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Crop Profile for Cranberry in Canada, 2013

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Canada

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Preface

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

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

For detailed information on growing 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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The large-fruited American cranberry, *Vaccinium macrocarpon*, is a member of the heath (Ericaceae) family. Native to North America, cranberry is a perennial evergreen vine that grows in wetland areas. Early European settlers were introduced to cranberries by First Nations peoples who used the fruit for food and medicines. Commercial production of the crop in Canada began in the late 1800s in Nova Scotia.

Crop Production

Industry Overview

Table 1. General production information

Canadian Production (2013)[1]	122,084 metric tonnes 6,946 hectares
Farm gate value (2013)[1]	$93 million
Fresh fruit available in Canada 2013[2]	1.77 kg/ person
Exports (2013)[3]	60,110 tonnes (fresh)
Imports (2013)[3]	2,760 tonnes (fresh)

[1]Statistics Canada. Table 001-0009 - Area, production and farm gate value of fresh and processed fruits, by province, annual CANSIM (database) (accessed: 2015-01-19).

[2]Statistics Canada. Table 002-0011- Food available in Canada. CANSIM (database) (accessed 2015-01-19).

[3]Source: Statistics Canada. Table 002-0010 - Supply and disposition of food in Canada. CANSIM (database) (accessed 2015-01-19).

Production Regions

The distribution of cranberry production is presented in Table 2. There were 6,946 hectares of cranberries grown in Canada in 2013. Major production areas include Quebec (3,622 hectares) and British Columbia (2,636 hectares).

Table 2. Distribution of cranberry production in Canada (2013)

Production Regions[1]	Cultivated Area, total 2013 (hectares)[1]	Percent National Production
British Columbia	2,636	38%
Quebec	3,622	52%
New Brunswick	362[E]	5%[E]
Canada	6,946	100%

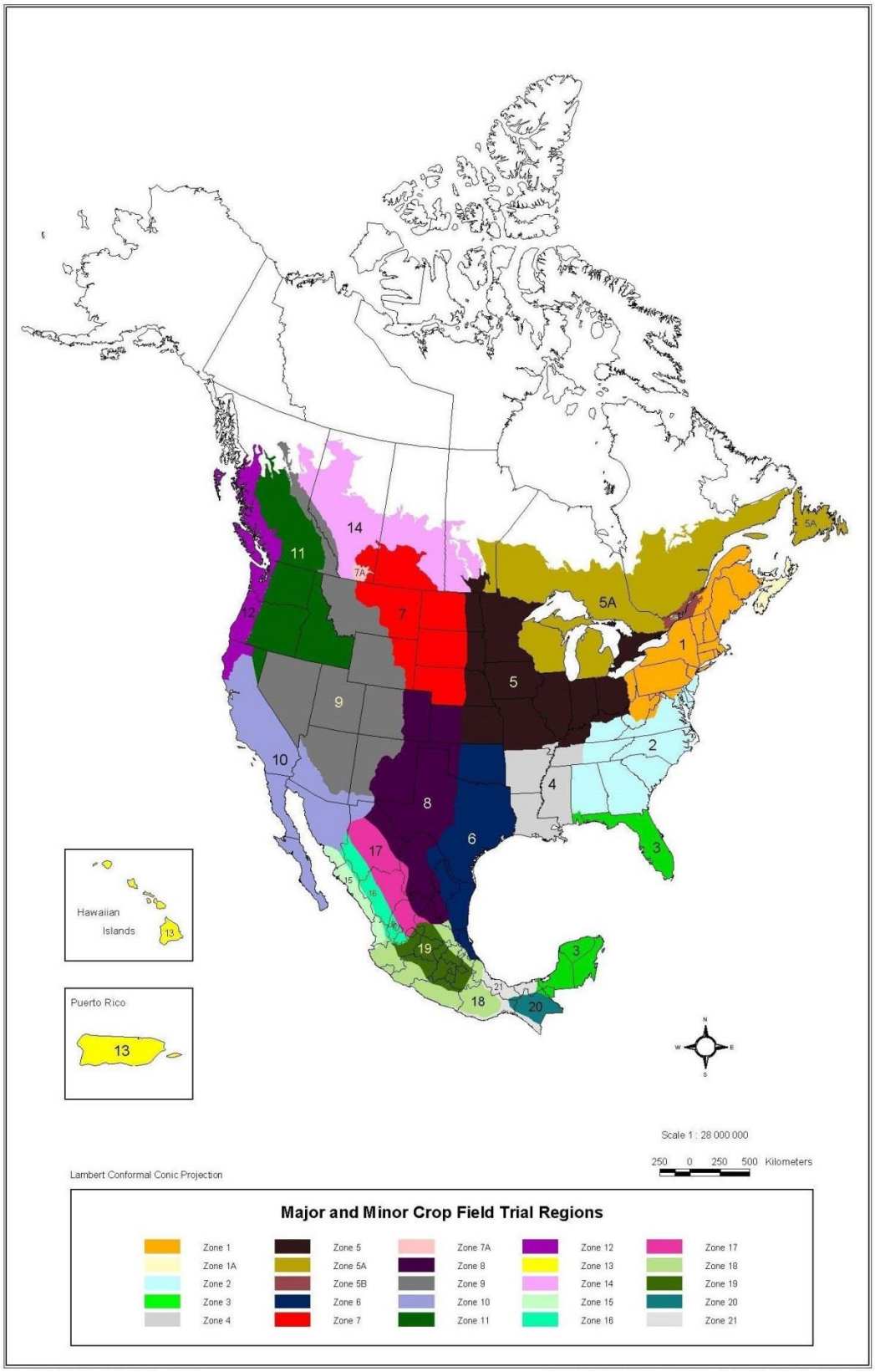
[1]Statistics Canada. Table 001-0009 - Area, production and farm gate value of fresh and processed fruits, by province, annual CANSIM (database) (accessed: 2015-01-19).

[E] Use with caution

North American Major and Minor Field Trial Regions

Major and minor crop field trial regions (Figure1) were developed following stakeholder consultation and are used by the Pest Management Regulatory Agency (PMRA) in Canada and the United States (US) Environmental Protection Agency (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, please consult the PMRA Regulatory Directive 2010-05 "*Revisions to the Residue Chemistry Crop Field Trial Requirements"* (www.hc-sc.gc.ca/cps-spc/pubs/pest/_pol-guide/dir2010-05/index-eng.php).

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



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

Cultural Practices

Commercial cranberry production differs from all other forms of small fruit production. The plant is a long-lived perennial that can be propagated vegetatively or by seed, although the former is preferred to retain cultivar purity in commercial plantings. The plant is a trailing, woody vine that produces runners from 0.3 to 1.8 meters long, from which emerge numerous, short (5 to 7.5 cm), vertical, upright branches known as "uprights". The upright branches form terminal buds that give rise to the flowers and in turn, the berries produced by the plant. Berries begin to ripen in late September and are harvested until late in the fall when freezing temperatures make the fruit unsuitable for use.

The cranberry is an evergreen plant with dark, glossy green leaves which become dull reddish brown during dormancy. Although evergreen, the cranberry is not truly hardy and depends on natural flooding to protect it from winter injury. In some areas of Canada, these conditions are simulated commercially by planting vines in well-engineered peat or sand beds that are located within 0.3 to 0.8 meters of the water table. Surrounding the beds and sometimes through the beds, are ditches, dykes and other water control structures used to regulate water flow into or away from the beds. This careful regulation of water allows for flooding for frost protection, pest management, harvest and winter protection. The ability to flood and hold water on the bed surface is critical to the success of the commercial cranberry operation. The cranberry thrives best where the summers are cool. It is an acid loving crop requiring soil conditions with a pH between 4.0 and 5.5.

