriculture, Food and Rural Affairs. *OMAFRA Vegetables: Sweet Corn*
http://www.omafra.gov.on.ca/english/crops/hort/sweet_corn.html

Ontario Ministry of Agriculture, Food and Rural Affairs. *Vegetable Production Recommendations (2009-10) Publication 363); Publication 363SE, Supplement - Vegetable Production Recommendations 2010-2011*
http://www.omafra.gov.on.ca/english/crops/vegpubs/vegpubs.htm

Ontario Ministry of Agriculture, Food and Rural Affairs. *Ontario Vegetable Crop Production Guide (2012-13) Publication 838*[E]
http://www.omafra.gov.on.ca/english/crops/vegpubs/vegpubs.htm

Provincial Crop Specialists and Provincial Minor Use Coordinators

Province	Ministry	Crop Specialist	Minor Use Coordinator
British Columbia	British Columbia Ministry of Agriculture and Lands www.gov.bc.ca/al	Susan Smith susan.l.smith@gov.bc.ca	Caroline Bédard caroline.bédard@gov.bc.ca
Alberta	Alberta Agriculture and Rural Development www.agric.gov.ab.ca/	Patricia McAllistair tricia.mcallister@gov.ab.ca	Jim Broatch jim.broatch@gov.ab.ca
Ontario	Ontario Ministry of Agriculture, Food and Rural Affairs www.omafra.gov.on.ca	Elaine Rody elaine.roddy@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	Brigitte Duval brigitte.duval@mapaq.gouv.qc.ca	Luc Urbain luc.urbain@mapaq.gouv.qc.ca

National and Provincial Vegetable Grower Organizations

British Columbia Potato and Vegetable Growers Association (http://www.bcfreshvegetables.com/bcfresh/associations)

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

Conseil Québecois de l'horticulture (CQH) (http://www.cqh.ca) (The site is available in French only).

National

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

Appendix 1

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

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

<table>
<tr><th>Presence</th><th colspan="4">Occurrence information</th><th>Colour Code</th></tr>
<tr><td rowspan="13">Present</td><td rowspan="10">Data available</td><td>Frequency</td><td>Distribution</td><td>Pressure</td><td></td></tr>
<tr><td rowspan="5">**Yearly** - Pest is present 2 or more years out of 3 in a given region of the province.</td><td rowspan="3">**Widespread** - The pest population is generally distributed throughout crop growing regions of the province. In a given year, outbreaks may occur in any region.</td><td>**High** - If present, potential for spread and crop loss is high and controls must be implemented even for small populations.</td><td>Red</td></tr>
<tr><td>**Moderate** - If present, potential for spread and crop loss is moderate: pest situation must be monitored and controls may be implemented.</td><td>Orange</td></tr>
<tr><td>**Low** - If present, the pest causes low or negligible crop damage and controls need not be implemented.</td><td>Yellow</td></tr>
<tr><td rowspan="3">**Localized** - The pest is established as localized populations and is found only in scattered or limited areas of the province.</td><td>**High** - see above</td><td>Orange</td></tr>
<tr><td>**Moderate** - see above</td><td>White</td></tr>
<tr><td>**Low** - see above</td><td>White</td></tr>
<tr><td rowspan="6">**Sporadic** - Pest is present 1 year out of 3 in a given region of the province.</td><td rowspan="3">**Widespread** - as above</td><td>**High** - see above</td><td>Orange</td></tr>
<tr><td>**Moderate** - see above</td><td>Yellow</td></tr>
<tr><td>**Low** - see above</td><td>White</td></tr>
<tr><td rowspan="3">**Localized** - as above</td><td>**High** - see above</td><td>Yellow</td></tr>
<tr><td>**Moderate** -see above</td><td>White</td></tr>
<tr><td>**Low** - see above</td><td>White</td></tr>
<tr><td rowspan="2">Data **not** available</td><td colspan="3">**Not of concern:** The pest is present in commercial crop growing areas of the province but is causing no significant damage. Little is known about its population distribution and frequency in this province; however, it is not of concern.</td><td>White</td></tr>
<tr><td colspan="3">**Is of concern:** The pest is present in commercial crop growing areas of the province. Little is known about its population distribution and frequency of outbreaks in this province and due to its potential to cause economic damage, is of concern.</td><td></td></tr>
<tr><td>Not present</td><td colspan="4">The pest is not present in commercial crop growing areas of the province, to the best of your knowledge.</td><td>black</td></tr>
<tr><td>Data not reported</td><td colspan="4">Information on the pest in this province is unknown. No data is being reported for this pest.</td><td>grey</td></tr>
</table>

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