Crop Profile for Cranberry in Canada, 2016

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Preface

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

Information on pest 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 cranberry, 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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Crop Profile for Cranberry in Canada

The large-fruited American cranberry, *Vaccinium macrocarpon*, also known as *atokas* is a member of the Ericaceae family. It is a perennial evergreen vine native to North America that grows naturally in wetland areas. Although the plant is an evergreen, it is not truly hardy and depends on flooding to protect it from winter injury. Plants can have a life-span of over 100 years. Early European settlers were introduced to cranberries by First Nations peoples who consumed the fruit fresh and in pemmican (dried meat or fish staple), or used it as a dye and for medicines. The name *cranberry* is derived from the German, *kraanbere* (English translation, *craneberry*), first named as *cranberry* in English in 1647, attributable to the shape of its flower. Just before it opens, the flower bud resembles a crane's neck, head and beak. Commercial production of the crop in Canada began in the late 1800s in Nova Scotia.

Cranberries are a tart fruit consumed in many forms, including fresh, frozen, dried, in sauces, in jams, as juice, in baking products, in granola bars and trail mixes, or as capsules. Value-added products such as seed oil, pomace and nutraceuticals are continually being developed. White cranberry juice is made from cranberries that have been harvested after the fruits are mature, but before they have attained their characteristic dark red colour. Cranberries are an excellent source of vitamin C, have moderate levels of dietary fiber and manganese, and contain no sodium and very little sugar or protein.

Cranberries have been associated to a range of health benefits, including cardiovascular, immune, and bone health. They are well known for their antioxidant and anti-adhesive properties. Polyphenols contained within cranberries are thought to be linked with the prevention of certain types of cardiovascular and cancerous diseases and their anti-adhesive properties may help prevent the adhesion of bacteria that cause dental plaque, urinary infections and intestinal disease.

Crop Production

Industry Overview

North America dominates the cranberry market worldwide, and Canada, accounting for about 27% of the global crop is the second largest producer behind the United States which has roughly twice the production of Canada. The hybrid cultivar 'Stevens' accounts for the majority of the planted area in North America, followed by 'Early Black', 'Howes', and 'Ben Lear'.

Most of the Canadian commercial cranberry crop is processed, with only seven percent of cranberries sold fresh. In Quebec, yields per hectare from cranberry production are the highest amongst all fruits produced, and this province is the number one producer of organic cranberries worldwide. Of the total area allotted to cranberry production in Quebec, 30 percent is grown organically.

Table 1. General production information for cranberry, 2016

Canadian Marketed Production[1]	180,282 metric tonnes 7,517 hectares
Farm Gate Value[1]	$158 million
Fresh Fruit Available in Canada[2]	3.14 kg/ person/ year
Exports[3]	63,720 metric tonnes (fresh)
Imports[3]	1,960 metric tonnes (fresh)

[1]Statistics Canada. Table 32-10-0364-01 (formerly CANSIM 001-0009) - Estimates, production and farm gate value of fresh and processed fruits (database) (accessed July 18, 2018).
[2]Statistics Canada. Table 32-10-0054-01 (formerly CANSIM 002-0011) - Food available in Canada (database) (accessed July 6, 2018).
[3]Statistics Canada. Table 32-10-0053-01 (formerly CANSIM 002-0010 - Supply and disposition of food in Canada (database) (accessed July 6, 2018).

Production Regions

The distribution of cranberry production in Canada is presented in Table 2. There were 7,517 hectares of cranberries grown in Canada in 2016. The two major production areas are Quebec (4,187 hectares) with 56% of national production, and British Columbia (2,643 hectares) at 35% of national production. Small commercial crops are also produced in New Brunswick and Nova Scotia.

Table 2. Distribution of cranberry production in Canada, 2016[1]

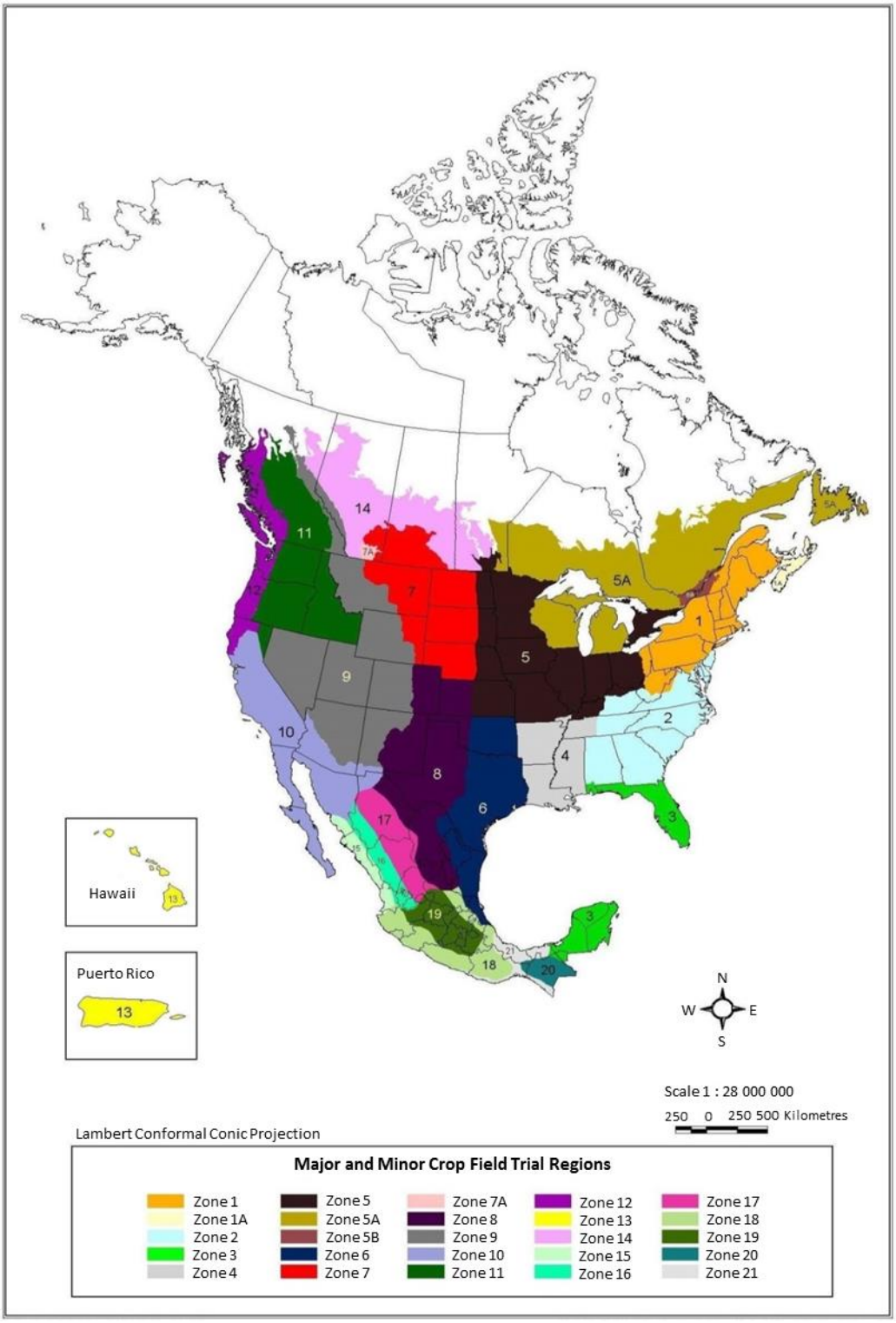
Production Regions	Cultivated Area (hectares)[2]	Percent of National Production
British Columbia	2,643	35%
Quebec	4,187	56%
New Brunswick	354	5%
Nova Scotia	135	2%
Canada	**7,517**	**100%**

[1]Statistics Canada. Table 32-10-0364-01 (formerly CANSIM 001-0009) - Estimates, production and farm gate value of fresh and processed fruits (database) (accessed July 9, 2018).
[2]Includes bearing and non-bearing area

North American Major and Minor Field Trial Regions

Major and minor crop field trial regions (Figure 1) are used by the Pest Management Regulatory Agency (PMRA) in Canada and the United States (US) Environmental Protection Agency (EPA) 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 on field trial regions and requirements, 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]



[1]Produced by: Spatial Analysis and Geomatics Applications, Agriculture Division, Statistics Canada, February 2001

Cultural Practices

Cranberry shrubs are composed of low, creeping vines (runners) that measure up to two metres long and vertical upright branches of five to twenty centimeters in height. Roots are very fine and fibrous and usually occupy the upper 10 to 20 cm of soil, but some may extend 45 cm deep. Upright branches originate from axillary buds on the vines or from older uprights and grow for several years. They have slender woody stems and small dark, glossy green leaves, that will turn reddish brown during the dormant season. The leaves remain on the plant for up to two years before senescing. Uprights can either be productive (fruiting) or vegetative. Berries develop through the summer and ripen to bright red in September, when they are ready for harvest.

The cranberry crop thrives in well-drained, acidic soils with a pH between 4.0 and 5.0, where the summers are cool, yet with adequate levels of sunshine. Optimal growth temperature is between 15 and 27ºC. For continued production, the crop requires a period of five months without frost. Fertilizer and pesticide requirements are generally low and pesticides are most often applied in localised problematic areas.

Cranberry plants live in symbiosis with mycorrhizal fungi, an association which benefits the plant in coping with drought and disease stresses and also aids it in nutrient uptake. When fertilizers are required, they are usually applied fractionated and according to the growth stage of the plant. Applications may vary depending on soil type, variety, weather and previous yields. In organic production, composted manure is typically used to fulfill nutrient requirements.

Commercial cranberry production differs from all other forms of small fruit production. It requires large amounts of water throughout the year and is highly automated and mechanised, making use of leading-edge technologies such as precision irrigation. The ability to flood and hold water on the bed surface is critical to the success of commercial operations. Although beds were historically constructed in wetlands, in current practice in Quebec beds are more typically built in levelled and well-drained mineral soils, surrounded by dikes. Because mineral soils are nutrient poor and dry, nutrients levels and water quantities can be better controlled in these soils compared to traditional peat bogs. Most farms are fitted with canals, closed-circuit reservoir systems, and other water control structures or equipment, such as overhead sprinklers and tensiometers to help regulate water flow into and away from the beds. The closed-circuit reservoir systems allow for the recuperation and recirculation of water, thus permitting optimal water management and limiting environmental impacts due to leaching of pesticides and fertilizers in adjacent waterways. In British Columbia, the majority of cranberries are still produced in organic (peat /muck) soils, with about 20 percent being produced on sawdust beds.

Irrigation provides moisture for growth and prevention of water stress during the growing season, and is also used for flooding for frost protection, pest management, harvest and winter protection. Over the years, the application of fertilizers and pesticides through “fertigation” and “chemigation” respectively has been gradually abandoned due to the normalisation of bed sizes which allowed for the construction of pesticide and fertilizer spray booms. These booms are more precise and more efficient than vast irrigation systems running below the surface of beds and permit localised applications, thus reducing environmental risks.

Cranberry plants can be propagated vegetatively or by seed. Plantings can be established by “pressing in” hardwood cuttings obtained by pruning or mowing mature beds or by using

rooted cuttings or “plugs”. The latter is preferred for the establishment of pure cultivar beds or when new breeds are available in limited quantities. The cuttings are spread over the surface of the new area and are mechanically pushed into a wet sand layer to a depth of five to ten cm. Pruning and/or mowing cranberry fields has the additional benefit of stimulating the production of new vigorous uprights, which produce more fruit the following year. The first economic harvest of a new cranberry bed is usually obtained by year three and maximum production, by year five when a mature bed consisting of a solid bed of vines with no aisles is established. With proper care, beds can be productive for several decades.

Cranberries require insect pollination, and farmed honeybee colonies are frequently used in commercial operations to optimize pollination and fruit set.

Cranberries are harvested in the fall, most commonly using a wet-harvest technique which takes advantage of the fact that sound, ripe cranberries will float. The beds are flooded to just above the top of the plant canopy, and a beater is used to detach the fruit from the vines. The water level is raised and the berries can then be corralled with floating booms and conveyed or pumped into a truck for transport to a cleaning and sorting facility. A small proportion of cranberries are dry-harvested to supply the fresh market.