A new cranberry bed is established by "pressing in" hardwood cuttings obtained from cranberry vines in mature beds or by using rooted cuttings or "plugs". The first economic harvest is usually obtained by year three and maximum production by year five. The productivity of the crop is optimized by good nutritional management, renovation of the beds with new sand layers every three to eight years, frost protection by flood or overhead irrigation and the use of integrated pest management (IPM) practices. If these management practices are maintained, production in a cranberry bed can continue for many years. Many beds have been in production for over 100 years.

As a wetland species, cranberry has traditionally been grown on wetland (organic) soils. However, environmental concerns, coupled with increased demand for fruit in the early 1990s, forced expansion onto non-traditional "upland" sites on mineral soils. If these soils meet the pH, drainage and flood requirements of modern production systems, they are as productive as the more traditional peat bog developments. Under-drainage from below the plants tends to be favoured in upland developments on mineral soils.

Irrigation has become a standard feature of the modern cranberry operation, providing the water needs of the crop during periods of water stress, for frost protection and in many cases for the addition of fertilizers and pesticides through "fertigation" and "chemigation" respectively.

The extensive use of water necessitates significant water holdings adjacent to the operations. This, coupled with a greater public concern over potential contamination of the water supply through the misuse of fertilizers and pesticides, has resulted in the cranberry industry being highly scrutinized and regulated in recent decades. Grower response to this has been exceptionally progressive and they are recognized leaders among agricultural commodities in the adoption of IPM strategies.

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	Apply winter flood, taking precautions to avoid oxygen deficiency injury (e.g. snow removal, draining water under ice, etc.); sanding for bed rejuvenation.
Spring - flood removal to bud break (late March to May)	Plant care	Apply fertilizers for oxygen deficiency injury treatment, etc.; pruning if required; pollinators (honeybees, bumblebees) may be introduced at 10% bloom.
	Soil care	Apply sulfur or lime for pH adjustment.
	Weed management	Monitor for weeds, apply pre-emergence herbicides before vines break dormancy; late water (spring flooding for one month) may be applied for dewberry control.
	Disease management	Application of late water for fruit rot reduction.
	Insect management	Application of late water for cranberry fruitworm and southern red mite reduction.
Summer – bud break to berry maturity (May to late September)	Plant care	Apply granular and foliar nutrients as required; apply frost protection and irrigate as required; calcium-boron may be applied for optimum fruit set; conduct leaf analyses; monitor fruit maturity.
	Soil care	Apply low rates of sulfur as required; take soil samples.
	Disease management	Monitor for disease (upright dieback, fruit rot, etc.); apply fungicides as required.
	Insect management	Monitor (sweep nets, pheromone traps, etc.) for cranberry fruitworm, blackheaded fireworm, cranberry tipworm, cranberry girdler, spanworms, false armyworm, cranberry blossomworm, flea beetle, loopers, weevils, tussock moth, Spargonothis fruitworm, green fruitworm, grubs and beneficial organisms; apply controls as needed; summer re-flood for grubs.
	Weed management	Monitor and map weeds; apply controls if needed.
	Other	Monitor for other pests (muskrats, etc.); control as required.
Fall – harvest period (September to November)	Plant care	Harvest berries; irrigate as needed after harvest; prune after harvest if desired; apply fall fertilizers.
	Soil care	Apply sulfur or lime for pH adjustment.
	Disease management	Remove trash piles after harvest.
	Insect management	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.

Abiotic Factors Limiting Production

Temperature extremes

Excessive heat (> 32˚C) in the summer months may result in sunscald and heat injury to berries. At temperatures below -1˚C, flowers and flower buds are damaged. Before bud break, mixed terminal buds (containing flower buds) will tolerate temperatures of -4˚C, while fully dormant buds will tolerate temperatures as low as -18˚C. Young, vegetative growth exposed to frost turns brown and eventually falls off. Berries become progressively more cold tolerant as they mature. The white-berry stage is tolerant to -2˚C, while well-coloured fruit will withstand temperatures of -5 to -7˚C, depending on cultivar and maturity.

Other climatic factors

Summer droughts can negatively impact vine growth and fruit production. 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. Lightning can also strike and cause damage to cranberry beds. Lightning strikes kill plants both above and below ground, in wavy patterns that emanate from a central point, with damage usually coinciding with a metal sprinkler head.

Soil pH, salts and drainage

Cranberries are acid-loving plants that require a soil pH between 4.0 and 5.5 for optimum growth. Vine 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 and salt injury. Vines can be injured 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. The regular sanding of cranberry beds reduces the buffering capacity of the soils, making the beds susceptible to rapid pH change if irrigated with water of pH outside the desired range. Water pH is extremely important in cranberry production due to the extensive use of water for irrigation, frost protection and flooding.

Water availability

Large volumes of water are required for successful cranberry production. In the colder eastern and central provinces, beds are flooded to a depth of 0.25 to 1.0 meter to prevent cold temperature damage and desiccation. In the spring, water is used extensively for frost protection and during the growing season about 3 cm of water is used per week to irrigate the crop. Prior to harvest, water is applied extensively for frost protection. The majority of beds are flooded to harvest the berries. Beds may also be periodically flooded for weed, disease and /or insect management (e.g. late water flood, summer flood, fall flood). The successful cranberry operation must have sufficient and reliable quantities of accessible water to meet the many needs of the crop.

Oxygen deficiency

Insufficient oxygen in winter flood water can severely injure cranberry plants and indirectly reduce subsequent yields. When sunlight is blocked from penetrating the ice layer (by sand, snow, etc.), plants begin to use more oxygen than they generate. When the oxygen content falls to below 40% of normal, injury will occur within two to three days.

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 the actual amount of this crop loss.

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

Disease	British Columbia	Quebec	New Brunswick
Fruit rot complex			
Early rot			
Ripe rot			
Black rot			
Blotch rot			
Cottonball			
Rose bloom			
Upright dieback			
Black spot			
Red leaf spot			
Twig blight			
Protoventuria leaf spot			
Phytophthora root and runner rot			

Widespread yearly occurrence with high pest pressure.

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

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

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

Pest not present.

Data not reported.

[1]Source: Cranberry stakeholders in reporting provinces.

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

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

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

.....continued

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

Practice / Pest		Cottonball	Fruit rot complex	Rose bloom	Twig blight	Upright dieback
Decision making tools	economic threshold					
	weather / weather-based forecast / predictive model					
	recommendation from crop specialist					
	first appearance of pest or pest life stage					
	observed crop damage					
	crop stage					
Suppression	pesticide rotation for resistance management					
	soil amendments					
	biological pesticides					
	controlled atmosphere storage					
	targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)					
Crop specific practices	sanding					
	late water (spring flooding)					
	fall flooding; post-harvest flood					
New practices (by province)	optimisation of drainage (Quebec)					
	timing of flooding at harvest (Quebec)					

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.

Information regarding the practice for this pest is unknown.

[1]Source: Stakeholders in cranberry producing provinces (British Columbia and Quebec).

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

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
azoxystrobin	methoxy-acrylate	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	fruit rots, cottonball (suppression)
chlorothalonil	chloronitrile (phthalonitrile)	multi-site contact activity	multi-site contact activity	M 5	RE	fruit rot, twig blight, leaf blight, upright dieback
copper (present as copper oxychloride)	inorganic	multi-site contact activity	multi-site contact activity	M1	R	fruit rot fungal complex, twig blight, leaf blight
cyprodinil + fludioxonil	anilino-pyrimidine + phenylpyrrole	D1: amino acids and protein synthesis + E2: signal transduction	methionine biosynthesis (proposed) (cgs gene) + MAP/histidine-kinase in osmotic signal transduction (os-2, HoG1)	9 + 12	R + R	botrytis fruit rot
ferbam	dithiocarbamate and relatives	multi-site contact activity	multi-site contact activity	M3	RE	fruit rot
folpet	phthalimide	multi-site contact activity	multi-site contact activity	M4	RE	fruit rot
fosetyl-Al	ethyl phosphonate	unknown mode of action	unknown	33	RE	phytophthora root rot

.....continued

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

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation status[3]	Targeted Pests[1]
penthiopyrad	pyrazole-4-carboxamide	C2: respiration	complex II: succinate-dehydro-genase	7	R	botrytis grey mould
propiconazole	triazole	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	cottonball
prothioconazole	triazolinthiuone	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	fruit rot, septoria leafspot (suppression)
triforine (British Columbia only)	piperazine	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	3	RE	cottonball

[1]Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of January 23, 2015. The product label is the final authority on pesticide use and should be consulted for application information. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

[2]Source: Fungicide Resistance Action Committee. *FRAC Code List 2014: Fungicides sorted by mode of action (including FRAC code numbering)* (www.frac.info/) (accessed February 17, 2015).

