Crop Profile for Lowbush Blueberry in Canada, 2017

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Preface

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

Information on pest management practices and pesticides is provided for information purposes only. No endorsement of any pesticide or pest control technique here 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 lowbush blueberry, 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.

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The lowbush blueberry is a perennial, native fruit that grows in treeless barrens, fields and burned-over areas of north-eastern North America. It is a member of the Ericaceae or Heath family. The crop is unique in that it is not planted, but is harvested from managed, wild stands, unlike the highbush blueberry that is planted and maintained in an orchard. Harvested lowbush blueberry species include *Vaccinium angustifolium,* which comprises most of the harvested lowbush blueberry in Canada, and the velvet leaf blueberry, *V. myrtilloides.* There are no different cultivars within these two species.

Lowbush blueberries were harvested by native peoples before European settlers arrived in North America. Some native peoples encouraged blueberry growth by periodically burning blueberry fields. Early settlers in the Atlantic Provinces harvested the fruit for their own use or for local distribution. Markets expanded following improvements in marketing and shipping and the establishment of canneries in Maine and along Canada's border with the United States in the mid-1800's. Improved harvesting methods and management resulted in an expansion of production throughout the 20^{th} century. Since the 1980s, production has increased dramatically because of advancements in management including improved weed control and the increased use of bees for pollination.

Lowbush blueberry fruit is rich in antioxidant compounds that fight free radicals associated with cancer, heart disease and premature aging and which may be protective against metabolic syndrome and diabetes. These small berries, considered now as 'super fruits' are also high in Vitamins A and C, minerals and fibre. Most of the lowbush blueberry crop is sent to processing plants to be frozen using "Individually Quick Freezing (IQF)" technology. The berries may then be sold frozen or further processed into products such as pies, yogurt, ice cream, jams, juices and syrup.

Crop Production

Industry Overview

Blueberries rank as the number one fruit crop in Canada with respect to area under production. Canada is a major producer and exporter of blueberries in the world. Canada exported $410 million worth of blueberries in 2017 (Table 1). The United States, Japan and Germany are the top markets for Canada's exports. Frozen lowbush blueberries made up 48% of Canada's blueberry exports in 2016. Blueberry-containing products grew worldwide at an average rate of 17% from 2007 to 2016.

Lowbush blueberry had a farm gate value of $47.5 million in 2017 which comprised 23% of the total farm gate value of all blueberries produced in Canada.

Table 1. General production information, 2017

	Lowbush blueberry
Canadian production[1]	95,203 metric tonnes 67,384 hectares
Farm gate value[1]: **Lowbush blueberry** **Total blueberries[2]**	$47.4 Million (23%) $203.4 Million
Fruit consumption[2,3]	1.1 kg/ person (fresh) 1.43 kg/ person (processed)
Total exports[2,4]	$409.6 Million (fresh and processed)
Total imports[2,4]	$282.4 Million (fresh and processed)

[1] Source: Statistics Canada. Table 32-10-0364-01 (formerly CANSIM 001-0009) - Area, production and farm gate value of fresh and processed fruits, by province (database accessed: 2019-02-11).

[2] Includes both lowbush and highbush blueberries.

[3] Source: Statistics Canada. Table 32-10-0054-01 (formerly CANSIM 002-0011) - Food available in Canada (database accessed: 2019-02-11).

[4]Source: Statistics Canada. CATSNET, March 2018.

Production Regions

Lowbush blueberries are produced commercially in eastern Canada, in the provinces of Nova Scotia, New Brunswick, Prince Edward Island, and Quebec. Most of lowbush blueberry production is located in the Atlantic provinces and in Quebec (Table 2).