In Canada, cranberry production is conducted in a manner that respects the principles of sustainable development. Not only do closed-circuit reservoir systems have very low environmental impacts, they have also been shown to benefit biodiversity by creating new habitats for birds, amphibians, turtles, etc. The preservation of woodlands, buffer zones and wind break hedges that many cranberry producers include in the landscape in proximity of cranberry fields also provides habitats for beneficial insects and natural pollinators. Cranberry growers are recognized as leaders among agricultural commodities in the adoption of integrated pest management (IPM) practices. Through prudent application of these practices, pesticide and fertilizer use has been significantly reduced over time.

The following table (Table 3) describes cranberry production practices and work carried out in cranberry beds throughout the seasons.

Table 3. Cranberry production and pest management schedule in Canada

Time of Year	Activity	Action
Winter – dormancy (December to late March)	Plant care	Prune in the fall if necessary. Apply winter flood, taking precautions to avoid oxygen deficiency injury. If necessary, irrigate for frost protection of vines once winter flood has been removed.
	Soil care	Sand every 3 to 5 years for bed rejuvenation.
	Weed management	Sand every 3 to 5 years.
	Insect management	Sand every 3 to 5 years.
Spring – flood removal to bud break (late March to May)	Plant care	Irrigate plants for frost protection of vines. Apply fertilizers for oxygen deficiency injury treatment. Prune or mow if required. Introduce pollinators (honeybees, bumblebees) at approx. 10% bloom after spraying (late spring).
	Soil care	Apply minerals and sulfur or lime for pH adjustment.
	Weed management	Apply pre-emergence herbicides before vines break dormancy. Late water (spring flooding for one month) may be applied for dewberry control.
	Disease management	Apply late water for fruit rot reduction. Apply fungicides in fields with a history of upright dieback.
	Insect management	Apply late water for cranberry fruitworm reduction. Monitor for blackheaded fireworm hatch in known field hot spots.
Summer – bud break to berry maturity (May to late September)	Plant care	Apply granular and foliar nutrients as required. Calcium-boron may be applied for optimum fruit set. Irrigate as required. Conduct leaf analyses every 2 to 4 years. Monitor fruit maturity.
	Soil care	Analyse soil samples every 3 to 5 years. Apply low rates of sulfur as required.
	Disease management	Monitor for diseases and apply fungicides as required.
	Insect management	Monitor for insects (plant visual inspection, sweep nets, pheromone traps, etc.) and for beneficial organisms, and apply controls as needed. Apply summer re-flood for grub control.
	Weed management	Monitor and map weeds. Remove weeds manually or mechanically and apply herbicides as needed.
	Other	Monitor for other pests (rodents, etc.) and control as required. Plant new beds (May-June). Construct new beds for next year (June-Sept).
Fall – harvest period (September to November)	Plant care	Irrigate plants for frost protection of fruit. Harvest berries (with or without flooding). Prune and apply fall fertilizers only if needed.
	Soil care	Analyse soil for springtime fertilization applications (NPK).
	Disease management	Remove trash piles after harvest.
	Insect management	Apply fall flood after harvest for cranberry girdler and root weevil reduction.
	Weed management	Remove trash piles after harvest. Apply pre-emergence weed controls as required. Apply fall flood if required.

Abiotic Factors Limiting Production

Sunscald and Heat Injury

Excessive temperatures (> 32˚C) in the summer months may result in sunscald and heat injury damage. Sunscald occurs on the top side of large berries that are exposed to the sun and is more common in newly planted fields with little or no overgrowth. Heat injury to cranberry plants can happen throughout the period of active upright growth and flowering. Blossom blast, the failure of blossoms to set fruit, may occur when temperatures above 30˚C are accompanied by low humidity and high winds. Heat damage may also occur on new shoots and leaves during active growth before bloom, resulting in upright dieback, suppressed growth, reduced flowering and lower productivity. Sunscald and heat injury can be substantially reduced by the use of overhead sprinkler irrigation systems for evaporative cooling.

Frost and Winter Injury

Although overwintering terminal buds of cranberry can tolerate temperatures as low as -18˚C, buds are very susceptible to frost damage following bud break in the spring, and berries can be damaged by early frosts in the fall. Berries become progressively more cold-tolerant as they mature on the vine. The white-berry stage is tolerant to -2˚C, while well-coloured fruit can withstand temperatures of -5 to -7˚C, depending on cultivar and maturity. Berries damaged by fall frost become opaque and soft. To mitigate frost damage, flooding or overhead sprinkler irrigation is used.

Cranberry vines may also be injured or killed by severe winter weather resulting in the phenomenon known as winterkill. Winterkill can occur via a combination of a frozen root zone to a depth of 10 cm, air temperature below freezing and strong winds. Symptoms appear as leaf discoloration (bronze-orange hue) and eventual leaf drop. In severe cases, the terminal bud is destroyed and the plant may die back to ground level. Injury is prevented by protecting vines with a winter flood kept in place until the risk of winterkill conditions subsides.

Lightning and Hail

Hailstorms can cause severe injury to blossoms and buds, impacting fruit set and may also physically bruise or cut fruit, predisposing them to field and storage rots. Fruit may become unsuitable for the fresh market. Lightning can cause damage to cranberry beds by killing plants both above and below ground. Killed plants appear in a characteristic wavy pattern that emanates from a central point, with damage usually coinciding with a metal sprinkler head.

Soil pH, Water pH, Salts and Drainage

Cranberries require a soil pH between 4.0 and 5.0 for optimum growth. Growth and yields will be poor in soils with a pH outside the desired range or in soils with poor drainage. Vines growing in poorly drained soils are susceptible to phytophthora root rot, salt injury, and the plant cover will wither, leading to an increase in hydrophilic weed invasion of the bed. Vines can be injured, and in severe cases may die from roadside run-off of salt and flooding from hurricane tides or seaside salt spray if drainage is insufficient to wash the salts out of the plant root zone. Long term exposure to salt causes visible symptoms on leaves, vegetative growth stimulation and decreased yield. Salt injury may be corrected or minimized by flushing with clean irrigation water or by applying a mixture of calcium sulfate and potassium magnesium sulfate. The regular sanding of cranberry beds reduces the buffering capacity of the soils, making the beds susceptible to rapid pH change if they are irrigated with water outside the desired pH range.

Oxygen Deficiency Injury

Insufficient dissolved oxygen in winter flood water can severely injure cranberry plants by causing leaf drop and reduced yields. When the oxygen content falls to below 40% of normal, injury will occur within two to three days. To mitigate this type of injury, water from under the iced-over flood can be removed as soon as a thick ice layer is formed to allow air to penetrate along the edges and through cracks in the ice, and exposing the vines to atmospheric oxygen.

Nutritional Disorders

Nutritional disorders appear in plants when the concentration of required nutrients in the growing medium are too high, too low, or out of balance. Although the requirements for nitrogen are low, the cultivation of cranberry in sandy soils makes it necessary to add nitrogen to meet the plant's nutritional needs. Excessive nitrogen application has been associated with poor cropping, rank vegetation (runner production), and an increase in the incidence of fruit rot disease. However, nitrogen deficiency results in reduced growth and abnormal colour development. Phosphorus deficiency reduces the growth rate of cranberry and potassium deficiency, which first appears as a reddening of the leaf margins at the tip of the shoot, can lead to retarded growth, eventual leaf necrosis and plant death.

Pesticide Toxicity Injury

Many herbicides have the capacity for causing injury to cranberry plants. Damage can range from inhibiting root formation and growth, to yellowing and necrosis of leaves, formation of witches broom, and reduced fruit production. Insecticides and fungicides may cause fruit lesions that develop some russeting as the fruit matures.

Physiological Breakdown

Physiological breakdown refers to the softening of stored berries without the involvement of microorganisms. Berries are susceptible to this injury when they are wet-harvested and the longer they remain in the flood water at harvest, the more susceptible they are to this injury. Bruised fruit are vulnerable to this breakdown in cold storage. As well, storage temperature between -1.1˚C and 1˚C for two weeks will cause an increase in physiological breakdown. The berries become water-soaked and rubbery, and red pigment which is normally restricted to the skin, leaches into the flesh, turning the normally white flesh pink.

Diseases

Key Issues

- Fruit rots and their impact on the storage life of fresh fruit are of concern. Studies are required on the management of fruit rots in the field, including the determination of rot pathogen species and the development of monitoring approaches and forecasting models to determine the need and timing of treatments.
- There is a need for the development of best management practices for use in storage facilities to increase the storage life of fresh cranberry fruit.
- At harvest, a portion of cranberries destined for processing is found to be unmarketable and is discarded. Studies are required to establish the cause and to determine the actual crop loss.

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

Disease	British Columbia	Quebec
Fruit rot complex		
Red leaf spot		
Cottonball		
Rose bloom		
Upright dieback		
Widespread yearly occurrence with high pest pressure.		
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.		
Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pest pressure.		
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.		

[1]Source: Cranberry stakeholders in reporting provinces. The data reflect the 2016, 2015, and 2014 production years.

[2]Refer to Appendix 1 for further information on colour coding of occurrence data.

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

Practice / Pest		Fruit rot complex	Cottonball	Rose bloom	Upright dieback
Avoidance	Varietal selection / use of resistant or tolerant varieties				
	Planting / harvest date adjustment				
	Rotation with non-host crops				
	Choice of planting site				
	Optimizing fertilization for balanced growth and to minimize stress				
	Minimizing wounding and insect damage to limit infection sites				
	Use of disease-free propagative materials (seed, cuttings or transplants)				
Prevention	Equipment sanitation				
	Canopy management (thinning, pruning, row or plant spacing, etc.)				
	Manipulating seeding / planting depth				
	Irrigation management (timing, duration, amount) to minimize disease infection periods and manage plant growth				
	Management of soil moisture (improvements in drainage, use of raised beds, hilling, mounds, etc.)				
	End of season or pre-planting crop residue removal / management				
	Pruning out / removal of infected material throughout the growing season				
	Removal of other hosts (weeds / volunteers / wild plants) in field and vicinity				

.....continued

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

Practice / Pest		Fruit rot complex	Cottonball	Rose bloom	Upright dieback
Monitoring	Scouting / spore trapping				
	Maintaining records to track diseases				
	Soil analysis for the presence of pathogens				
	Weather monitoring for disease forecasting				
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of diseases				
Decision making tools	Economic threshold				
	Use of predictive model for management decisions				
	Crop specialist recommendation or advisory bulletin				
	Decision to treat based on observed disease symptoms				
	Use of portable electronic devices in the field to access pathogen / disease identification / management information				
Suppression	Use of diverse product modes of action for resistance management				
	Soil amendments and green manuring involving soil incorporation as biofumigants, to reduce pathogen				
	Biopesticides (microbial and non-conventional pesticides)				
	Controlled atmosphere storage				
	Targeted pesticide applications (banding, spot treatments, use of variable rate sprayers, etc.)				
	Selection of pesticides that are soft on beneficial insects, pollinators and other non-target organisms				

...continued

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

Practice / Pest		Fruit rot complex	Cottonball	Rose bloom	Upright dieback
Crop specific practices	Sanding				
	Use of late water (spring flooding)				
	Fall flooding; post-harvest flood				
This practice is used to manage this pest by at least some growers.					
This practice is not used by growers to manage this pest.					
This practice is not applicable for the management of this pest.					

[1]Source: Cranberry stakeholders in reporting provinces (British Columbia and Quebec). The data reflect the 2016, 2015 and 2014 production years.

Fruit Rot Complex: Early Rot (*Phyllosticta vacinii*), End Rot (*Godronia cassandrae*), Viscid Rot (*Phomopsis vaccinii*), Botryosphaeria Fruit Rot, Berry Speckle (*Phyllosticta elongata*), Ripe Rot (*Coleophoma empetri*), Black Rot (*Allantophomopsis lycopodina*), Yellow Rot (*Botrytis cinerea*) and Blotch Rot (*Physalospora vaccinii*)

Pest Information

Damage: In Canada, fruit rots are most prevalent in British Columbia. They are caused by a complex of fungi affecting the cranberry fruit, either pre-harvest, referred to as field rots or post-harvest, referred to as storage rots. Infected berries are unmarketable. They may display superficial speckling, become soft, turn tan or black in colour, become dried and shriveled, and develop a watery decay. Losses of 33% are commonly reported in untreated beds, and there is the potential for up to 100% fruit loss.