[3]PMRA re-evaluation status: R - full registration RE (yellow) - under re-evaluation , RES (yellow) - under special review as published in PMRA Re-evaluation note REV2013-06, Special Review Initiation of 23 Active Ingredients, RES* (yellow) - under re-evaluation and special review, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA as of December 31, 2014.

Fruit rot complex: early rot (*Phyllosticta vacinii*), end rot (*Godronia cassandrae*), viscid rot (*Phomopsis vaccinii*), botryosphaeria fruit rot and berry speckle (*Botryosphaeria vaccinii*), ripe rot (*Coleophoma empetri*), black rot (*Allantophomopsis lycopodina*), yellow rot (*Botrytis cinerea*) and blotch rot (*Physalospora vaccinii*)

Pest information

Damage: Fruit rots are caused by a collection of pathogens affecting the cranberry fruit, either before harvest when they are referred to as field rots or after harvest when they are referred to as storage rots. Affected berries become soft and tan or black in color and are unmarketable. Losses of 33% are commonly reported in untreated beds, but there is a 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 and persistent pedicels. Depending on the species, infections generally begin during bloom and early fruit set. However, 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. Warm temperatures favour some rot species while cooler temperatures favour others.

Pest management

Cultural controls: Cultural practices that reduce fruit rot include sanding, drainage improvement, harvest trash removal, proper pruning and nitrogen management, use of "late water", minimizing berry bruising and injury by proper harvest equipment set-up, minimizing the length of time berries remain in the harvest flood water and maintaining optimum temperatures and humidity (2-4˚C, 90% humidity) during storage.

Resistant cultivars: There are several varieties known to have resistance to field rot, including 'Black Veil', 'Foxboro', 'Howes', 'Matthews', 'Shaw's Success', 'Stevens' and 'Wilcox'.

Chemical controls: Fungicides registered for control of fruit rot in Canada are listed in Table 6. Fungicides and biofungicides registered for disease management in cranberry in Canada.

Issues for fruit rot

1. At harvest of cranberries destined for processing, a percentage of fruit is 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 determine the actual amount of 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. The 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.

Cottonball (*Monilinia oxycocci*)

Pest information

Damage: Cottonball results in tip blight of young succulent shoots and a fruit rot known as hard rot.

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. This disease develops under wet conditions with moderate temperatures. Conidia (asexual spores) are produced in infected tissues and are released during a separate 10 to14 day window coinciding with full bloom. Conidia release is favoured by warm temperatures, low relative humidity and high wind speed. Conidia only infect open flowers. 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% 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. Cottonball can be moved to new fields in imported vines from regions where the disease is problematic. Extreme care needs to be taken to prevent the introduction of this disease into new areas.

Resistant cultivars: None identified.

Chemical controls: Fungicides registered for control of cottonball are listed in Table 6. Fungicides and biofungicides registered for disease management in cranberry in Canada.

Issues for cottonball

None identified.

Rose bloom (*Exobasidium oxycocci*)

Pest information

Damage: Rose bloom causes abnormal branching of uprights with fleshy, pink leaves that resemble miniature roses and results in a reduction of yield on affected shoots. Affected uprights are scattered throughout the beds and are visible from late April through mid-June. Affected tissues are initially pale green but become pink as they enlarge, eventually becoming powdery white when spores are produced on the surface of infected tissues. By mid-bloom, the affected uprights harden and become dry and dark brown and withered.

Life cycle: Spores are produced on the surface of the affected shoots and are dispersed by wind to nearby, lateral buds. Newly infected buds do not show symptoms until the following spring.

Pest management

Cultural controls: None available.
Resistant cultivars: None identified.
Chemical controls: There are no fungicides registered for this disease.

Issues for rose bloom

None identified.

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

Pest information

Damage: The visible symptoms of upright dieback include yellowing of the leaves which progresses to orange or bronze and eventually becomes brown as the upright dies. The incidence of the disease is generally greater in young (one to three year old) beds where large patches of uprights can become infected. In well-established beds, infected uprights tend to be more scattered throughout the bed. Symptoms usually develop in early spring after the winter flood is removed. Roots of infected vines remain unaffected, but berries attached to affected uprights wither and desiccate as the upright dies. 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 and therefore some fruit rot is often associated with upright dieback. Upright dieback is of greater concern in dry pick operations than wet-pick.

Life cycle: Diaporthe vaccinii does not overwinter well in diseased vines and how it infects new tissue is not known. It is thought that ascospores are released from perithecia (fruiting bodies) at the time of bud swell and form hyphae that penetrate the new tissue. 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. Dieback may occur at any time during the growing season, but is more likely to occur when vines are under stress from hot or dry conditions. It is not known whether ascospores are capable of infecting blossoms and fruit. Environmental conditions that favour infection by *Synchronoblastia crypta* parallel those of *D. vaccinii.* However, *S. crypta* is spread by conidia and infects uprights, blossoms and fruit.

Pest management

Cultural controls: Optimal fertility programs make vines more resistant to infection. 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.

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

Chemical controls: Fungicides registered for control of upright dieback rot are listed in Table 6. Fungicides and biofungicides registered for disease management in cranberry in Canada.

Issues for upright dieback

None identified.

Black spot *(Mycosphaerella migromaculans)*

Pest information

Damage: Black spot is actually a secondary invader that colonizes stem lesions and leaf spots caused by *Exobasidium rostrupii*, the red leaf spot pathogen. Black lesions are formed on runners and uprights and often girdle the stem leading to defoliation and death of the tissue beyond the girdling point. This usually occurs in late August or September when it is too late in the season for lateral branches to set a mixed (fruiting) bud. As such, yield reduction is usually seen in the year following infection. Berries may also be attacked but the incidence is generally not considered to be economically important. Lesions do not lead to rotting in storage.

Life cycle: The life cycle of this fungus is not fully understood, but it is believed to overwinter in stem lesions as immature perithecia. It is hypothesized that saprophytic growth of the fungus in the duff layer or bark of older runners produces conidia that infect the host later in the summer when red leaf spot lesions are present. Like red leaf spot, black spot prefers cloudy, rainy or misty weather for infection and development, tending to be most common in shaded areas of the bog.

Pest management

Cultural controls: The cutting back of trees and shrubs surrounding the bog helps reduce shading and improves air movement and sun exposure, making conditions less favourable for the disease. Cultural practices that reduce red leaf spot disease will typically also control black leaf spot.

Resistant cultivars: None identified.

Chemical controls: There are no registered chemical controls for this disease.

Issues for black spot

None identified.

Red leaf spot (*Exobasidium rostrupii*)

Pest information

Damage: Young plantings are more susceptible to red leaf spot. Symptoms of red leaf spot are circular, bright red spots on the upper side of leaves and sometimes on young, green berries. Expanding spots often overlap and infected leaves are usually shed prematurely. The disease may also spread through leaf petioles to new stem growth where it can cause reddening and swelling, sometimes resulting in tissue death. The most serious effect of the disease is the loss of vegetative and fruiting buds due to the death of young shoots. Black spot disease often develops on plants already affected by red leaf spot and some damage attributed to red leaf spot damage may actually be caused by black spot.

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. Excessive vine growth, in over-fertilized beds, also favours disease development.