Table 2. Distribution of total production in Canada, 2017

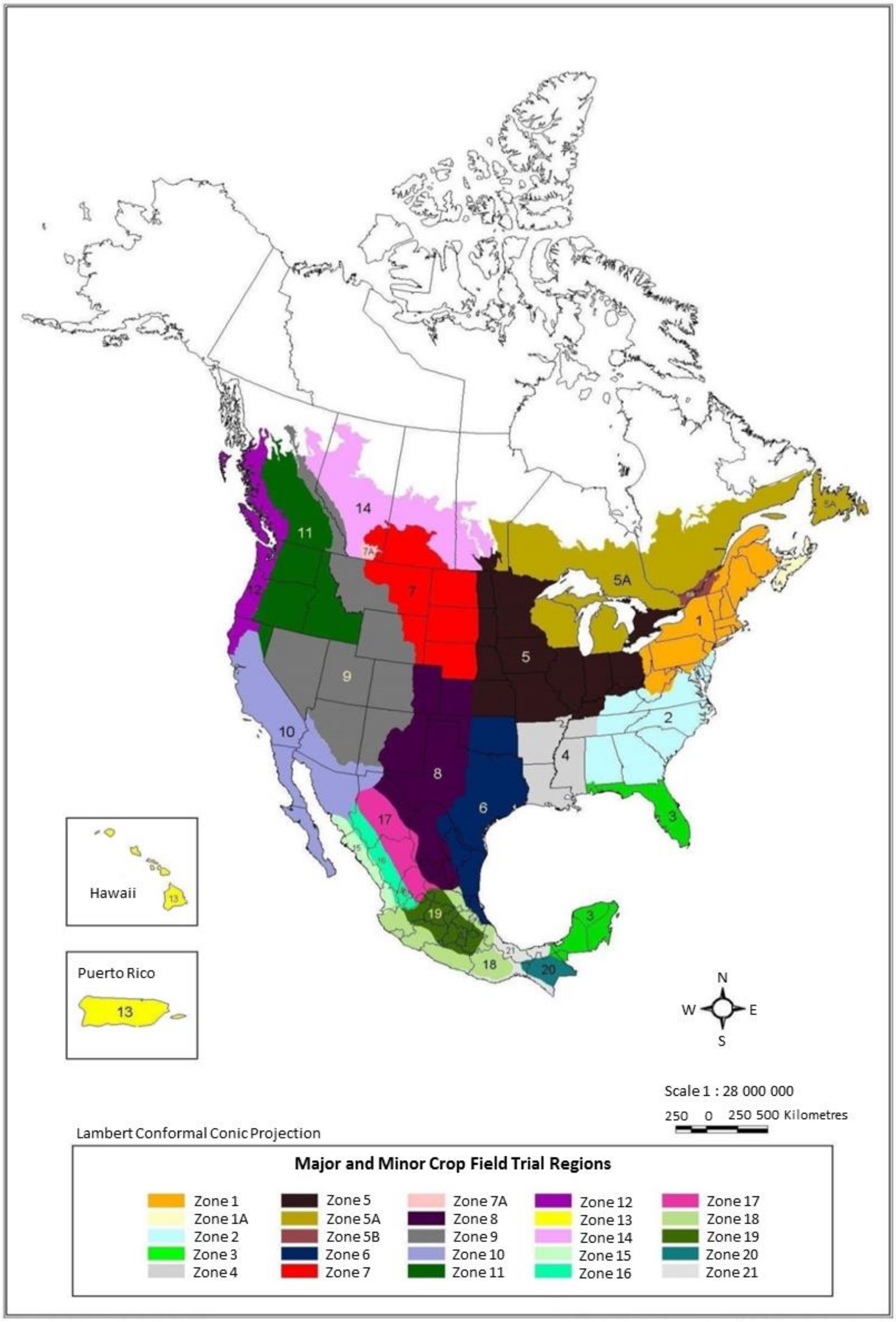
Production Regions	Cultivated area[1] (hectares) and percentage ( )	Marketed production[1] (metric tonnes)	Farm gate value[1] ($)
	Lowbush Blueberry		
Quebec	29,275 ha (43%)	35,578 m. t.	$18.1 Million
New Brunswick	16,681 ha (25%)	26,784 m. t.	$12.9 Million
Nova Scotia	15,514 ha (23%)	21,982 m. t.	$10.7 Million
Prince Edward Island	5,424 ha (8%)	10,658 m. t.	$5.3 Million
Canada	**67,384 ha**	**95,203 m. t.**	**$47.4 Million**

[1] Source: Statistics Canada. Table 32-10-0364-01 (formerly CANSIM 001-0009)-Area, production and farm gate value of fresh and processed fruits, by province (database accessed: 2019-02-11).

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

The major and minor crop field trial regions 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

Lowbush blueberries are a perennial, native growing crop. The plants grow in areas of sandy, gravelly, well-drained soils with an optimum soil acidity level of 4.3 to 5.0. The blueberry bush spreads vegetatively through slow-growing, underground stems called rhizomes which produce roots and shoots. An individual plant along with its system of rhizomes, shoots and roots, is called a “clone”. In managed fields, rhizomes have been found to spread as much as 38 cm in one season.