Life Cycle: The fungi that cause fruit rot are present in most bogs and overwinter in infected stems, leaves, blossoms, pedicels and fruit left behind after harvest. Spores can disperse by wind or by wind-driven rain and land on leaves, blossoms and small developing fruit. If there is a suitable layer of moisture present on these structures for an extended period of time, the fungi will infect the plant tissue. Infections may also occur at wound sites during water harvest. Some of these infections lead to classic rot symptoms immediately, while others remain dormant within the berry until suitable conditions occur later in the season, or appear after the berries have been harvested and are held in storage. Warm temperatures favour some rot species while cooler temperatures favour others.

Pest Management

Cultural Controls: Cultural practices that reduce fruit rot include sanding to bury excess runners and sources of inoculum, drainage improvements, morning irrigation to promote vine drying during the day, holding late water to disrupt life cycles of rot-inducing fungi, removal of harvest trash, pruning to increase air circulation, avoiding excess nitrogen applications to prevent vine overgrowth, minimizing berry bruising and injury by harvest equipment, minimizing the length of time berries remain in the harvest flood water, promptly drying and freezing fruit after harvest and maintaining optimum temperatures and humidity (2 to 4˚C, 90% humidity) during storage. Additional management practices for fruit rot are listed in *Table 5. Adoption of disease management practices in cranberry production in Canada*.

Resistant Cultivars: There are several varieties known to have high fruit rot resistance, including *Scarlett Knight*, *Mullica Queen*, *Haines*, *Black Veil*, and *Howes*. Moderate fruit rot resistance has been observed with *Stevens*, *Crimson Queen*, *Demoranville* and *Early Black*.

Issues for Fruit Rot Complex

1. At harvest, a portion of cranberries destined for processing is found to be unmarketable and is discarded. The cause of this fruit loss, whether due to pathogens or abiotic factors is unknown. Studies are required to establish the cause and to quantify the crop loss.
2. Fruit rots and their impact on the storage life of fresh fruit are of concern. Studies are required on the management of fruit rots in the field, including the development of

monitoring approaches and forecasting models to determine the need and timing of treatments.

3. Increased testing of fruit rot samples to determine which rot species is present in the field is required.
4. There is a need for the development of best management practices for use in storage facilities to increase the storage life of fresh cranberries.

Red Leaf Spot (*Exobasidium rostrupii*)

Pest Information

Damage: Red leaf spot is most prevalent in British Columbia, with young plantings being more susceptible to the disease. Mature cranberry beds are usually less affected than young bogs where excessive growth occurs due to high nitrogen availability. Symptoms appear as bright, circular, glossy red spots on the upper side of leaves and sometimes on young green berries. Cream-coloured spores appear below the spots on the lower surface. Expanding spots often overlap and infected leaves usually fall prematurely. The disease may also spread to leaf petioles and to new stem growth where it can cause reddening and swelling, sometimes resulting in tissue death. Fruit is occasionally infected. Buds and blossoms injured by frost and insects are very susceptible to red leaf spot infection. Black spot disease often develops on plants already infected by red leaf spot and some damage attributed to red leaf spot damage may actually be caused by black spot. Invasion by the black spot fungus will cause the reddened tissues to turn black. The most serious effect of the disease is the loss of vegetative and fruiting buds due to the death of young shoots, which will reduce the crop the following year.

Life Cycle: The life cycle of this fungus is not fully understood, but it is thought to overwinter on diseased leaves and stems as dormant mycelium. It is believed that this mycelium serves as the primary inoculum, infecting young leaves and stems in spring after growth resumes. The disease is favoured by high levels of moisture from rain, fog, poor drainage, etc. and is more prevalent in shaded areas where air circulation is poor.

Pest Management

Cultural Controls: Practices that improve air circulation, such as limiting tree plantings around the edges of the bed and improving plant drying may help to control this disease. Avoiding over-fertilization will help reduce disease incidence by limiting vegetative growth.

Resistant Cultivars: None available.

Issues for Red Leaf Spot

None identified.

Cottonball (*Monilinia oxycocci*)

Pest Information

Damage: Cottonball results in tip blight of young succulent shoots and a secondary fruit rot, known as hard rot, caused by infection of flowers during bloom. The tip blight is characterized by tan V- or U-shaped lesions centered on the leaf mid-vein. Although immature diseased berries show no external symptoms, they are filled with a white cottony mass of fungus that surrounds the seeds. In the fall, these infected berries will remain firm and yellowish-tan, but later, will turn brown then black, and eventually mummify. Infected berries are unmarketable.

Life Cycle: Cottonball overwinters as sclerotia (fungal resting bodies), often in the form of mummified berries, on or below the cranberry bed surface. The sclerotia are tolerant of winter flooding and germinate in early spring, with apothecia (fruiting bodies) maturing around bud break. Ascospore (sexual spore) release is greatest over a 10 to14 day period coinciding with new shoot growth, when shoots are very susceptible to infection. Disease incidence is greatest under prolonged wet conditions and moderate temperatures. During bloom several weeks later, conidia (asexual spores) are produced in infected tissues and are dispersed to infect open flowers. Conidia release is favoured by warm temperatures, low relative humidity and high wind speed. After bloom, infected shoots desiccate and fall off. Infected berries remain on the plant where the disease progresses and eventually develops into the characteristic fruit rot. Sclerotia develop in 25 to 50 percent of infected berries by the end of the growing season. Berries that do not develop sclerotia decompose normally while those with sclerotia often float and may be disseminated by moving water.

Pest Management

Cultural Controls: The removal and destruction of mummified fruit at harvest reduces inoculum for infection the following season. Adequate drainage is also helpful for limiting the spread of the disease by limiting the ability of spores to travel in water on the soil surface. Because cottonball can be introduced to new fields by imported vines from regions where the disease is problematic, caution is appropriate when procuring vines to establish new plantings. Additional management practices for cottonball are listed in *Table 5. Adoption of disease management practices in cranberry production in Canada.*

Resistant Cultivars: McFarlin and *Stevens* show some resistance.

Issues for Cottonball

None identified.

Rose Bloom (*Exobasidium oxycocci*)

Pest Information

Damage: Rose bloom is most prevalent in British Columbia. It is commonly seen from late-April through mid-June on buds scattered throughout the beds. The disease causes abnormal thick

swollen branches with fleshy, pink leaves that resemble miniature roses, and results in a reduction of yield on affected shoots. Infected tissues are initially pale green, but become pink as they enlarge, eventually becoming powdery white when spores are produced on their surface. Infected blossoms and berries are usually deformed. By mid-bloom, affected uprights harden and become dry and dark brown and withered.

Life Cycle: The disease has a one-year life cycle. Infections occurring in the spring do not develop symptoms until the following spring. Spores are produced on the surface of affected lateral shoots and are dispersed by wind to nearby lateral buds.

Pest Management

Cultural Controls: Adequate drainage in low areas of the bed and good air circulation will help minimize the spread of the disease Additional management practices for rose bloom are listed in *Table 5. Adoption of disease management practices in cranberry production in Canada.*

Resistant Cultivars: None available.

Issues for Rose Bloom

None identified.

Upright Dieback *(Diaporthe vaccinii (anamorph Phomopsis vacinii)* and *Synchronoblastia crypta)*

Pest Information

Damage: Upright dieback is most prevalent in British Columbia. Symptoms include yellowing of the leaves which progress to orange or bronze and eventually become brown as the uprights defoliate and die. Uprights die back from the growing point and necrosis progress downward towards the runner. On some runners, every upright can be affected while on others, only one or a few are affected. The incidence of the disease is generally greater in younger beds (one to three years old), where whole patches of dieback may be observed. Damage is more likely to occur when vines are under stress from hot or dry conditions. Roots of infected vines remain unaffected, but berries attached to affected uprights wither and desiccate as the upright dies. Dieback symptoms may appear during three phases of the growing season: one shortly after the winter flood has been withdrawn, another in June and early July, and another in late August and September. Normally, upright dieback does not cause significant economic loss, but in cases where greater than 20% of uprights are infected, crop loss can be significant. One of the fruit rots, viscid rot, is caused by the same species (*Phomopsis vaccinii*), and therefore some fruit rot is often associated with upright dieback. Upright dieback is of greater concern in dry pick operations than in wet pick.

Life Cycle: It is thought that *Diaporthe vaccinii* may overwinter as mycelium in young uprights or it may form black fruiting structures on the undersides of dead leaves. Ascospores are then released from perithecia (fruiting bodies) at the time of bud swell and form hyphae that penetrate the new tissue. It is not known whether ascospores are capable of infecting blossoms and fruit. The fungus can be isolated from visually healthy uprights, suggesting infections may be symptomless for several weeks before environmental factors and stresses affecting the

plant favour expression. *Synchronoblastia.crypta* is spread by conidia and can infect uprights, blossoms and fruit.

Pest Management

Cultural Controls: Optimal fertilisation programs make vines more tolerant of infection by limiting nutrient stress on the plants. Avoiding moisture stress through good irrigation management and the use of overhead irrigation for vine cooling during hot temperatures may inhibit the progression of infections. Avoiding other stresses, such as oxygen deficiency and winter injury, are also thought to help limit infection. Additional management practices for upright dieback are listed in *Table 5. Adoption of disease management practices in cranberry production in Canada*.

Resistant Cultivars: The cultivar *Franklin* is thought to have some resistance to this disease, but further research is required for confirmation.

Issues for Upright Dieback

1. In the recent years in British Columbia, there have been observations of increased vine damage leading to unproductive areas.

Fungicides and biofungicides registered in Canada for disease management in cranberry production

Active ingredients registered for the management of **diseases** in cranberry are listed below in *Table 6. Fungicides and biofungicides registered for disease management in cranberry production in Canada*. This table also provides registration numbers for products registered on cranberry **as of January 20, 2019** for each active ingredient, in addition to information about chemical family and re-evaluation status. For more information about active ingredients registered for specific **diseases**, the reader is referred to individual product labels on the PMRA label database http://pr-rp.hc-sc.gc.ca/ls-re/index-eng.php and to provincial crop production guides.

Table 6. Fungicides and biofungicides registered for disease management in cranberry production in Canada

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
Aureobasidium pullulans DSM 14940 and DSM 14941	31248	biological	N/A	unknown	unknown	R
azoxystrobin	26153, 32263, 32416, 32417, 32418	methoxy-acrylate	11	C: respiration	C3 complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	RE
canola oil	32408	diverse	NC	NC: not classified	unknown	R
chlorothalonil	15723, 28900, 29225, 29306, 29355, 29356	chloronitrile (phthalonitrile)	M05	M: chemicals with multi-site activity	multi-site contact activity	R (RVD2018-11)
copper (present as copper oxychloride)	13245, 19146	inorganic (electrophile)	M01	M: chemicals with multi-site activity	multi-site contact activity	R
copper octanoate	31825	inorganic (electrophile)	M01	M: chemicals with multi-site activity	multi-site contact activity	R
ferbam	20136, 20536	dithiocarbamate and relatives (electrophile)	M03	M: chemicals with multi-site activity	multi-site contact activity	PO (RVD2018-37)

...continued

Table 6. Fungicides and biofungicides registered for disease management in cranberry production in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
fluopyram	30509, 32108	pyridinyl-ethyl-benzamide	7	C: respiration	C2 complex II: succinate-dehydrogenase	R
fluxapyroxad	30565, 31697	pyrazole-4-carboxamide	7	C: respiration	C2 complex II: succinate-dehydrogenase	R
folpet	15654, 27733	phthalimide (electrophile)	M04	M: chemicals with multi-site activity	multi-site contact activity	RE
fosetyl-Al	24458, 27688	ethyl phosphonate	P07	P: host plant defence induction	P7 phosphonate	RE
isofetamid	31555, 31758	phenyl-oxo-ethyl thiophene amide	7	C: respiration	C2 complex II: succinate-dehydrogenase	R
minerol oil	27666, 33099	diverse	NC	NC: not classified	unknown	R

...continued

Table 6. Fungicides and biofungicides registered for disease management in cranberry production in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
oriental mustard seed meal (oil) (*Brassica juncea*)	30263	diverse	NC	NC: not classified	unknown	R
penthiopyrad	30331	pyrazole-4- carboxamide	7	C: respiration	C2 complex II: succinate-dehydrogenase	R
polyoxin D zinc salt	32688, 32918	polyoxin	19	H: cell wall biosynthesis	H4 chitin synthase	R
propiconazole	numerous products	triazole	3	G: sterol biosynthesis in membranes	G1 C14- demethylase in sterol biosynthesis (erg11/cyp51)	R
prothioconazole	28359	triazolinthione	3	G: sterol biosynthesis in membranes	G1 C14- demethylase in sterol biosynthesis (erg11/cyp51)	R

...continued

Table 6. Fungicides and biofungicides registered for disease management in cranberry production in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
triforine	27686	piperazine	3	G: sterol biosynthesis in membranes	G1 C14-demethylase in sterol biosynthesis (erg11/cyp51)	RE

[1] Source: Pest Management Regulatory Agency pesticide 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 20, 2019.** While every effort has been made to ensure all fungicides, bactericides and biofungicides registered in Canada on cranberry have been included in this list, some active ingredients or products may have been inadvertently omitted. 'Numerous products' is entered where there are more than ten products for an active ingredient. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The product label is the final authority on pesticide use and should be consulted for application information. 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 2018: Fungicides sorted by mode of action (including FRAC code numbering).* February 2018. (www.frac.info/) (accessed August 20, 2018).