Pest management

Cultural controls: Practices that improve air circulation and plant drying help to control this disease. Avoiding over-fertilization will help reduce disease incidence.

Resistant cultivars: Greenhouse studies have reported little variation in disease susceptibility among cultivars tested, although the cultivars ‘Ben Lear’ and ‘Stevens’ exhibit more susceptibility than other cultivars in the field.

Chemical controls: There are no registered fungicides for this disease in Canada.

Issues for red leaf spot

None identified.

Twig blight (*Lophodermium oxycocci* and *L. hypophyllum*)

Pest information

Damage: Twig blight can affect scattered uprights or large patches in the beds. In severe outbreaks entire beds can be blighted. In winter and early spring, the foliage on one-year old wood turns brown. As the disease progresses, the blighted leaves become bleached tan and then silvery gray. The disease kills only one-year old wood, though runners may also be affected. Vines are unable to compensate for the loss of fruit buds by increased fruit set or berry size and consequently, yield reduction is directly proportional to the percentage of uprights with mixed (fruiting) buds that have been blighted. In severe cases where the disease is untreated, up to 80% of uprights may be affected.

Life cycle: The fungus overwinters as mycelium in infected leaves and twigs. Ascospores are released between June and August and are disseminated by wind to new leaves suitable for infection. Moisture, from rain or irrigation, is required for four to 28 hours for spore release, with moisture from fog or dew being insufficient to trigger spore release. Leaves on new upright growth are susceptible to new infections for only about 30 days each summer. New infections occur in the summer, but symptoms are not expressed until winter and early spring.

Pest management

Cultural controls: Removing trees causing shading is effective in reducing the incidence of twig blight in these areas. Efforts should be made to obtain twig blight free planting stock when planting new beds, as beds infected with the disease fill in very slowly without treatment.

Resistant cultivars: The cultivars 'McFarlin', 'Stevens', 'Bergman' and 'Crowley' are known to be susceptible.

Chemical controls: Fungicides registered for control of twig blight are listed in Table 6. Fungicides and biofungicides registered for disease management in cranberry in Canada.

Issues for twig blight

None identified.

Protoventuria leaf spot and berry speckle (*Protoventuria myrtilli*)

Pest information

Damage: Small, red or purple spots develop on leaves in the fall. The lesions enlarge and by late spring of the following year, affected leaves become yellow and many drop prematurely. Small, red, superficial lesions develop on fruit giving the fruit a speckled appearance. Although berry speckle makes the fruit less attractive for fresh market, it does not affect fruit quality.

Life cycle: Leaf infections occur in the summer and are caused by ascospores produced in perithecia in leaf lesions of the previous year.

Pest management

Cultural controls: None available.

Resistant cultivars: None available.

Chemical controls: Fungicides applied for the management of other diseases in July and August will also control protoventuria leafspot.

Issues for protoventuria leaf spot

None identified.

Phytophthora root and runner rot (*Phytophthora* spp.)

Pest information

Damage: Phytophthora root and runner rot affects the roots and underground runners of cranberries. The disease occurs most often in areas that have poor drainage and areas with prolonged periods of soil saturation or standing water during the growing season. Above ground symptoms are weak vines that have stunted, weak uprights with fewer and smaller leaves that turn red prematurely in late summer. Similarly, flower and fruit production is reduced and in advanced cases, discrete patches without vines develop in the beds. Underground symptoms include reduced numbers of fibrous feeder roots and discoloration below the periderm in infected roots and runners. Where symptoms are severe, there can be significant yield reduction.

Life cycle: The life cycle of this disease has not been fully elucidated. However, based on phytophthora species affecting other crop plants, it is surmised that the species affecting cranberry overwinter as mycelium, chlamydospores (resting spores) or oospores (sexual spores) in infected plants, colonized plant debris or soil. Primary infection is likely on new, fibrous roots and from there progresses into the woody, underground runners. Saturated or flooded soil conditions promote sporangium (asexual fruiting body) production and zoospore (motile spore) release, the latter constituting the primary unit of infection. Disease spread within a bed is most likely through flowing water and disease spread between bogs or regions via infected vines used to plant new beds.

Pest management

Cultural controls: Improving drainage by installing drains, ditches, etc. and removing low-lying areas in beds so there is less standing water is beneficial. Avoiding over-watering and planting beds only with healthy vines will help to minimize infections. As well, additional fertilizer may be beneficial in promoting new root production in weak, diseased vines.

Resistant cultivars: Very little is known about the relative resistance of cranberry cultivars to this disease. Results from studies of artificially inoculated, greenhouse-grown plants have been inconsistent.

Chemical controls: Fungicides registered for control of phytophthora root and runner rot are listed in Table 6. Fungicides and biofungicides registered for disease management in cranberry in Canada.

Issues for phytophthora root and runner rot

None identified.

Insects and Mites

Key Issues

- There is a need for the development of non-chemical approaches, such as pheromone-mediated mating disruption and the use of biological control agents, as alternatives to pesticides for the management of a number of insect pests of cranberry.
- Reduced-risk products, including biopesticides, are required for the control of many insects in cranberry. 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.

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

Insect	British Columbia	Quebec	New Brunswick
Blackheaded fireworm			
Cranberry girdler			
Cranberry tipworm			
Spanworms			
Blueberry spanworm			
Green spanworm			
Bruce spanworm			
Big cranberry spanworm			
Spiny looper			
Stout spanworm			
Caterpillars			
Cranberry blossomworm			
False armyworm			
Speckled green fruitworm			
Rusty tussock moth			
Cranberry fruitworm			
Sparganothis fruitworm			
Redheaded flea beetle			
Cranberry weevil			
Root weevils			
Black vine weevil			
Strawberry root weevil			
Claycoloured weevil			
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 pressure.			
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.			
Pest not present.			
Data not reported.			

[1]Source: Cranberry stakeholders in reporting provinces.

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

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

	Practice / Pest	Spanworms	Blackheaded fireworm	Cranberry fruitworm	Cranberry girdler	Root weevils (British Columbia only)	Cranberry weevil (Quebec only)
Avoidance	resistant varieties						
	planting / harvest date adjustment						
	crop rotation						
	choice of planting site						
	optimizing fertilization						
	reducing mechanical damage						
	thinning / pruning						
	trap crops / perimeter spraying						
	physical barriers						
Prevention	equipment sanitation						
	mowing / mulching / flaming						
	modification of plant density (row or plant spacing; seeding rate)						
	seeding depth						
	water / irrigation management						
	end of season crop residue removal / management						
	pruning out / removal of infested material before harvest						
	tillage / cultivation						
	removal of other hosts (weeds / volunteers / wild plants)						

....continued

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

Practice / Pest		Spanworms	Blackheaded fireworm	Cranberry fruitworm	Cranberry girdler	Root weevils (British Columbia only)	Cranberry weevil (Quebec only)
Monitoring	scouting - trapping						
	records to track pests						
	soil analysis						
	weather monitoring for degree day modelling						
	use of portable electronic devices in the field to access pest identification /management information						
	use of precision agriculture technology (GPS, GIS) for data collection and field mapping of pests						
Decision making tools	economic threshold						
	weather / weather-based forecast / predictive model (eg. degree day modelling)						
	recommendation from crop specialist						
	first appearance of pest or pest life stage						
	observed crop damage						
	crop stage						
Suppression	pesticide rotation for resistance management						
	soil amendments						
	biological pesticides						
	arthropod biological control agents						
	beneficial organisms and habitat management						
	ground cover / physical barriers						
	pheromones (eg. mating disruption)						
	sterile mating technique						
	trapping						
	targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)						

....continued

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

Practice / Pest		Spanworms	Blackheaded fireworm	Cranberry fruitworm	Cranberry girdler	Root weevils (British Columbia only)	Cranberry weevil (Quebec only)
Crop specific practices	sanding						
	late water (spring flooding)						
	fall flooding; post-harvest flood						
New practices (by province)	summer flood (British Columbia)						
	spring flooding (24 - 48 hours)(Quebec)						

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.