Pollination is an important component of lowbush blueberry production. The presence of windbreaks in blueberry fields will improve the effectiveness of insect pollinators, resulting in improved fruit set. Pesticide selection is done in such a way as to avoid killing pollinators necessary for fruit production and natural insect predators which are essential to lower production costs.

Blueberries grow best in undisturbed ground, so producers manage fields without cultivation, by pruning, fertilizing, and controlling weeds, insects and diseases. Pruning by mowing or burning encourages the growth of vigorous new stems from underground rhizomes and increases flower bud set. Generally, blueberry fields are completely pruned every two years. Blueberries have a competitive advantage during re-growth due to their extensive root system, as well as increasing the number of flower buds present. The crop is usually pruned after harvest, late in the fall or in the early spring and then allowed to re-grow during the non-crop “sprout” year. Flower buds are set in the fall of the sprout year. The crop bears fruit the following year or “crop year”. Only half of the acreage is harvested in any one year.

Most of the crop is mechanically harvested (up to 80 percent in some areas. Fields in rough terrain and in forested areas are still harvested by hand-raking.

The following (Table 3) describes typical production practices and worker activities for lowbush blueberry throughout the seasons.

Table 3. Lowbush blueberry production and pest management schedule in Canada

Time of Year	Activity	Action
April	Plant care	Pruning by flail mowing or burning; application of pre-emergence fertilizer (PEI) during sprout year (SY)
	Weed management	Pruning by flail mowing or burning; application of pre-emergent herbicides and of pre-emergent sulfur in PE (SY)
	Insect Control	Use sweep net to sample for spanworm larvae (PE); apply control measures if counts exceed threshold during crop year (**CY**)
May	Plant care	Pollination (CY) and fertilization (SY)
	Disease management	Monitoring and spraying, if necessary (CY)
	Insect and mite management	Monitoring and spraying, if necessary (CY, SY)
	Weed management	Application of pre-emergent herbicides (SY)
June	Plant care	Pollination (CY) and fertilization (SY); foliar nutrients (SY, CY); beehive removal from fields after bloom (NS)
	Disease management	Monitoring and spraying if necessary (CY)
	Insect and mite management	Monitoring and spraying if necessary (CY, SY)
	Weed management	Application of post-emergent herbicides and spot applications, if necessary (CY, SY)
July	Plant care	Leaf tissue sampling () (SY); foliar nutrients (NS) (SY, CY)
	Soil care	Soil sampling (same time as leaf sampling) (SY)
	Disease management	Monitoring and spraying if necessary (SY)
	Insect and mite management	Monitoring and spraying if necessary (CY)
	Weed management	Spot herbicide applications (i.e. Round-Up) and physical control options (SY)
August	Plant care	Harvest (prune later in season or in spring) (CY) ; leaf tissue sampling () (SY)
	Soil care	Soil sampling done at the same time as leaf sampling (SY)
	Disease management	Monitoring and spraying if necessary, in NB (SY)
	Insect and mite management	Limited activity
	Weed management	Monitoring and herbicide spraying, if necessary (CY, SY) for NB; wipe-on selective post-emergence herbicides on weeds taller than blueberry plants (PE)
September	Plant care	Limited activity
	Soil care	Soil sampling (SY)
	Disease management	Disease management (SY)
	Insect and mite management	Limited activity
	Weed management	Focused weed specific herbicide treatments (SY, CY)

…continued

Table 3. Lowbush blueberry production and pest management schedule in Canada (continued)

Time of Year	Activity	Action
October	Plant care	Pruning post-harvest (CY)
	Soil care	Mulching post-harvest (CY)
	Disease management	Limited activity
	Insect and mite management	Limited activity
	Weed management	Use of fall burn-down herbicides post-harvest (CY)
November	Plant care	Pruning post-harvest (CY)
	Soil care	Limited activity
	Disease management	Limited activity
	Insect and mite management	Limited activity
	Weed management	Use of fall burn down herbicides; post-harvest (CY), fall grass controls for fescue (CY, SY)

Abiotic Factors Limiting Production

Pollination

Pollination is critical for successful blueberry production. Poor pollination may result from adverse weather conditions or low numbers of pollinators. Many native bee species pollinate lowbush blueberries. However, during most years, growers use managed pollinators (e.g. honeybees, alfalfa leaf cutter bees) to maximize pollination.

Temperature extremes

Frost and cold temperatures during bloom (June) and prior to harvest later in the summer, can cause yield losses. During winter and spring, upper parts of plants can become desiccated due to cold temperatures, drying winds and insufficient snow cover. Windbreaks can be planted and snow fencing can be used to reduce wind and keep snow from blowing off fields. Dry, hot conditions in the summer can affect fruit quality and reduce yields by as much as 50 percent.