[3] PMRA re-evaluation status as published in *Re-evaluation Note REV2018-06 Pest Management Regulatory Agency Re-evaluation and Special Review Work Plan 2018-2023* **and other re-evaluation documents**: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review. Other codes include: DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

Insects

Key Issues

- There is a need for the development of non-chemical approaches such as pheromone-mediated mating disruption, the use of biological control agents, and other alternatives to pesticides for the management of a number of insect pests of cranberry, including dearness scale.
- Reduced-risk products, including biopesticides, are required for the control of many insects in cranberry, especially for cranberry tipworm as there is only one registered product. It is important that the new products have short residual activity and different modes of action for resistance management.
- The registration of control products based on insect families would be of benefit, given the number of different but related insect pests affecting cranberry.
- There is a need for additional information on the biology and potential impact of cranberry tipworm. Approaches to monitoring, action thresholds and the impact of cultural practices, such as fertilization on populations need to be developed.
- The cranberry weevil is an insect that is becoming more prevalent in cranberry fields. There are few tools available to fight against the advance of this insect, and new means of control must be found to prevent damage from this pest.

Table 7. Occurrence of insect pests in cranberry production in Canada[1,2]

Insect	British Columbia	Quebec
Blackheaded fireworm		
Cranberry girdler		
Cranberry tipworm		
Spanworms		
Big cranberry spanworm		
Black (blueberry) spanworm		
Chain-spotted geometer		
Cleft-headed looper		
Green spanworm		
Hemlock looper		
Horned spanworm		
Small engrailed or saddledback looper		
Spiny looper		
Stout spanworm		
Triangle marked or pale-winged grey moth		
Rannock looper		
Caterpillars		
Canadian melanolophia or Signate melanolophia		
Cranberry blossomworm		
False armyworm		
Leafroller		
Putnam`s false looper		
Rear-humped caterpillar or Humped green fruitworm		
Speckled green fruitworm		
Zebra caterpillar		
Gypsy moth		
Rusty tussock moth		
Whitemarked tussock moth		
Cranberry fruitworm		
Sparganothis fruitworm		
Red-headed flea beetle		

...continued

Table 7. Occurrence of insect pests in cranberry production in Canada[1,2] (continued)

Insect	British Columbia	Quebec
Cranberry weevil		
Root weevils		
Dearness scale		
Widespread yearly occurrence with high pest pressure.		
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.		
Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pest pressure.		
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.		
Pest not present.		

[1]Source: Cranberry stakeholders in reporting provinces (British Columbia and Quebec). The data reflect the 2016, 2015 and 2014 production years.

[2]Refer to Appendix 1 for further information on colour coding of occurrence data.

Table 8. Adoption of insect management practices in cranberry production in Canada[1]

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

...continued

Table 8. Adoption of insect management practices in cranberry production in Canada[1] (continued)

Practice / Pest		Blackheaded fireworm	Cranberry tipworm	Spanworms	Cranberry fruitworm
Monitoring	Scouting / trapping				
	Maintaining records to track pest				
	Soil analysis for pests				
	Weather monitoring for degree day modelling				
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of pests				
Decision making tools	Economic threshold				
	Use of predictive model for management decisions				
	Crop specialist recommendation or advisory bulletin				
	Decision to treat based on observed presence of pest at susceptible stage of life cycle				
	Use of portable electronic devices in the field to access pest identification / management information				

...continued

Table 8. Adoption of insect management practices in cranberry production in Canada[1] (continued)

	Practice / Pest	Blackheaded fireworm	Cranberry tipworm	Spanworms	Cranberry fruitworm
Suppression	Use of diverse pesticide modes of action for resistance management				
	Soil amendments and green manuring involving soil incorporation as biofumigants, to reduce pest populations				
	Biopesticides (microbial and non-conventional pesticides)				
	Release of arthropod biological control agents				
	Preservation or development of habitat to conserve or augment natural controls (e.g. preserve natural areas and hedgerows, adjust crop swathing height, etc.)				
	Mating disruption through the use of pheromones				
	Mating disruption through the release of sterile insects				
	Trapping				
	Targeted pesticide applications (banding, variable rate sprayers, spot treatments, etc.)				
	Selection of pesticides that are soft on beneficial insects, pollinators and other non-target organisms				
Crop specific Practices	Sanding				
	Use of late water (spring flooding)				
	Fall flooding; post-harvest flood				
	Summer flooding				

This practice is used to manage this pest by at least some growers.

This practice is not used by growers to manage this pest.

This practice is not applicable for the management of this pest.

[1]Source: Cranberry stakeholders in reporting provinces (British Columbia and Quebec). The data reflect the 2016, 2015 and 2014 production years.

Blackheaded Fireworm *(Rhopobota naevana)*

Pest Information

Damage: This insect is one of the major pests of cranberry in British Columbia and Quebec. Spring damage is caused by first generation larvae that feed on leaves from the previous season, before moving on to feed on expanding terminal buds and new leaves, the latter feeding directly reducing yield. Blackheaded fireworm larvae may tunnel into unopened buds or produce characteristic "tents" by webbing together several leaves at the tip of an upright or even several uprights. The greatest damage is inflicted by the summer feeding of second-generation larvae, which attack new leaves, flowers and fruit. Damage to fruit is very similar to that of cranberry fruitworm except that blackheaded fireworm larvae do not seal their holes with silk and do not generally produce frass in the fruits. When larval population is high and injury is severe, damaged plant tissues dry out and appear scorched and only the veins remain on the leaves.

Life Cycle: There are two generations of blackheaded fireworm per year. It overwinters as eggs on the underside of cranberry leaves. Hatching of the first generation usually begins in late April to mid-May depending on the province and is completed by mid-June. Larvae feed for three to five weeks, then pupate in the trash layer or within a "tent" made up of webbed leaves. Adult moths start to emerge two weeks later and soon after mating, females begin laying eggs (approx. 80) on leaf undersides. Some of these second-generation eggs may overwinter, but most will hatch in late June or early July. Following pupation, second generation adults emerge in August through September and produce overwintering eggs (approx. 80). Although most eggs laid by second-generation moths will not hatch until the next spring, a third generation of larvae may occur if conditions are warm and could lead to fruit injury.

Pest Management

Cultural Controls: The blackheaded fireworm is difficult to manage, and timing of treatments is critical. First generation larvae may be controlled by re-flooding beds (spring flood) for a period of 10 to 48 hours. However, for second generation larval control, re-flooding is usually not practiced as blossoms and newly set berries could be killed. Larvae can be monitored by sweep netting before terminal buds begin to swell or by counting the number of "tents" and checking the size of the larvae. Thresholds for treatment are available. If first generation larvae are successfully controlled, treatment for the more damaging second generation should be minimal. Pheromone-baited traps can be used for monitoring the emergence of first-generation adults. Second generation larvae often begins 10 to 14 days following the peak of adult trap counts. Pheromone mating disruptors can be used to reduce the successful mating of adults and may lead to the reduction or elimination of the use of chemical controls. *Trichogramma sibericum*, a parasitic wasp that is native to British Columbia, can attack and parasitize blackheaded fireworm eggs and is commercially available. It can be used as a companion treatment to mating disruption and is especially effective at reducing hot spots and along edges of fields. Other Trichogramma species have been reported to provide up to ten percent natural parasitism in Quebec fields. Other biological agents known to attack or infect blackheaded fireworm are the parasitic insects *Hemisturmia tortricis, Sympiesis*

bimaculatipennis and *Microplitis* sp. and a granulosis virus. Additional management practices for blackheaded fireworm are listed in *Table 8. Adoption of insect management practices in cranberry production in Canada.*

Resistant Cultivars: None available.

Issues for Blackheaded Fireworm

1. Reduced risk products, especially biopesticides are needed to control the blackheaded fireworm. It is important that the new products have short re-entry periods and short pre-harvest intervals and that they have different modes of action for resistance management. As second-generation larvae are present during bloom, the new products must also be safe for pollinators.
2. There is a need to develop non-chemical methods for the control of blackheaded fireworm.
3. There is also a need to improve the use of pheromones for mating disruption for inclusion in biological control strategies.

Cranberry Girdler (*Chrysoteuchia topiara*)

Pest Information

Damage: Young larvae feed on soft tissues such as crowns, leaves and roots of grasses. Mature larvae feed on the bark and wood of cranberry roots and crowns causing girdling or severing of roots in the top five centimetres of the soil. This feeding leads to the destruction of the xylem which will lead to a loss in plant vigor. Most of the damage occurs in late August to early September and becomes more visible in late fall when leaves turn orange-brown. The following spring, damaged plants will have lost their leaves and will likely end up dying. Girdler larvae leave characteristic brown to orange sawdust-like frass near damaged stems. Damage is often localised and affected areas vary in size.

Life Cycle: There is usually one generation of the cranberry girdler per year, but in warm years, a second generation of moths may occur in late summer. The insect overwinters as mature larvae wrapped in a silk cocoon in the trash layer on the bed surface. In British Columbia, pupation may occur in the fall and the cranberry girdler may overwinter as pupae. Moths emerge from early June until mid-July and after mating, female moths lay eggs (up to 700) in plant debris on the bed surface. Depending on temperature, eggs hatch four to fourteen days later and larvae feed actively from August to September. The pest seems more apt to establish itself in older, un-sanded fields that contain a thick layer of vegetative debris.

Pest Management

Cultural Controls: Cranberry girdler moths can be monitored with pheromone traps or visually by walking through the field and recording the number of flying moths. Larvae can be monitored by visually scouting for signs of damage on the plant. Entomopathogenic nematodes can be applied two to four weeks after peak flight to help control young larval populations. Providing suitable habitat for insect-feeding birds such as swallows and other natural enemies may help reduce girdler populations. Regular sanding and sanding of "hot

spots" in the summer can help reduce cranberry girdler damage by covering fungi, moss and small plants on which young larvae feed. A 24 to 48-hour pre-harvest flood, with water levels covering the highest weeds can also be beneficial in reducing larval populations, but may increase the risk of fruit rot. Flood-harvesting in early September may kill larvae that have not yet spun their cocoons and become impervious to flooding. A post-harvest flood (fall flood) may also be beneficial, but may negatively impact vine health. Removing alternate hosts, such as grasses and some coniferous species around the beds may also help by reducing sources of the pest.

Resistant Cultivars: None available.

Issues for Cranberry Girdler

1. There is a need for the registration of control products for the cranberry girdler.

Cranberry Tipworm (*Dasineura oxycoccana*)

Pest Information

Damage: Most of the damage caused by the cranberry tipworm occurs during the second and third larval stages, when larvae are aggressively feeding on the buds of upright shoots. During this feeding, leaf and bud tissues are damaged, causing stunting, distortion, and sometimes death, and yield is directly reduced. Larvae can also feed on new leaves by rasping the upper surface causing colour loss and leaf cupping, which eventually leads to leaves turning brown and dropping off. Feeding on the terminal growth of new shoots can also cause lateral vegetative branching, thereby reducing the number of flowering shoots. This is especially damaging if it occurs in the latter part of the growing season (August), as the plant will not have enough time to regenerate flowering shoots to bear fruit for the following year.