Information regarding the practice for this pest is unknown.

[1]Source: Stakeholders in cranberry producing provinces (British Columbia and Quebec).

Table 9. Pesticides and biopesticides registered for insect management in cranberry production in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
acephate	organophosphate	acetylcholinesterase (AChE) inhibitor	1B	RES*	blackheaded fireworm
Bacillus thuringiensis subsp. *kurstaki* strain ABT-351	*Bacillus thuringiensis* and the insecticidal proteins they produce	microbial disruptor of insect midgut membranes	11A	R	green spanworm, brown spanworm, fruittree leafroller, European leafroller, obliquebanded leafroller, threelined leafroller
Bacillus thuringiensis subsp. *kurstaki* strain EVB113-19	*Bacillus thuringiensis* and the insecticidal proteins they produce	microbial disruptor of insect midgut membranes	11A	R	green spanworm, brown spanworm, fruittree leafroller, European leafroller, obliquebanded leafroller, threelined leafroller
carbaryl	carbamate	acetylcholinesterase (AChE) inhibitor	1A	RES*	bluntnosed cranberry leafhopper, cranberry fruitworm, cutworms (climbing), fireworms
chlorantraniliprole	diamide	ryanodine receptor modulator	28	R	obliquebanded leafroller, threelined leafroller, climbing cutworm, Japanese beetle (suppression), Sparganothis fruitworm, blackheaded fireworm, cranberry fruitworm
diazinon	organophosphate	acetylcholinesterase (AChE) inhibitor	1B	PO (expiry date of use Dec. 31, 2016)	cranberry fruitworm, blackheaded fireworm, Sparganothis fruitworm
imidacloprid	neonicotinoid	nicotinic acetylcholine receptor (nAChR) agonist	4A	RES	reduction in numbers of European Chafer larvae

....continued

Table 9. Pesticides and biopesticides registered for insect management in cranberry production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
malathion	organophosphate	acetylcholinesterase (AChE) inhibitor	1B	R	blackheaded fireworm, cranberry fruitworm, leafhopper, meadow spittlebug (nymphs)
methoxyfenozide	diacylhydrazine	ecdysone receptor agonist	18	R	blackheaded fireworm, Sparganothis fruitworm, cranberry fruitworm, spanworms
phosmet	organophosphate	acetylcholinesterase (AChE) inhibitor	1B	RE	blackheaded fireworm
potassium salts of fatty acids	inorganic	unknown	N/A	R	aphids, mealybugs, mites, scale insects
spinetoram	spinosyn	nicotinic acetylcholine receptor (nAChR) allosteric activator	5	R	blackheaded fireworm, Sparganothis fruitworm, cranberry tipworm (suppression)
spinosad	spinosyn	nicotinic acetylcholine receptor (nAChR) allosteric activator	5	R	cranberry fruitworm (suppression), blackheaded fireworm, sparganothis fruitworm
spirotetramat	tetronic and tetramic acid derivative	inhibitor of acetyl CoA carboxylase	23	R	aphids, blueberry maggot, blueberry gall midge/ cranberry tipworm, lecanium scale (suppression)

....continued

Table 9. Pesticides and biopesticides registered for insect management in cranberry production in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
tebufenozide	diacylhydrazine	ecdysone receptor agonist	18	R	blackheaded fireworm, Sparganothis fruitworm
thiamethoxam	neonicotinoid	nicotinic acetylcholine receptor (nAChR) agonist	4A	RES	blackvine weevil (adult), cranberry weevil, strawberry root weevil (suppression)

[1]Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of January 23, 2015. The product label is the final authority on pesticide use and should be consulted for application information. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

[2]Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (Version 7.3; 2014)* (www.irac-online.org) (accessed February 17, 2015).

[3]PMRA re-evaluation status: R - full registration RE (yellow) - under re-evaluation , RES (yellow) - under special review as published in PMRA *re-evaluation notes REV2013-06, Special Review Initiation of 23 Active Ingredients* OR PMRA *Re-evaluation Note REV2014-06 Initiation of Special Reviews: Potential Environmental Risk Related to Peponapis pruinosa Exposure to Clothianidin, Imidacloprid and Thiamethoxam Used on Cucurbits,* RES* (yellow) - under re-evaluation and special review, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA as of December 31, 2014.

Blackheaded fireworm (BHF) *(Rhopobota naevana)*

Pest information

Damage: 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. Summer damage is caused by second generation larvae feeding on new leaves, flowers and fruit. Damage to fruit is very similar to that of cranberry fruitworm except that BHF larvae do not seal their holes with silk. BHF larvae produce characteristic "tents" by webbing together several leaves at the tip of an upright or even several uprights.

Life cycle: BHF overwinters as eggs on the underside of cranberry leaves. They hatch over a three to six week period beginning in May. Larvae feed for two to three weeks after which they drop to the trash layer where they pupate, emerging as adult moths in June. Moths begin laying eggs on leaf undersides only 24 hours after emergence. Some of these eggs overwinter but most hatch in July into second generation larvae that feed on leaves, flowers and fruit. Following pupation, second generation adults emerge in August through September and produce overwintering eggs.

Pest management

Cultural controls: The BHF is difficult to manage. The timing of treatments is critical. First generation larvae may be controlled by re-flooding beds for a period of 10 hours. Re-flooding for second generation larval control is not recommended as blossoms and newly set berries will be killed. Larvae can be monitored by sweep netting before terminal buds begin to swell or by counting the number of fireworm "tents" and checking the size of the larvae. If first generation larvae are successfully controlled, treatment for the more damaging second generation should not be required. Monitoring for the emergence of first generation adults using pheromone baited traps is highly recommended. The use of chemical controls may be reduced or eliminated through the use of pheromone mating disruption. A biological control is also commercially available for BHF control. *Trichogramma sibericum* is a parasitic wasp that attacks and parasitizes BHF eggs. It is most effective in reducing high fireworm populations and works well as a companion treatment to mating disruption.

Resistant cultivars: None identified.

Chemical controls: Insecticides registered for the management of BHF are listed in Table 9. Pesticides and biopesticides registered for insect management in cranberry production in Canada.

Issues for blackheaded fireworm

1. Reduced risk products, including biopesticides are required for the control of BHF, to replace the organophosphates which are under regulatory phase out, and for organic production which has few alternatives. It is important that the new products have short re-entry and pre-harvest periods and different modes of action for resistance management. As second generation larvae are present during bloom, the new products must also be pollinator-friendly.

2. There is a need for the development of non-chemical approaches to the management of BHF in cranberry. The refinement of pheromone-mediated mating disruption is required for use in biological control strategies.

Cranberry girdler (*Chrysoteuchia topiara*)

Pest information

Damage: Larvae of the cranberry girdler feed on the bark and wood of roots and runners causing girdling. This damage becomes more visible in late fall when leaves turn brown and in spring when the damaged plants have lost their leaves altogether.

Life cycle: The cranberry girdler overwinters as a larva inside a cocoon in the trash layer on the bed surface. Pupae complete their development in the spring and adult moths emerge in late June and are present until August. Female moths lay eggs in plant debris on the bed surface. Following egg hatch, caterpillars actively feed from August to September. There is only one generation per year.

Pest management

Cultural controls: Regular sanding and sanding of "hot spots" reduce cranberry girdler damage. A six-day, post-harvest flood also is beneficial in reducing overwintering populations, but may reduce the next season's crop. Cranberry girdlers may be monitored with pheromone traps and also by looking for signs of larval damage in August and September when damage is most visible.

Resistant cultivars: None identified.

Chemical controls: There are no insecticides available for the control of cranberry girdler.

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: Cranberry tipworm larvae feed on the terminal growth of new shoots and often cause lateral branching if the growth point is injured. The larvae also feed on new leaves by rasping the upper surface causing colour loss and leaf cupping. Eventually the leaves turn brown and drop off. Plants recover well from early season injury but damage to developing buds in August directly reduces yield.