Life Cycle: There are two to three overlapping generations of cranberry tipworm during the growing season. The life cycle from egg to adult takes four to five weeks. It overwinters as pupae in the trash layer of the soil. Adults emerge and mate in the spring and first-generation females begin laying one to five eggs singly in the tips of cranberry upright shoots in late May. After two to three days, eggs hatch and larvae begin to feed on the tender meristem tissue of buds. Larvae go through three instar stages before pupation. Pupae form white silken cocoons on the inside of damaged cranberry leaves in upright tips and later emerge as adults. In August, larvae of the final generation drop to the bed surface to pupate and overwinter in the trash layer.

Pest Management

Cultural Controls: Cranberry tipworm can be difficult to monitor as symptoms are often not observed until after damage has occurred. The pest may be detected by collecting cranberry shoots which have cupped, puckered, or silvery leaves and opening these for visual inspection of eggs, larvae and pupae under a microscope. Sanding can reduce the emergence of adult flies in the spring by covering and smothering overwintering pupae. Experience has shown notable infestations in mowed cranberry fields and highly fertilized fields, and so limiting these practices may be helpful in reducing cranberry tipworm infestations. Ensuring adequate

drainage may also be helpful in minimizing pest infestations. There are several known natural enemies of cranberry tipworm, including four parasitoids *Aprostocetus*, *Platygaster*, *Ceraphron*, and *Inostemma*. Providing conditions that enhance the habitat of these natural species may provide some control. Additional management practices for cranberry tipworm are listed in *Table 8. Adoption of insect management practices in cranberry production in Canada.*

Resistant Cultivars: Cranberry tipworm reportedly has low preference for the variety *Stevens*.

Issues for Cranberry Tipworm

1. There is insufficient information available on the biology and potential impact of the cranberry tipworm. Approaches to monitoring and economic thresholds for treatment need to be established.
2. There is a need to determine the impact of cultural practices (e.g. fertilization) on cranberry tipworm populations.
3. There is a need for more control options for cranberry tipworm as there is only one product available.

Large Spanworms: Big Cranberry Spanworm (*Eutrapela clemataria),* Spiny Looper (*Phigalia titea*) and Stout Spanworm (*Lycia ursaria*)

Pest Information

Damage: Although these species are less common than the small spanworms, when they do occur, they can do serious damage as the larvae are very large at maturity. Of the three species, the big cranberry spanworm is the most destructive. Large spanworms are voracious feeders of buds, leaves and blossoms and can defoliate the cranberry bed in localized areas. Damage appears as dark areas in the field caused by old leaves left untouched.

Life Cycle: Large spanworms have one generation per year. They overwinter as pupae in a cocoon in the soil. Moths emerge at varying times in April and May, with the spiny looper often being the first spanworm observed in the field. Depending on species, females lay egg masses of 150 to 600 eggs on stems, and larvae are present from May to June. The big cranberry spanworm and the spiny looper are generally more abundant and more frequently observed in Quebec cranberry fields. Female spiny loopers are flightless.

Pest Management

Cultural Controls: Large spanworms are less common in new fields due to more regular sanding, a practice that may be helpful in managing these pests. Populations can be monitored by sweep netting for larvae. Late water can kill eggs laid on the bog as well as prevent the establishment of tiny caterpillars that drift in from infested uplands. Various parasitoid wasps can attack spiny looper eggs, larvae and pupae. Additional management practices for spanworms are listed in *Table 8. Adoption of insect management practices in cranberry production in Canada.*

Resistant Cultivars: None available.

Issues for Large Spanworms

1. There is a need for the registration of reduced risk pesticides, including biopesticides for the control of spanworms.

Small Spanworms: Black (blueberry) Spanworm (*Macaria argillacearia*), Green Spanworm (*M. sulphurea)*, Rannoch Looper (*M. brunneata*) and Horned Spanworm (*Nematocampa resistaria*)

Pest Information

Damage: At bud break, a single hole in a bud provides evidence of young larvae feeding, whereas older larvae completely destroy buds. Some spanworms will also feed on new shoots. Damaged areas within the bog are evident by their darker colour, a result of loss of the lighter green, new growth, leaving the older, darker green leaves.

Life Cycle: There is one generation of these species per year. They overwinter as eggs on cranberry stems and runners (rannoch looper) or in the leaf trash at the bed surface (*Macaria* spp.) and hatch early in the spring. Larvae develop quickly from May to June by feeding voraciously, mostly at night, until pupating in the plant debris. Depending on the species, adults emerge from June to August and 125 to 200 eggs are laid singly or in small clusters in the trash layer at the bed surface, from late July to August. Black spanworm females cannot fly.

Pest Management

Cultural Controls: Monitoring for bud damage caused by small spanworms in the field is difficult. However, monitoring for larvae can be done by sweep netting from mid-May to flowering. An action threshold for some small spanworms is available. Sanding is helpful for reducing spanworm populations by covering the eggs and preventing them from hatching. Late water can kill eggs laid on the bog as well as prevent the establishment of tiny caterpillars that drift in from infested uplands. Several natural wasp species can parasitize the black spanworm and help keep populations under control. Additional management practices for spanworms are listed in *Table 8. Adoption of insect management practices in cranberry production in Canada.*

Resistant Cultivars: None available.

Issues for Small Spanworms

1. Monitoring techniques and economic thresholds need to be developed for black spanworm.
2. There is a need for the registration of reduced risk pesticides, including biopesticides, for the control of black spanworm.
3. There is a need to the development of non-chemical approaches for the management of black spanworm.
4. The registration of control products based on insect families would be of benefit, given the number of different, but related insect pests affecting cranberry.

Minor Looper Species: Cleft-Headed Looper (*Biston betularia*), Hemlock Looper (*Lambdina fiscellaria*), Small Engrailed or Saddleback Looper (*Ectropis crepuscularia*), and Chain-Spotted Geometer (*Cingilia catenaria*)

Pest Information

Damage: Damage is caused by larvae that attack flowers, fruit and leaves at night, causing visible defoliation.

Life Cycle: There is one generation of cleft-headed, hemlock looper and chain-spotted geometer per year, and two of small engrailed. Overwintering occurs in the pupal stage in the soil (cleft-headed looper, small engrailed) or as eggs (hemlock looper, chain-spotted geometer). Hemlock looper and chain-spotted geometer larvae are present from mid-June to mid-August and following a short pupation period, adults emerge from August to early October. Chain-spotted geometer females can lay over 360 eggs on leaves and runners beginning in mid-September that will later fall to the ground to overwinter. For the other species, adults start to emerge from late April until June. Eggs are laid on vegetation in the spring, larvae are active from late May until early September, and adults are present from late May to September, with cleft-headed looper adults emerging earliest.

Pest Management

Cultural Controls: Monitoring can be done with nets from bud break to flowering. An action threshold is available for hemlock looper. Keeping ditches clean and partially filled with water may help prevent infestations of the chain-spotted geometer. Small engrailed looper infestations may be controlled by natural parasites, predators and polyhedral viruses.

Resistant Cultivars: None available.

Issues for Minor Loopers

None identified.

Triangle-Marked Moth or Pale-Winged Gray Moth (*Iridopsis ephyraria*)

Pest Information

Damage: Larvae cause damage to leaves, buds and flowers, and damaged areas are usually scattered in the field and not well defined.

Life Cycle: There is one generation of the triangle-marked moth per year. It overwinters as eggs. Larvae develop from June to early July and then pupate in the soil. Pupation lasts between 13 and 20 days, after which adults become active in July and August. Females lay eggs in bunches under lifted bark.

Pest Management

Cultural Controls: Monitoring of triangle-marked moth can be done by sweep netting.

Resistant Cultivars: None available.

Issues for Triangle-Marked Moth or Pale-Winged Gray Moth

None identified.

Canadian Melanolophia (*Melanolophia canadaria* or *M. signataria*)

Pest Information

Damage: Damage is caused by larvae that attack leaves, flowers and fruit and infestations are usually localised.

Life Cycle: There is one generation of these species per year in Quebec. They overwinter as pupae. In the spring, moths mate then females lay eggs. Larvae are observed beginning in mid-June and they develop during the month of July.

Pest Management

Cultural Controls: None available.

Resistant Cultivars: None available.

Issues for Melanolophia spp.

None identified.

Cranberry Blossomworm (*Epiglaea apiata*)

Pest Information

Damage: The cranberry blossomworm is a cutworm. Larvae start feeding on leaves and buds in May during both day and night, and as they develop, feeding becomes mainly nocturnal. Older leaves are skeletonized and the insect also bores into buds and severs flower blossoms. Damage is usually scattered in the field.

Life Cycle: There is one generation of cranberry blossomworm per year. It overwinters as eggs in the leaf trash on the bed surface or attached to leaves. Eggs start hatching in mid-May and the larvae are active until early July, mostly at night. Mature larvae then enter a two to four-week dormancy period in the trash layer burrowed in vegetative debris slightly below the soil surface. Pupation occurs in August; moths emerge in September and weather permitting, are active through November. Females lay 100 to 200 eggs singly in the plant debris at the bed surface in the fall.

Pest Management

Cultural Controls: Holding late water for 30 days and a 24-hour spring flood reflow is reported to reduce cranberry blossomworm populations. Sanding may be beneficial as overwintering

eggs become buried. Sweep netting can be performed to monitor larvae populations from mid-May to flowering. An action threshold has been established for cranberry blossomworm.

Resistant Cultivars: None available.

Issues for Cranberry Blossomworm

1. There is a need for the registration of reduced risk pesticides, including biopesticides, for the control of cranberry blossomworm.
2. There is a need for the development of non-chemical approaches for the control of cranberry blossomworm.

False Armyworm (*Xylena nupera*)

Pest Information

Damage: The false armyworm is a cutworm. Young larvae feed during the day on the inner part of terminal buds before new growth occurs, and, when older and larger, they feed voraciously at night on new leaves and flower blossoms, consuming all new growth. False armyworms characteristically chew and "cut-off" leaves and buds when they are feeding. Damage is usually scattered in the field.

Life Cycle: There is one generation of false armyworm per year. It overwinters as adults that become active again in April. Females lay eggs in masses of up to 600 on stems and lower surfaces of leaves in late April or early May. Eggs hatch beginning in mid-May, making these larvae among the first to be seen in the cranberry field. In late June, mature larvae burrow into the soil for a two to six-week dormancy period. Pupation begins in late July and adults start emerging in mid-August.

Pest Management

Cultural Controls: Holding late water for 30 days and a 24-hour spring flood is reported to reduce false armyworm populations. Night sweep netting is an effective monitoring technique. An action threshold has been established for false armyworm. There are natural parasitoids that attack larvae and prevent them from completing their development.

Resistant Cultivars: None available.

Issues for False Armyworm

1. There is a need for the registration of reduced risk pesticides, including biopesticides, for the control of false armyworm.
2. There is a need for the development of non-chemical approaches, such as spring flood, for the control of false armyworm on organic farms.

Putnam's False Looper (*Plusia putnami*)

Pest Information

Damage: Young larvae cause damage to the buds, new leaves and flower buds both during the day and at night. As larvae mature, activity becomes more pronounced during the night.

Life Cycle: There are two generations of Putnam's false looper per year. The insect overwinters as eggs, and larvae of the first generation are present in May. After pupation, adults emerge from mid-June to October, with the two generations overlapping.

Pest Management

Cultural Controls: Monitoring can be done by sweep netting from mid-May to flowering. An action threshold for Putnam's false looper is available.

Resistant Cultivars: None available.

Issues for Putnam's False Looper

None identified.

Rear-Humped Caterpillar or Humped Green Fruitworm (*Amphipyra pyramidoides*)

Pest Information

Damage: Damage is caused by larvae that attack leaves, buds, flowers and fruit and is scattered in the field.

Life Cycle: There is one generation of rear-humped caterpillar per year. It overwinters as eggs. Larvae are present from May until June. Mature larvae burrow in the soil where they remain in a cocoon made up of silk and vegetative debris for a dormancy period before pupation. From mid-July to late September, females lay approximately 275 eggs.

Pest Management

Cultural Controls: Use of late water and spring flood is reported to reduce rear-humped caterpillar populations.

Resistant Cultivars: None available.

Issues for Rear-Humped Caterpillar or Humped Green Fruitworm

None identified.

Speckled Green Fruitworm (*Orthosia hibisci)*

Pest Information

Damage: Larvae of the speckled green fruitworm can cause serious damage to leaves, buds and blossoms during feeding. Damage is scattered in the field. Larvae are known to be particularly voracious as they approach maturity.

Life Cycle: There is one generation of the speckled green fruitworm per year. It overwinters as pupae burrowed in the soil in a cocoon. Adults emerge from late April to early May and are active at night. Females lay eggs in irregular masses (totalling 150) beginning shortly after their emergence. Larvae start appearing in mid-May and can be present until late August, but are most abundant in June. Young larvae are active during the day whereas mature larvae are mostly nocturnal. Mature larvae burrow in the soil where they build a cocoon and enter a dormancy period for several weeks before pupation.

Pest Management

Cultural Controls: There are no cultural controls reported specifically for speckled green fruitworm, although late water flooding, reported to be effective against related species such as false armyworm and cranberry blossomworm, may be effective.

Resistant Cultivars: None available.

Issues for Speckled Green Fruitworm

1. There is a need for the registration of reduced risk pesticides, including biopesticides, for the control of the speckled green fruitworm.

Zebra Caterpillar (*Melanchra picta)*

Pest Information

Damage: Damage is caused by larvae that attack leaves, buds, flowers and fruit. Young larvae are voracious, feeding on the underside of leaves until only the veins remain. Older larvae also feed on flowers and fruit. Larvae may disperse throughout the field causing scattered damage. In damaged areas, leaves turn red and appear water-stressed.

Life Cycle: The zebra caterpillar is a cutworm. There are two generations per year. It overwinters as partially grown larvae or as pupae, and adults become active in mid-May. Eggs are laid in clumps on diverse plant leaves and larvae feed in June and July. The second-generation larvae are present from late July until late September. In the fall, mature larvae burrow into the soil or transform into pupae to overwinter.

Pest Management

Cultural Controls: The tachinid beneficial insect *Winthemia quadripustulata*, is known to parasitize these larvae. Providing habitat conditions suitable for this natural enemy may be helpful in controlling the zebra caterpillar.

Resistant Cultivars: None available.

Issues for Zebra Caterpillar

None identified.

Gypsy Moth (*Lymantria dispar)*

Pest Information

Damage: The gypsy moth is a regulated pest in Canada. Damage is caused by larvae that initially attack terminal buds, but later, attack new leaves, flower buds, and blossoms. When high infestation rates occur, older foliage may be consumed and the bark of the stems may be gnawed. Damage is usually scattered in the field.

Life Cycle: There is one generation of gypsy moth per year. It overwinters as eggs ubiquitously laid in masses in flooded bogs, on tree/shrub branches and trunks, and on stones. Eggs hatch mostly in May and June. Larvae arrive on beds by falling from overhanging trees, being carried by the wind via silk filaments or by crawling, moving towards cranberry leaves and breaking buds. Mature larvae build a silk cocoon where they will remain for 10 to 13 days. Moths are generally present from mid-July to late August and are nocturnal. Females are incapable of flight.

Pest Management

Cultural Controls: Sweep netting from bud break to flowering can be performed to monitor populations and an action threshold has been established. Late water can help manage overwintering eggs and prevent the establishment of tiny larvae that drift from infested uplands.

Resistant Cultivars: None available.

Issues for Gypsy Moth

None identified.

Rusty Tussock Moth (*Orgyia antiqua*) and Whitemarked Tussock Moth (*O. leucostigma*)

Pest Information

Damage: Tussock moth larvae feed on buds, leaves and flower blossoms causing localized damage. However, larvae can also cause scattered damage in the field. Defoliated areas appear as dark patches in the cranberry field and often only nude peduncles and new leaves remain on the plant.

Life Cycle: There is one generation of rusty tussock moth and two generations of whitemarked tussock moth per year. Both species overwinter as eggs on the female cocoon in the cranberry canopy. Eggs start to hatch near the end of spring and larvae are present from late May until early July. Young larvae may also arrive windborne on long silk threads from adjacent forests, and can travel up to 500 metres. Pupation occurs shortly thereafter and cocoons can typically be found on cranberry stems in July. Moths of *O. leucostigma* emerge within 2 weeks or pupation, enabling an additional generation, while those of *O. antiqua* emerge in August and September, then mate and lay eggs that overwinter. Eggs are laid in masses on the cocoon from which the female moth emerged. Females are incapable of flight.

Pest Management

Cultural Controls: Early detection of the tussock moth is important because most damage is done by mature larvae. Monitoring can be done by sweep netting for larvae in the field, as well as in headlands and ditch vegetation from bud break to flowering. Observing surrounding forests and tree stands for outbreaks is also helpful. An action threshold for the rusty tussock moth is available. Flooding and sanding are potential cultural controls for these species. Tussock moths are naturally heavy parasitized, so maintaining habitats suitable for these beneficial organisms is helpful.

Resistant Cultivars: None available.

Issues for Tussock Moths

1. There is a need for the registration of reduced risk pesticides, including biopesticides, for the control of tussock moths.
2. There is a need for improved approaches to monitoring for tussock moths.

Cranberry Fruitworm (*Acrobasis vaccinii*)

Pest Information

Damage: Cranberry fruitworm is the most significant pest of Quebec cranberry fields. Damage is caused by the larvae burrowing into berries, feeding on seeds and pulp, and leaving behind excrement (frass) in the hollowed-out berries. Larvae usually exit the berry by boring through the side and into an adjoining berry. One larva may tunnel through up to eight berries. Infested green berries turn prematurely red and eventually wither and shrivel up like raisins. Bigger fruit become brown or black and soft.

Life Cycle: There is one generation of the cranberry fruitworm per year. It overwinters as larvae inside a cocoon made of silk, sand, soil and other materials under vines on the bed floor. Pupation occurs in the spring and the moths typically appear from mid-June to August. Moths are strong fliers, readily moving between cranberry beds. They are primarily active at night and rest under the plants during the day. Egg-laying coincides with berry set. Females lay up to 50 eggs, one per berry at the calyx end. Eggs are more often found at the edges of cranberry beds, in ditches, in weedy areas, and on berries that extend above the canopy. Eggs hatch in five to ten days, after which young larvae crawl to the stem end, and bore into the fruit (one larva per fruit), sealing the opening inconspicuously with white silk. The larvae feed on

berries from July to September, going through six larval stages before dropping to the ground to build an overwintering cocoon in the trash layer for the winter.

Pest Management

Cultural Controls: Holding late water can significantly reduce cranberry fruitworm populations, especially if the water is warm (approx. 15°C). Monitoring of male adults can be accomplished with pheromone traps placed in the cranberry bed. Examining berries at the edges of beds under a magnifier or microscope to look for eggs when berries are larger than the pinhead stage may help with the timing of treatments. An action threshold based on egg counts is available for regions in the northeastern United States and may be adaptable for use in Eastern Canadian growing regions. Additional management practices for cranberry fruitworm are listed in *Table 8. Adoption of insect management practices in cranberry production in Canada.*

Resistant Cultivars: None available.

Issues for Cranberry Fruitworm

1. Reduced risk products, primarily biopesticides, are needed for the control of cranberry fruitworm. It is important that the new products have short re-entry periods, short pre-harvest intervals, that they have different modes of action for resistance management, and that they are safe for pollinators.
2. There is a need to establish a reliable basis for treatment decisions for cranberry fruitworm (e.g. an action threshold based on egg counts, pheromone trapping of adult moths, or estimation of damage).
3. There is a need for the development of non-chemical approaches for the control of fruitworm.

Sparganothis Fruitworm (*Sparganothis sulfureana*)

Pest Information

Damage: First generation larvae selectively feed on flower buds and new foliage, indirectly reducing yield whereas second generation larvae have a direct impact on yield by selectively feeding on fruit and hollowing out the contents. Each larva can feed on as many as five berries, often damaging the outer surface of others surrounding the feeding area. Not only do these wounds decrease the aesthetic value of the crop, but they are an entryway for fruit diseases.

Life Cycle: There are two generations of the Sparganothis fruitworm per year. It overwinters as first instar larvae in the trash layer at the bed surface or webbed into leaves on the cranberry plant. It resumes activity in the spring at bud break. At this time, larvae feed on buds and as they mature, they web together uprights to form a pupation site and feed on leaves within this protective web. Pupation can also occur in the berries. Adults emerge in mid-June and one to two days after emergence, females lay eggs in masses of 20 to 50 eggs on the upper side of cranberry leaves, on fruit or on weeds. The second-generation larvae emerge in July and feed

on leaves and berries. Second generation adults are present by late August and actively lay eggs on foliage until the end of September. Eggs hatch and young larvae enter diapause.

Pest Management

Cultural Controls: Monitoring is usually done by visual inspection for webbed tents and hollowed out berries that do not contain frass. However, sweep netting can also be performed to monitor populations and an action threshold has been established for regions in the northeastern United States and may be adaptable for use in Eastern Canadian growing regions. Male moths can be monitored with pheromone traps. Although late water has not been shown to be effective against this insect, it synchronizes moth emergence which may facilitate management. Natural enemies of Sparganothis fruitworm include egg parasites such as *Trichogramma* spp. and the parasitic tachinid fly *Erynnia tortricis*. Providing habitat conditions suitable for these natural enemies may be helpful in controlling Sparganothis fruitworm.

Resistant Cultivars: Howes tends to be the cultivar least susceptible to this pest.

Issues for Sparganothis Fruitworm

1. The registration of additional reduced risk insecticides, including biopesticides, with different modes of action for resistance management, is required for Sparganothis fruitworm.

Red-Headed Flea Beetle (*Systena frontalis*)

Pest Information

Damage: Red-headed flea beetle are polyphagous across many plant families. In cranberries, adults primarily feed on the underside of leaves, leaving behind the veins, but they can also feed on fruit when infestation rates are high. Leaves on terminal buds and runners are generally preferred and this feeding can impact bud development for the coming year. Damaged areas in the field tend to be patchy and can be detected in late July or early August by the appearance of a slightly browner canopy. Larvae can feed on plant roots; however, this behaviour has not been observed in Quebec.

Life Cycle: There is one generation of red-headed flea beetle per year. It overwinters mostly as eggs in the soil, but sometimes as adults. Eggs begin hatching from late May to early June and larvae feed on plant roots. Adults emerge from the soil from mid-July to August and females lay overwintering eggs throughout August.

Pest Management

Cultural Controls: Monitoring can be done by visually inspecting for damage or by sweep netting in the field. An action threshold is available for regions in the northeastern United States and may be adaptable for use in Eastern Canadian growing regions.

Resistant Cultivars: None available.

Issues for Red-Headed Flea Beetle

1. There is a need for the registration of reduced risk insecticides, including biopesticides, for the control of red-headed flea beetle.
2. There is a need for further studies on economic thresholds for damage caused by both larvae and adults of the red-headed flea beetle in cranberry beds.

Cranberry Weevil (*Anthonomus musculus*)

Pest Information

Damage: Both larvae and adult weevils cause damage to cranberry plants. In the spring, adults feed first on old leaves and buds, and as the plant develops, they feed on new leaves and blossoms. Adults make small holes in the bud causing browning which resembles frost injury, and damaging the next year's terminal buds. Female adults bore holes in flower blossoms during oviposition and make a small incision in the peduncle which will often cause the flower to drop and thus eliminate the development of a potential fruit. Larvae devour the interior of blossoms, further limiting fruit development, and will also bore holes in the developing fruit, directly reducing yield.

Life Cycle: There is one generation of cranberry weevil per year. Adults overwinter in flooded fields, on adjacent dikes and margins of beds or in wooded areas alongside the cranberry field. After the winter flood is removed, adults become active in mid to late May and reproduce until late June. Female weevils lay eggs (20 on average) singly in flower blossoms and seal the holes with a viscous liquid. After three to nine days, the eggs hatch and each larva feeds in the flower for ten to fourteen days. Pupation also occurs in the flowers in July and adults emerge about the time fruit are forming. Adults are active throughout July and August before migrating to the soil surface where they overwinter in the trash layer.

Pest Management

Cultural Controls: Sweep netting can be performed to monitor populations, but this activity is only effective when there is no wind and temperatures are warm. Spring and summer action thresholds are available for regions in the northeastern United States and may be adaptable for use in Eastern Canadian growing regions. It may also be helpful to use yellow sticky traps (without pheromones) in areas that are prone to infestations in the spring in order to determine the level of risk. Entomopathogenic nematodes applied in the spring or early fall and the native parasitic wasp (*Habrocytus* sp.,) which attacks larvae may help keep infestations under control. Late water is not effective against cranberry weevil.

Resistant Cultivars: None available.