Life cycle: Cranberry tipworms have two to three generations during the growing season. First generation females mate and begin laying eggs in late May. Eggs are usually laid on the leaf surface near the base of terminal leaves. Larvae hatch and begin to feed on leaves. There are three larval instars followed by pupation in a cupped leaf at the shoot tip. The next generation adults emerge soon after. Pupae of the final generation drop to the bed surface when the leaves turn brown and overwinter in the trash layer. The life cycle from egg to adult takes only two to four weeks.

Pest management

Cultural controls: Re-sanding reduces the emergence of adult flies in spring by covering and smothering overwintering pupae.

Resistant cultivars: Cranberry tipworm reportedly prefers the variety 'Early Black', followed by 'Howes'. Among cultivars, the variety 'Stevens' seems to be the least preferred by the pest.

Chemical controls: Insecticides registered for the management of cranberry tipworm are listed in Table 9. Pesticides and biopesticides registered for insect management in cranberry production in Canada.

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 (eg. fertilization) on tipworm populations.

Blueberry (black) spanworm (*Macaria argillacearia* (syn. *Itame argillacearia*)) and green spanworm (*M. sulphurea*)

Pest information

Damage: Damage is caused by the larvae that feed on buds beginning at bud break and then on new leaves and flower blossoms. Damaged areas are evident by their darker colour in the bog, a result of loss of the lighter green, new growth, leaving the older, darker green leaves.

Life cycle: Blueberry and green spanworms are among the earliest caterpillars to be seen in the spring. They overwinter as eggs in the leaf trash at the bed surface and hatch in early May to early June. The caterpillars feed voraciously until pupating in the plant debris. Adults emerge in late June for blueberry spanworm and early July to August for green spanworm. Eggs are laid singly or in small clusters in the trash layer at the bed surface, through late July and August.

Pest management

Cultural controls: Sanding is helpful for managing spanworms. Spanworms are less common in new fields due to more regular sanding. Monitoring is done effectively by sweep netting for larvae.

Resistant cultivars: None identified.

Chemical controls: Insecticides registered for the management of spanworms are listed in Table 9. Pesticides and biopesticides registered for insect management in cranberry production in Canada.

Issues for spanworms

1. Monitoring techniques and economic thresholds need to be developed for blueberry spanworm.
2. There is a need for the registration of reduced risk pesticides, including biopesticides, for the control of blueberry spanworm.
3. There is a need to the development of non-chemical approaches for the management of blueberry 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 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 blueberry and green spanworms, when they do occur they can do serious damage. They are voracious feeders and can defoliate the cranberry bed, often in localized areas. Infestations of the big cranberry spanworm and stout spanworm can be particularly damaging as the larvae of these species are large, up to 60 mm in length at maturity.

Life cycle: Each of these spanworms has one generation per year and overwinters as pupae in a cocoon in the soil. Moths emerge at varying times, laying egg masses of 150 to 600 eggs, depending on species. Caterpillars feed on buds, leaves and blossoms before pupating to repeat their life cycle.

Pest management

Cultural controls: Spanworms are less common in new fields due to more regular sanding. Sanding is thought to be a helpful cultural practice in managing this pest. Populations can be monitored by sweep netting for larvae.

Resistant cultivars: None identified.

Chemical controls: There are no chemicals registered specifically for the control of these spanworms.

Issues for minor spanworms

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

Cranberry blossomworm (*Epiglaea apiata*)

Pest information

Damage: Cranberry blossomworm is also a cutworm. Cranberry blossomworm larvae skeletonize the older leaves and bore into buds and "cut-off" flower blossoms.

Life cycle: Cranberry blossomworm overwinters as eggs in the leaf trash on the bed surface. The eggs hatch in mid-May and the larvae begin to feed on leaves and buds. The larvae mature by July and enter a two to four week dormancy period in the trash layer before burrowing into the soil and pupating. Moths emerge in September and are active through to November, laying eggs singly in the plant debris at the bed surface.

Pest management

Cultural controls: Late water is reported to reduce cranberry blossomworm populations. Also, sanding may be beneficial as overwintering eggs are buried by this operation.

Resistant cultivars: None identified.

Chemical controls: There are no insecticides registered for cranberry blossomworm control.

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: Larvae of the false armyworm feed during the day on the inner part of terminal buds, and when older and larger, feed voraciously on new leaves and flower blossoms. As a cutworm species, false armyworms characteristically chew and "cut-off" leaves and buds when they are feeding.

Life cycle: There is only one generation of false armyworm per season and it begins with an overwintering adult that becomes active in April. Females lay eggs in masses of about 100 on the stems or lower surfaces of leaves. Eggs hatch in late May making these caterpillars among the first to be seen in the cranberry marsh. Young larvae feed during the day on buds (before new growth) but as they get older become nocturnal, feeding aggressively on new leaves and flower blossoms. In late June, the mature caterpillars burrow into the soil for a two to six week dormancy period. Pupation follows with adults emerging in mid-August.

Pest management

Cultural controls: Late water is reported to reduce false armyworm populations.
Resistant cultivars: None identified.
Chemical controls: There are no insecticides registered for false armyworm control in cranberry.

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.

Speckled green fruitworm (*Orthosia hibisci*)

Pest information

Damage: Feeding by larvae of the speckled green fruitworm can cause serious damage to leaves, buds and blossoms. The larvae are known to be particularly voracious as they approach maturity.
Life cycle: There is only one generation per year of this pest. It overwinters as pupae in the soil, with adult moths emerging from late April to early May. They are active at night, laying eggs in irregular masses beginning shortly after their emergence. Larvae hatch from the eggs in mid-May and may be present in beds until late August.

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 identified.
Chemical controls: There are no pesticides specifically registered for speckled green fruitworm.

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.

Rusty tussock moth (*Orgyia antiqua*)

Pest information

Damage: Rusty tussock moth larvae feed on buds, leaves and flower blossoms. Infestations tend to be localized, with defoliated areas appearing as dark areas in the cranberry bed.

Life cycle: There is one generation per year. The rusty tussock moth overwinters as eggs that are laid in masses on the cocoon from which the female moth emerged. Eggs hatch in late spring and larvae feed on buds, leaves and flower blossoms. The insect pupates in cocoons on cranberry stems from which moths emerge in August and September.

Pest management

Cultural controls: Rusty tussock moth larvae are relatively small (25 to 35 mm. at maturity). Monitoring can be done by net sweeping for larvae. Flooding and sanding are potential cultural controls for the rusty tussock moth.

Resistant cultivars: None identified.

Chemical controls: None available.

Issues for rusty tussock moth

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

Cranberry fruitworm (*Acrobasis vaccinii*)

Pest information

Damage: Cranberry fruitworm damage is caused by the larvae burrowing into berries, feeding on seeds and pulp and leaving behind excrement in the hollowed out berries. One larva may tunnel through up to eight berries. Infested berries turn prematurely red and eventually wither, when they are sometimes called “raisins”.

Life cycle: Cranberry fruitworms overwinter as larvae inside cocoons in the soil and pupate in the spring. From mid-June to August, the brownish grey moths emerge. The moths are primarily active at night. Egg-laying coincides with berry set. Females lay up to 50 eggs, one per berry at the calyx end. Eggs hatch in five to 10 days and young larvae bore into the fruit, sealing the opening inconspicuously with silk. The larvae feed on berries from July to September before dropping to the ground to build an overwintering cocoon in the soil.

Pest management

Cultural controls: Monitoring to determine whether large numbers of cranberry fruitworm adults are present can be accomplished with pheromone traps placed in the cranberry bog, although a correlation between trap catch and egg-laying has not been established. The timing of treatments is based on stage of crop development and the presence of viable eggs.

Resistant cultivars: None identified.

Chemical controls: Insecticides registered for the management of cranberry fruitworm are listed in Table 9. Pesticides and biopesticides registered for insect management in cranberry production in Canada.