Issues for Cranberry Weevil

1. There is a need for the registration of reduced risk insecticides, including biopesticides, for the control of cranberry weevil.
2. The prevalence of cranberry weevil is increasing in cranberry fields. There is a need to develop non-chemical approaches to the management of this insect.

Root Weevils: Black Vine Weevil (*Otiorhynchus sulcatus*), Strawberry Root Weevil (*O. ovatus*) and Clay-Coloured Weevil (*O. singularis*)

Pest Information

Damage: Root weevil larvae feed voraciously on cranberry roots and bark, often causing girdling injury similar to that caused by cranberry girdler, except that there is no excrement left at the feeding sites. Larvae can completely girdle roots up to the crown of the plants. Wilting, weakening and browning develop on the above ground parts of the plants and damage is noticeable in late spring, becoming more severe as the season progresses. Adults can cause minor damage to the leaf margins as they feed.

Life Cycle: Hosts of root weevils include small fruits, fruit trees, shrubs and many nursery conifers. There is one generation of these species per year. They typically overwinter as larvae in cranberry soils and pupate in early spring, but in some locations some adults may live through the winter. Depending on species, adults emerge from pupal cells starting in May until the end of summer. Adults of the strawberry root weevil and black vine weevil are exclusively females and reproduce by parthenogenesis. They feed at night on leaves for four to six weeks before laying 300 to 400 eggs on the soil surface beneath the vines. Eggs hatch two to three weeks later into legless, white grubs that feed on cranberry roots and root bark. Larvae go through several stages of development. Temperature permitting, they can feed continuously until they pupate the following spring.

Pest Management

Cultural Controls: Monitoring in the spring can be done by visually inspecting through the top five centimetres of soil for girdled roots and white C-shaped larvae. Adult weevil detection can be done with a sweep net after dusk or by observing alternate vegetation in the vicinity of the cranberry bed for leaf-notching. Wet-harvesting is effective in reducing root weevil populations as these will generally drown. On dry-pick farms or unharvested beds, a ten to fourteen day fall flood as soon as possible after harvest, or a two to four-week winter flood may help to reduce weevil populations. Entomopathogenic nematodes can be applied in the spring or fall to target weevil larvae in the soil.

Resistant Cultivars: None available.

Issues for Root Weevil

1. There is a need for the development of additional management options for root weevils.

Dearness Scale (*Rhizaspidiotus dearnessi*)

Pest Information

Damage: Dearness scale is a problem in British Columbia. Crawlers (live young) insert their needle-like mouthpart in the leaves, shoots or ripening fruit and feed continuously, causing discolouration, leaf drop and weakening of the plants. During heavy infestations, shoots can

turn red and become brittle, which can lead to a reduction in canopy fullness and death of the plant.

Life Cycle: There is one generation per year and adults overwinter on the stems. Adult males are winged and mobile and seek out stationary females for mating. Females lay eggs under their "shell" and crawlers begin to hatch sequentially from a slit in this protective shield over about four weeks starting in June. Crawlers move about along stems or are wind-blown to other sites where they settle down singly or in clusters within one to three days to feed. They sometimes settle on ripening fruit. Once settled, they secrete a white, waxy protective covering. Adult males begin emerging in late August and females, in September. The adults mate before overwintering.

Pest Management

Cultural Controls: Dearness scale is readily visible and can be monitored by visual inspection of weak areas of the cranberry bed. When establishing new plantings, it is helpful to use cuttings from non-infested fields to prevent spreading the pest. Since crawlers can attach themselves to clothing, shoes, and machinery, it is important to disinfect these on a regular basis to prevent the spread of the pest. Naturally occurring biological controls of the dearness scale, including the parasitic wasp *Coccidencyrtus dearnessi* are often present in cranberry fields and can help keep populations low.

Resistant Cultivars: None available.

Issues for Dearness Scale

1. The development of alternative management approaches and the registration of reduced-risk insecticides is required for the management of dearness scale. Since treatments against crawlers must be applied during bloom, new products must be safe for pollinators.

Insecticides and bioinsecticides registered in Canada for the management of insect pests in cranberry production

Active ingredients registered for the management of **insect** pests in cranberry are listed below in *Table 9. Insecticides and bioinsecticides registered for insect management in cranberry production in Canada*. This table also provides registration numbers for products registered on cranberry **as of January 20, 2019** for each active ingredient, in addition to information about chemical family and re-evaluation status. For more information about active ingredients registered for specific **insect** pests, the reader is referred to individual product labels on the PMRA label database http://pr-rp.hc-sc.gc.ca/ls-re/index-eng.php and to provincial crop production guides.

Table 9. Insecticides and bioinsecticides registered for insect management in cranberry production in Canada

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Re-evaluation Status (re-evaluation decision document)[3]
acephate	14225	organophosphate	1B	acetylcholinesterase (AChE) inhibitor	RES*
Bacillus thuringiensis subsp. *kurstaki* strain ABTS-351	11252, 26508, 26854, 27750	*Bacillus thuringiensis* and the insecticidal proteins they produce	11A	microbial disruptor of insect midgut membranes	R
Bacillus thuringiensis subsp. *kurstaki* all strains	32425	*Bacillus thuringiensis* and the insecticidal proteins they produce	11A	microbial disruptor of insect midgut membranes	R
canola oil	32408, 32819	not classified	NC[4]	unknown	R
carbaryl	17534, 22339, 27876	carbamate	1A	acetylcholinesterase (AChE) inhibitor	RE (REV2018-17)
chlorantraniliprole	28981	diamide	28	ryanodine receptor modulator	R
cyantraniliprole	30895	diamide	28	ryanodine receptor modulator	R

...continued

Table 9. Insecticides and bioinsecticides registered for insect management in cranberry production in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Re-evaluation Status (re-evaluation decision document)[3]
cypermethrin	30316	pyrethroid, pyrethrin	3A	sodium channel modulator	R (RVD2018-22)
ferric phosphate	27085, 30025	not classified	N/A	unknown	R (RVD2018-23)
ferric sodium ethylenediamine tetra acetic acid (EDTA)	28774	not classified	N/A	unknown	R
flonicamid	29796	flonicamid	29	chlordotonal organ modulator - undefined target site	R
imidacloprid	24094	neonicotinoid	4A	nicotinic acetylcholine receptor (nAChR) competitive modulator	RES*
malathion	4590, 8372	organophosphate	1B	Acetylcholinesterase (AChE) inhibitor	R
metaldehyde	26650, 32149	not classified	N/A	unknown	R
methoxyfenozide	27786	diacylhydrazine	18	ecdysone receptor agonist	R
mineral oil	27666, 33099	not classified	N/A	unknown	R

...continued

Table 9. Insecticides and bioinsecticides registered for insect management in cranberry production in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Re-evaluation Status (re-evaluation decision document)[3]
*Nosema locusta*e Canning	29197	biological	N/A	unknown	R
phosmet	23006, 29064	organophosphate	1B	Acetylcholinesterase (AChE) inhibitor	RE
potassium salts of fatty acids	14669, 27886, 28146, 31433	not classified	N/A	unknown	R
spinetoram	28778	spinosyn	5	nicotinic acetylcholine receptor (nAChR) allosteric modulator	R
spinosad	26835, 27825, 30382	spinosyn	5	nicotinic acetylcholine receptor (nAChR) allosteric modulator	RE
spiromesifin	28905	tetronic and tetramic acid derivative	23	inhibitor of acetyl CoA carboxylase	R
spirotetramat	28953	tetronic and tetramic acid derivative	23	inhibitor of acetyl CoA carboxylase	R
tebufenozide	24503	diacylhydrazine	18	ecdysone receptor agonist	RE

…continued

Table 9. Insecticides and bioinsecticides registered for insect management in cranberry production in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Re-evaluation Status (re-evaluation decision document)[3]
thiamethoxam	28408	neonicotinoid	4A	nicotinic acetylcholine receptor (nAChR) competitive modulator	RES*
triethanolamine salts of fatty acids	28270	not classified	N/A	unknown	R

[1] Source: Pest Management Regulatory Agency pesticide 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 20, 2019.** While every effort has been made to ensure all insecticides, miticides and biopesticides registered in Canada on cranberry have been included in this list, some active ingredients or products may have been inadvertently omitted. 'Numerous products' is entered where there are more than ten products for an active ingredient. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The product label is the final authority on pesticide use and should be consulted for application information. The information in this table should not be relied upon for pesticide application decisions and use.

[2] Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (Version 9.1; December 2018)* (excluding pheromones) (www.irac-online.org) (accessed January 28, 2019).

[3] PMRA re-evaluation status as published in *Re-evaluation Note REV2018-06 Pest Management Regulatory Agency Re-evaluation and Special Review Work Plan 2018-2023* **and other re-evaluation documents**: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review. Other codes include: DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

[4] Source: Fungicide Resistance Action Committee. *FRAC Code List 2018: Fungicides sorted by mode of action (including FRAC code numbering).* February 2018. (www.frac.info/) (accessed August 20, 2018).

Weeds

Key Issues

- There is a need for the registration of herbicides for the management of woody plants and for perennial weeds, including rushes and sedges, legumes, grasses and broadleaf weeds, and for herbicides with different modes of action for resistance management.

- There is a need for the registration of bioherbicides and the development of non-chemical approaches for the control of perennial weeds in organic production.

Table 10. Occurrence of weeds in cranberry production in Canada[1,2]

Weed	British Columbia	Quebec
Annual broadleaf weeds		
Annual grass weeds		
Perennial broadleaf weeds		
Perennial grass weeds		
Sedges		
Rushes		
Mosses		

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

[1] Source: Cranberry stakeholders in reporting provinces. The data reflect the 2016, 2015 and 2014 production years.

[2] Refer to Appendix 1 for further information on colour coding of occurrence data.

Table 11. Adoption of weed management practices in cranberry production in Canada[1]

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

...continued

Table 11. Adoption of weed management practices in cranberry production in Canada[1] (continued)

Practice / Pest		Annual broadleaf weeds	Annual grasses	Perennial broadleaf weeds	Perennial grasses	Woody plants	Sedges and rushes
Decision making tools	Economic threshold						
	Crop specialist recommendation or advisory bulletin						
	Decision to treat based on observed presence of weed at susceptible stage of development						
	Decision to treat based on observed crop damage						
	Use of portable electronic devices in the field to access weed identification / management information						
Suppression	Use of diverse herbicide modes of action for resistance management						
	Soil amendments and green manuring involving soil incorporation as biofumigants to reduce weed populations						
	Biopesticides (microbial and non-conventional pesticides)						
	Release of arthropod biological control agents						
	Mechanical weed control (cultivation / tillage)						
	Manual weed control (hand pulling, hoeing, flaming)						
	Use of stale seedbed technique						
	Targeted pesticide applications (banding, spot treatments, variable rate sprayers, etc.)						
	Selection of herbicides that are soft on beneficial insects, pollinators and other non-target organisms						

...continued

Table 11. Adoption of weed management practices in cranberry production in Canada[1] (continued)

Practice / Pest		Annual broadleaf weeds	Annual grasses	Perennial broadleaf weeds	Perennial grasses	Woody plants	Sedges and rushes
Crop specific practices	Sanding						
	Use of late water (spring flooding)						
	Fall flooding; post-harvest flood						
This practice is used to manage this pest by at least some growers.							
This practice is not used by growers this pest.							
This practice is not applicable for the management of this pest.							

[1] Source: Cranberry stakeholders in reporting provinces (British Columbia and Quebec). The data reflect the 2016, 2015 and 2014 production years.

Annual and Biennial Weeds

Pest Information

Damage: Grasses and broadleaf weeds compete for light, water and nutrients with cranberry plants. If not controlled effectively in new beds, they will reduce establishment and expansion of the cranberry and significantly reduce the yield potential of the bed for future years. Annual grasses cause significant problems because of their fast growth and tolerance of extremes in moisture and temperature once established. Annual weed germination is limited due to the limited soil disturbance which suppresses germination. However, bare areas in the field resulting from abiotic or biotic factors, such as ice damage or insects, can allow annual weeds to become re-established.

Life Cycle: Annual grass and broadleaf weeds complete their life cycle from seed germination to new seed production in a single season. Spring annuals germinate in the early spring and produce seed in the summer or fall of the same year. Winter annuals grow to the rosette stage in the fall and mature and produce seed early the following year. Annual weeds produce large numbers of seeds which can be spread to new fields by wind, water, animals, machinery and human activities, such as sanding or transplanting using contaminated materials. Biennial weeds germinate in the spring, producing a rosette of leaves, and remain vegetative during the first summer. They overwinter as rosettes and in the next season, flower and produce seed. The plant dies at the end of the second growing season.

Pest Management

Cultural Controls: Primary preventative measures to control weeds are the mechanical removal of weeds and the use of weed-free materials (cuttings, sand, etc.) when establishing a new cranberry bed. Once a bed has been established, it is important to maintain a dense crop canopy that will out-compete weed invaders. Additional management practices for weeds are listed in *Table 11. Adoption of weed management practices in cranberry production in Canada*.

Resistant Cultivars: None available.

Issues for Annual and Biennial Weeds

None identified.

Perennial Weeds

Pest Information

Damage: Certain perennial weeds, such as woody plants, can greatly affect yield, quality and harvest efficiency if not controlled. Perennials, like goldenrod and silverweed, can choke out cranberry plants, reducing density and vigour.

Life Cycle: Perennial grass and broadleaf weeds can live for many years. Perennials usually flower and produce seeds every year as well as expand their root system, so can spread effectively by both methods.

Pest Management

Cultural Controls: Hand weeding, as well as cutting and removing small perennial weeds established in limited areas can be helpful. Maintaining a healthy crop that competes well with weeds will also reduce weed establishment. Additional management practices for weeds are listed in *Table 11. Adoption of weed management practices in cranberry production in Canada*.

Resistant Cultivars: None available.

Issues for Perennial Weeds

1. There is a need for the registration of additional herbicides for the management of woody plants and perennial weeds, including rushes and sedges, legumes, grasses and broadleaf weeds, for resistance management.
2. Herbicides, including biological herbicides with short pre-harvest intervals, are required for the management of perennial grasses late in the season.
3. Current label rates for mesotrione use for perennial broadleaf weed control in Canada allow for some weed survival if the second follow-up application is missed. There is a need to assess rates to ensure effective control and prevent the potential development of resistance in the weed population.
4. There is a need for the development of non-chemical approaches for the control of perennial weeds, particularly for organic production.
5. Due to the low-growing nature of various sedge and rush species, they are difficult to control with current practices. Further research is required on how to control these species.
6. Perennial weeds of concern for British Columbia include: yellow loosestrife (*Lysimachia vulgaris*), sheep sorrel (*Rumex acetosella*), field horsetail *(Equisetum arvense*), bog violet (*Viola nephrophylla*), bog St. John's wort (*Hypericum perforatum*) (annual or perennial), fireweed (*Chamerion angustifolium*), purslane (*Portulaca* spp.) and false lily of the valley (*Maianthemum dilatum*).
7. Perennial weeds of concern for Quebec include: common woolgrass (*Scirpus cyperinus*), black girded woolgrass (*Scirpus atrocinctus*), false nutsedge (*Cyperus stigosus*), grass leaved rushes (*Juncus* spp), narrow-leaved goldenrod (*Enthamia gramninifolia*), short-tailed rush (*Juncus brevicaudatus*), soft rush (*Juncus effusus*), mosses, sensitive fern (*Onoclea sensibilis*) and common reed (*Phragmites asustralis*).

Herbicides and bioherbicides registered in Canada for weed management in cranberry production

Active ingredients registered for the management of **weeds** in cranberry are listed below in *Table 12. Herbicides and bioherbicides registered for weed management in cranberry production in Canada*. This table also provides registration numbers for products registered on cranberry **as of January 20, 2019** for each active ingredient, in addition to information about chemical family and re-evaluation status. For more information about active ingredients registered for specific **weeds**, the reader is referred to individual product labels on the PMRA label database http://pr-rp.hc-sc.gc.ca/ls-re/index-eng.php and to provincial crop production guides.

Table 12. Herbicides and bioherbicides registered for weed management in cranberry production in Canada

Active Ingredient[1]	**Product Registration Numbers**[1]	**Chemical Family**[2]	**Resistance Group**[2]	Site **of Action**[2]	**Re-evaluation Status (Re-evaluation Decision Document)**[3]
2,4-D	5931, 14725, 14726, 17511, 26163, 28271, 29248, 31332, 32412	phenoxy-carboxylic-acid	4	synthetic auxin	R (REV2017-08)
acetic acid	31447	not classified	N/A	unknown	R (RVD2018-13)
ammonium soap of fatty acids	30012	not classified	N/A	unknown	R
clethodim	22625, 27598, 28224	cyclohexanedione 'DIMs'	1	inhibition of acetyl CoA carboxylase (ACCase)	R
clopyralid	23545, 30620, 31039, 32265	pyridine carboxylic acid	4	synthetic auxin	R
dichlobenil	12533	nitrile	20	inhibition of cell wall synthesis site A	R
fluazifop-P	21209	aryloxyphenoxy-propionate 'FOP'	1	inhibition of acetyl CoA carboxylase (ACCase)	R
glyphosate (present as dimethylamine salt)	28840, 28977, 29774, 29775, 30319, 30423, 30516, 31090, 32314	glycine	9	inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	R
glyphosate (present as ethanolamine salt)	26920	glycine	9	inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	R

…continued

Table 12. Herbicides and bioherbicides registered for weed management in cranberry production in Canada (continued)

Active Ingredient[1]	**Product Registration Numbers**[1]	**Chemical Family**[2]	**Resistance Group**[2]	Site **of Action**[2]	**Re-evaluation Status (Re-evaluation Decision Document)**[3]
glyphosate (present as isopropylamine salt)	numerous products	glycine	9	inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	R
glyphosate (present as isopropylamine salt and potassium salt)	29888, 31316, 32228, 32532, 33029, 33030	glycine	9	inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	R
glyphosate (present as potassium salt)	numerous products	glycine	9	inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	R
mesotrione	27833	triketone	27	inhibition of 4-hydroxyphenyl-pyruvate-dioxygenase (4-HPPD)	R
mineral spirits	2076	not classified	N/A	unknown	RE
napropamide	25230, 25231, 31081, 31688	acetamide	15	inhibition of mitosis	R

…continued

Table 12. Herbicides and bioherbicides registered for weed management in cranberry production in Canada (continued)

Active Ingredient[1]	**Product Registration Numbers**[1]	**Chemical Family**[2]	**Resistance Group**[2]	Site **of Action**[2]	**Re-evaluation Status (Re-evaluation Decision Document)**[3]
sethoxydim	24835	cyclohexanedione 'DIM'	1	inhibition of acetyl CoA carboxylase (ACCase)	R
sulfentrazone	29012	triazolinone	14	inhibition of protoporphyrinogen oxidase (Protox, PPO)	R

[1] Source: Pest Management Regulatory Agency pesticide 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 20, 2019.** While every effort has been made to ensure all herbicides, bioherbicides and plant growth regulators registered in Canada on cranberry have been included in this list, some active ingredients or products may have been inadvertently omitted. 'Numerous products' is entered where there are more than ten products for an active ingredient. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The product label is the final authority on pesticide use and should be consulted for application information. The information in this table should not be relied upon for pesticide application decisions and use.

[2] Source: Weed Science Society of America (WSSA). Herbicide Site of Action Classification list (last modified December 5, 2018) http://wssa.net (accessed January 28, 2019)

[3] PMRA re-evaluation status as published in *Re-evaluation Note REV2018-06 Pest Management Regulatory Agency Re-evaluation and Special Review Work Plan 2018-2023* **and other re-evaluation documents**: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review. Other codes include: DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

Vertebrate Pests

Rodents: Muskrat (*Ondatra zibethicus*), Beaver (*Castor canadensis*), Townsend's Vole (*Microtus townsendii*), and Mouse (*Mus musculus*)

Pest Information

Damage: Muskrats dig into cranberry beds looking for succulent roots. This destroys plants and makes the bed surface uneven. Muskrats and beavers may build dens in the side of dams which reduces the stability and is a concern for safety when heavier machinery travels over these weakened areas. Dams have been known to collapse due to muskrat damage. In Canada, Townsend's vole is present in British Columbia and causes damage in the winter by tunnelling in cranberry vines. Patches of dying vines could be indicative of feeding, however, can easily be mistaken for cranberry girdler damage. Mice can also feed on roots during the winter and will reduce plant vigor and also kill areas within the field.

Pest Management

Cultural Controls: Controlling weed populations in the bed and trapping and removing animals will reduce problems. Mowing dike and ditch areas can help destroy vole and other rodent habitats by exposing them to predatory birds, snakes and mammals. Muskrats do not like crown vetch when it is planted along berms; however, this may lead to weed control issues in the bed itself. Rodenticide bait stations can be used around the field edges or areas where rodents may go to nest.

Issues for Rodents

None identified.

Birds

Pest Information

Damage: Birds can feed on cranberries in the fall and may also cause damage when nesting in the beds in the spring and early summer. Large groups of migratory birds may cause physical damage to the plants by digging in the beds in search for food.

Pest Management

Cultural Controls: Minimizing insect and weed pests will reduce potential food sources for birds. Propane scare guns and netting above bogs may also deter birds.

Issues for Birds

None identified.

Resources

Integrated pest management / Integrated crop management resources for production of cranberry in Canada

Agri Réseau, *Petits fruits*.
http://www.agrireseau.qc.ca/petitsfruits/

British Columbia Ministry of Agriculture. Berry Production Guide - *Beneficial management practices for berry growers in British Columbia*.
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http://www.perennia.ca/portfolio-items/cranberries/?portfolioCats=87

Statistics Canada.
https://www150.statcan.gc.ca/n1/en/type/data

Provincial Fruit Crop Specialists and Provincial Minor Use Coordinators

Province	Ministry	Crop Specialist	Minor Use Coordinator
British Columbia	British Columbia Ministry of Agriculture www.gov.bc.ca/al	Carolyn Teasdale carolyn.teasdale@gov.bc.ca	Caroline Bédard caroline.bédard@gov.bc.ca
Québec	Ministry of Agriculture, Fisheries and Food of Québec www.mapaq.gouv.qc.ca	Jacques Painchaud jacques.painchaud@mapaq.gouv.qc.ca Sam Chauvette sam.chauvette@mapaq.gouv.qc.ca	Mathieu Côté mathieu.cote@mapaq.gouv.qc.ca

National and Provincial Grower Organizations

Canadian Horticulture Council
www.hortcouncil.ca/chcmain.htm

British Columbia Cranberry Growers Association
www.bccranberrygrowers.com

Association des producteurs de canneberges du Québec
http://www.notrecanneberge.com/Home

Appendix 1: Definition of terms and colour coding for pest occurrence tables of the crop profiles

Information on the occurrence of disease, insect and mite, and weed pests in each province is provided in Tables 4, 7 and 10 of the crop profile, respectively. The colour coding of the cells in these tables is based on three pieces of information, namely pest frequency, distribution and pressure in each province as presented in the following chart.

<table>
<tr><th>Presence</th><th colspan="4">Pest occurrence information</th><th>Colour Code</th></tr>
<tr><td rowspan="12">Present</td><td rowspan="10">Data available</td><th>Frequency</th><th>Distribution</th><th>Pressure</th><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="2">Localized - The pest is established as localized populations and is found only in scattered or limited areas of the province.</td><td>High - see above</td><td>Orange</td></tr>
<tr><td>Moderate - see above</td><td>White</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="5">Sporadic - Pest is present 1 year out of 3 in a given region of the province.</td><td rowspan="3">Widespread - as above</td><td>High - see above</td><td>Orange</td></tr>
<tr><td>Moderate - see above</td><td>Yellow</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="3">Localized - as above</td><td>High - see above</td><td>Yellow</td></tr>
<tr><td>Moderate -see above</td><td>White</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="2">Data not available</td><td colspan="3">Not of concern: The pest is present in commercial crop growing areas of the province but is causing no significant damage. Little is known about its population distribution and frequency in this province; however, it is not of concern.</td><td>White</td></tr>
<tr><td colspan="3">Is of concern: The pest is present in commercial crop growing areas of the province. Little is known about its population distribution and frequency of outbreaks in this province and due to its potential to cause economic damage, is of concern.</td><td>Blue</td></tr>
<tr><td>Not present</td><td colspan="4">The pest is not present in commercial crop growing areas of the province, to the best of your knowledge.</td><td>Black</td></tr>
<tr><td>Data not reported</td><td colspan="4">Information on the pest in this province is unknown. No data is being reported for this pest.</td><td>Grey</td></tr>
</table>

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