Issues for cranberry fruitworm

1. Reduced risk products, including biopesticides, are required for the control of cranberry fruitworm to replace the organophosphates which are under regulatory phase out, and for organic production which has few alternatives. It is important that the new products have short re-entry and pre-harvest intervals, have different modes of action for resistance management, and that they be pollinator friendly.
2. There is a need to establish a reliable basis for treatment decisions for cranberry fruitworm (eg. 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: Two generations of larvae of the Sparganothis fruitworm cause damage. The first generation selectively feeds on flower buds, indirectly reducing yield. The second-generation larvae have a direct impact on yield as they feed selectively on fruit, hollowing out the contents.

Life cycle: There are two generations per year. The Sparganothis fruitworm overwinters as a young larva in the trash layer at the bed surface and resumes activity at bud break. At this time it feeds on buds and as it gets older, webs together uprights and feeds on leaves within the protective web. Adults emerge in mid-June and lay eggs in masses of 20 to 50 eggs on the upper side of cranberry leaves or on weeds. The second-generation caterpillars emerge by late July and feed on leaves and fruit. Second-generation adults are present by early August and actively lay eggs until the end of September. Eggs hatch and young larvae overwinter.

Pest management

Cultural controls: Flooding is ineffective in controlling the larvae. Second-generation moths can be monitored with pheromone traps.

Resistant cultivars: None identified.

Chemical controls: Insecticides registered for the management of Sparganothis fruitworm are listed in Table 9. Pesticides and biopesticides registered for insect management in cranberry production in Canada.

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.

Redheaded flea beetle (*Systena frontalis*)

Pest information

Damage: Adult flea beetles feed on leaves of cranberry and weeds within the bog. This impacts bud development for the coming year. There is also some feeding by larvae on plant roots but the impact of this feeding has not been quantified.

Life cycle: There is one generation per year of this pest. Flea beetles overwinter as eggs and sometimes as adults. Eggs begin hatching in late May and larvae feed on plant roots. Adults emerge from the soil from mid-July to August and feed on plant leaves, impacting bud development for the following year. Eggs that overwinter are laid in the soil from August until September.

Pest management

Cultural controls: None identified.

Resistant cultivars: None identified.

Chemical controls: There are no insecticides registered for redheaded flea beetle in cranberry.

Issues for redheaded flea beetle

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

Cranberry weevil (*Anthonomus musculus*)

Pest information

Damage: Both larvae and adult weevils damage cranberry. Adults bore holes in flower blossoms during oviposition, often causing the flower to drop and loss of a potential fruit. They also bore holes in terminal buds, causing browning which resembles frost injury when the bud develops. The larvae feed on the developing flower blossom. Adult weevils emerge in summer and bore holes in the developing fruit, reducing yield directly.

Life cycle: Adults overwinter in flooded fields or on adjacent dykes and margins of beds. After the winter flood is removed, the adults become active and feed first on old leaves and buds, and then on new leaves and blossoms as the plant develops. Female weevils lay their eggs singly in flower blossoms and after hatching, larvae feed in the flower. Pupation also occurs in the flowers and adults emerge about the time fruit are forming. They feed on leaves, fruit and new buds throughout July and August before migrating to the soil surface where they overwinter in the trash layer.

Pest management

Cultural controls: None available.

Resistant cultivars: None identified.

Chemical controls: There are no chemicals registered specifically for this weevil in Canada.

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 (O*tiorhynchus sulcatus*), strawberry root weevil (*O. ovatus*) and claycoloured 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. Wilting and browning develops on above ground parts of the plants and shows in late spring, becoming more severe as the season progresses. Weevils are killed by flooding during harvest so this pest is generally only a problem in beds that are dry-harvested.

Life cycle: Larvae overwinter in cranberry soils and pupate in early spring. Adults emerge from pupal cells in late May through June depending on location. Adult weevils feed on leaves for four to six weeks before egg-laying in the soil begins. The eggs hatch two to three weeks later into legless, white grubs that feed on cranberry roots and root bark. Temperature permitting, they feed continuously until they pupate the following spring.

Pest management

Cultural controls: Wet-harvesting is effective in reducing root weevil populations. Alternatively, a 10 to 14 day fall flood as soon as possible after harvest or winter flooding also reduces populations. Monitoring for adults can be done by sweep netting or looking for the presence of leaf notching. Monitoring for larvae can be done in the spring by pulling areas of dying vines and looking for the white C-shaped grubs in the soil below.

Resistant cultivars: None identified.

Chemical Controls: 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: Scales suck plant juices from the stems of cranberry causing discolouration and leaf drop and weakening the plants.

Life cycle: Adult female scales overwinter and produce live young called crawlers in late spring-early summer. Crawlers move about on the plant surface or are wind-blown to suitable sites where they settle down and feed. The insects secrete a white, waxy protective covering. Adult males are mobile and winged and seek out female scales for mating.

Pest management

Cultural controls: Dearness scale is readily visible and can be monitored by visual inspection of weak areas of the cranberry bog. It is important to use cuttings from non-infested fields to establish new plantings and prevent spread of the scale.

Resistant cultivars: None identified.

Chemical controls: Insecticides registered for the management of scale insects are listed in Table 9. Pesticides and biopesticides registered for insect management in cranberry production in Canada.

Issues for Dearness scale

1. The registration of reduced risk insecticides to replace organophosphates is required for the management of Dearness scale. Since treatments against crawlers must be applied during bloom, new products must be pollinator friendly.

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	New Brunswick
Annual broadleaf weeds			
Annual grass weeds			
Annual bluegrass			
Barnyard grass			
Perennial broadleaf weeds			
Goldenrod			
Vetch			
Perennial grass weeds			
Woody plants			
Trailing blackberry			
Dodder			
Rushes			
Sedges			
Widespread yearly occurrence with high pest pressure.			
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.			
Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pressure.			
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.			
Pest not present.			
Data not reported.			

[1]Source: Cranberry stakeholders in reporting provinces.

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

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

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

....continued

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

Practice / Pest		Annual broadleaf weeds	Perennial broadleaf weeds	Annual grass weeds	Perennial grass weeds	Woody plants
Decision making tools	economic threshold					
	weather / weather-based forecast / predictive model					
	recommendation from crop specialist					
	first appearance of weed or weed growth stage					
	observed crop damage					
	crop stage					
Suppression	pesticide rotation for resistance management					
	soil amendments					
	biological pesticides					
	arthropod biological control agents					
	habitat / environment management					
	ground cover / physical barriers					
	mechanical weed control					
	targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)					
Crop specific practices	sanding					
	late water (spring flooding)					
	fall flooding; post-harvest flood					

....continued

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

Practice / Pest		Annual broadleaf weeds	Perennial broadleaf weeds	Annual grass weeds	Perennial grass weeds	Woody plants
New practices (by province)	prevention of contamination of cuttings (Quebec)					
	optimization of drainage (Quebec)					
	removal of weed residues (Quebec)					

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.

Information regarding the practice for this pest is unknown.

[1]Source: Stakeholders in cranberry producing provinces (British Columbia and Quebec).

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

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
2,4-D	phenoxy-carboxylic-acid	action like indole acetic acid (synthetic auxins)	4	RES	broadleaf weeds
acetic acid	not classified	unknown	N/A	R	perennial plants with growth in tillers or compact tufts such as grasses, sedges and rushes (suppression)
clethodim	cyclohexanedione 'DIMs'	inhibition of acetyl CoA carboxylase (ACCase)	1	RE	annual grass weeds, quackgrass
clopyralid	pyridine carboxylic acid	action like indole acetic acid (synthetic auxins)	4	R	vetch
dichlobenil	nitrile	inhibition of cell wall (cellulose) synthesis	20	RES	annual broadleaf weeds
fluazifop-P-butyl	aryloxyphenoxy-propionate 'FOP'	inhibition of acetyl CoA carboxylase (ACCase)	1	RES	grasses
glyphosate	glycine	inhibition of EPSP synthase	9	RE	annual and perennial weeds
mesotrione	triketone	bleaching: inhibition of 4-hydroxyphenyl-pyruvate-dioxygenase (4-HPPD)	27	R	annual and perennial weeds
mineral spirits	not classified	unknown	N/A	R	cottontop, cloudberry (partial control), annual grasses, sedges, bracken fern, broadleaf seedlings

....continued

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

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
napropamide	acetamide	inhibition of VLCFA (inhibition of cell division)	15	R	annual grasses
sethoxydim	cyclohexanedione 'DIM'	inhibition of acetyl CoA carboxylase (ACCase)	1	R	annual grasses

[1]Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of January 23, 2015. The product label is the final authority on pesticide use and should be consulted for application information. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

[2]Source: Herbicide Resistance Action Committee (HRAC). *Classification of Herbicides According to Site of Action (2014)* (www.hracglobal.com) (accessed February 17, 2015). Herbicide resistance groups are based on the Weed Science Society of America classification system as reported by HRAC.(www.hracglobal.com).

[3]PMRA re-evaluation status: R - full registration RE (yellow) - under re-evaluation , RES (yellow) - under special review as published in PMRA Re-evaluation note REV2013-06, Special Review Initiation of 23 Active Ingredients, RES* (yellow) - under re-evaluation and special review, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA as of December 31, 2014.

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 bog for future years. Annual grasses cause significant problems because of their fast growth and tolerance of extremes in moisture and temperature once established. With limited soil disturbance to stimulate germination annual weed germination is limited. 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 when establishing a cranberry bed. Once a bed has been established, it is important to maintain a dense crop canopy that will out-compete weed invaders.

Resistant cultivars: None available.

Chemical controls: Refer to Table 12 for a list of herbicides and bioherbicides registered for use in cranberry production in Canada.

Issues for annual and biennial weeds

None identified.

Perennial weeds

Pest information

Damage: Certain perennial weeds, such as woody plants, can greatly affect yield, 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 of weeds, is an option with small perennial weeds that are established in limited areas. Maintaining a healthy crop that competes well will also reduce weed establishment.

Resistant cultivars: None identified.

Chemical controls: Refer Table 12 for a list of herbicides and bioherbicides registered for use in cranberry production in Canada.

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, for perennial broadleaf weed control in Canada, are low and allow for some weed survival if the second follow-up application is missed. There is a need to bring rates more in-line with those in the United States to enable 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. Additional 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. Additional 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*).

Vertebrate Pests

Muskrats

Pest information

Damage: Muskrats dig into cranberry beds looking for succulent roots. This destroys plants and makes the bed surface uneven. They also 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.

Pest management

Cultural controls: Controlling weed populations in the bog and trapping and removing animals will reduce problems due to muskrats. Muskrats do not like crown vetch when it is planted along berms; however, this may lead to weed control issues in the bog itself.

Issues for muskrats

None identified.

Birds

Pest information

Damage: Birds feed on cranberry in the fall and also may cause damage when nesting in the bogs in the spring and early summer. Large groups of migratory birds may cause physical damage to the plants by digging for food in the bogs, and some species may nest in bogs in the spring

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. 2012 Berry Production Guide- Beneficial Management Practices for Berry Growers in British Columbia (updated 12/12/2013). Available online at: http://productionguide.agrifoodbc.ca/

Health Canada, Pest Management Regulatory Agency. *Eastern Canada Cranberry IPM Manual*. 2004. Isabelle Le Duc, France Allard and Caroline Turcotte (Catalogue Number H114-10/2004E-PDF) 142 pp. www.publications.gc.ca/pub?id=244769&sl=0

Maurice, Celine, Caroline Bedard, Sheila M. Fitzpatrick, Jim Troubridge and Deborah Henderson. December 2000. *Integrated Pest Management for Cranberries in Western Canada- A Guide to identification, monitoring and decision making for pests and diseases*. Technical Report #163. http://www.bccranberries.com/pdfs/ipm_guide.pdf

Perennia. *Cranberry Management Schedule – A guide to insect, weed and disease management in cranberries in Nova Scotia 2014*. http://perennia.ca/fruit.php

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	Mark Sweeney mark.sweeney@gov.bc.ca	Caroline Bédard caroline.bédard@gov.bc.ca
Quebec	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec www.mapaq.gouv.qc.ca	Luc Urbain Luc Urbain@mapaq.gouv.qc.ca Joseph Savard joseph.savard@mapaq.gouv.qc.cq	Luc Urbain luc.urbain@mapaq.gouv.qc.ca
New Brunswick	New Brunswick Department of Agriculture, Aquaculture and Fisheries http://www2.gnb.ca/content/gnb/en/departments/10.html	Roger Tremblay roger.tremblay@gnb.ca	Gavin Graham gavin.graham@gnb.ca

National and Provincial Grower Organizations

British Columbia Cranberry Growers Association
www.bccranberrygrowers.com

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

Canneberges NB Cranberries
www.nbcranberries.com

L'association des producteurs de canneberges du Québec
www.producteurscanneberge.com

Nova Scotia Cranberry Growers Association www.nscranberry.ca/

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

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

<table>
<tr><th>Presence</th><th colspan="4">Occurrence information</th><th>Colour Code</th></tr>
<tr><td rowspan="12">Present</td><td rowspan="10">Data available</td><th>Frequency</th><th>Distribution</th><th>Pressure</th><td></td></tr>
<tr><td rowspan="6">Yearly - Pest is present 2 or more years out of 3 in a given region of the province.</td><td rowspan="3">Widespread - The pest population is generally distributed throughout crop growing regions of the province. In a given year, outbreaks may occur in any region.</td><td>High - If present, potential for spread and crop loss is high and controls must be implemented even for small populations.</td><td>Red</td></tr>
<tr><td>Moderate - If present, potential for spread and crop loss is moderate: pest situation must be monitored and controls may be implemented.</td><td>Orange</td></tr>
<tr><td>Low - If present, the pest causes low or negligible crop damage and controls need not be implemented.</td><td>Yellow</td></tr>
<tr><td rowspan="3">Localized - The pest is established as localized populations and is found only in scattered or limited areas of the province.</td><td>High - see above</td><td>Orange</td></tr>
<tr><td>Moderate - see above</td><td>White</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="6">Sporadic - Pest is present 1 year out of 3 in a given region of the province.</td><td rowspan="3">Widespread - as above</td><td>High - see above</td><td>Orange</td></tr>
<tr><td>Moderate - see above</td><td>Yellow</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="3">Localized - as above</td><td>High - see above</td><td>Yellow</td></tr>
<tr><td>Moderate -see above</td><td>White</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="2">Data not available</td><td colspan="3">Not of concern: The pest is present in commercial crop growing areas of the province but is causing no significant damage. Little is known about its population distribution and frequency in this province; however, it is not of concern.</td><td>White</td></tr>
<tr><td colspan="3">Is of concern: The pest is present in commercial crop growing areas of the province. Little is known about its population distribution and frequency of outbreaks in this province and due to its potential to cause economic damage, is of concern.</td><td></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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British Columbia Ministry of Agriculture. Berries Production Guide: Cranberries. http://productionguide.agrifoodbc.ca/guides/14/section/25/chapter/

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

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Health Canada, Pest Management Regulatory Agency. *Regulatory Directive DIR98-02, Residue Chemistry Guidelines*. 1998. www.hc-sc.gc.ca/cps-spc/pest/index-eng.php

Health Canada, Pest Management Regulatory Agency. Regulatory Directive DIR99-06 Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action. www.pmra-arla.gc.ca/english/pdf/dir/dir9906-e.pdf

Health Canada, Pest Management Regulatory Agency. *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

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

University of Massachusetts Amherst, Cranberry Station. *Cranberry 1999 Chart Book. Management Guide for Massachusetts*. April 1999.