Diseases

Key issues

- There is a need for the development of products suitable for use in organic production, including biological pesticides, for the management of a number of diseases in lowbush blueberry.
- There is a need for greater understanding of the yield impact of foliar diseases and the mitigating effects of cultural practices such as pruning and fertilization on lowbush blueberry.
- It is critical that pre-harvest intervals of all new product registrations be set so as to enable the crop to meet Maximum Residue Limits (MRLs) for export as well as domestic markets, to ensure the marketability of the crop.
- There is a need to determine the effects of long-term fungicide use on beneficial soil micro-organisms, particularly mycorrhizae, which play an important role in nutrient absorption in lowbush blueberry.
- A protocol for equipment sanitization is required for transfer to industry to help growers reduce the spread of pathogens between fields.

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

Disease	Quebec	New Brunswick	Nova Scotia	Prince Edward Island
Botrytis blight				
Canker diseases				
Godronia canker				
Leaf spot complex				
Leaf rust				
Septoria leaf spot				
Valdensinia leaf spot				
Monilinia blight				
Powdery mildew				
Red leaf				
Exobasidium leaf and fruit spot				
Witches' broom				
Widespread yearly occurrence with high pest pressure.				
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.				
Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pest pressure.				
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.				
Pest is present and of concern, however little is known of its distribution, frequency and pressure.				
Pest not present.				
Data not reported.				

[1]Source: Lowbush blueberry stakeholders in reporting provinces (Quebec, New Brunswick, Nova Scotia and Prince Edward Island); the data reflect the 2017, 2016 and 2015 production years.

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

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

Practice / Pest		Botrytis blight	Monilinia blight	Septoria leaf spot	Valdensinia leaf spot	Leaf rust
Avoidance	Varietal selection / use of resistant varieties					
	Planting/ harvest date adjustment					
	Rotation with non-host crops					
	Choice of planting site					
	Optimizing fertilization for balanced growth and to minimize stress					
	Minimizing wounding and insect damage to limit infection sites					
	Use of disease-free propagative materials (seed, cuttings or transplants)					
Prevention	Equipment sanitation					
	Canopy management (thinning, pruning, row or plant spacing, etc.)					
	Manipulating seeding / planting depth					
	Irrigation management (timing, duration, amount) to minimize disease infection periods and manage plant growth					
	Management of soil moisture (improvements in drainage, use of raised beds, hilling, mounds, etc.)					
	End of season or pre-planting crop residue removal / management					
	Pruning out / removal of infected material throughout the growing season					
	Removal of other hosts (weeds / volunteers / wild plants) in field and vicinity					
Monitoring	Scouting / spore trapping					
	Maintaining records to track diseases					
	Soil analysis for the presence of pathogens					
	Weather monitoring for disease forecasting					
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of diseases					

…continued

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

Practice / Pest		Botrytis blight	Monilinia blight	Septoria leaf spot	Valdensinia leaf spot	Leaf rust
Decision making tools	Economic threshold	Used	Used	Used	Used	Used
	Use of predictive model for management decisions	Used	Used	Not used	Not used	Not used
	Crop specialist recommendation or advisory bulletin	Used	Used	Used	Used	Used
	Decision to treat based on observed disease symptoms	Used	Used	Used	Used	Used
	Use of portable electronic devices in the field to access pathogen / disease identification / management information	Used	Used	Used	Used	Used
Suppression	Use of diverse product modes of action for resistance management	Used	Used	Used	Used	Used
	Soil amendments and green manuring involving soil incorporation as biofumigants to reduce pathogen populations	Not used	Not used	Not used	Not used	Not used
	Bio-pesticides (microbial and non-conventional pesticides)	Used	Used	Used	Not used	Used
	Controlled atmosphere storage	Not used	Not used	Not used	Not used	Not used
	Targeted pesticide applications (banding, spot treatments, use of variable rate sprayers, etc.)	Used	Used	Used	Used	Used
	Selection of pesticides that are soft on beneficial insects, pollinators and other non-target organisms	Used	Used	Used	Used	Used
Crop specific practices	Pruning by mowing or burning	Used	Used	Used	Used	Used
	Sickle bar mowing pre-burn treatment	Used	Used	Used	Used	Not used

This practice is used to manage this pest by at least some growers. (green)
This practice is not used by growers to manage this pest. (red)
This practice is not applicable for the management of this pest. (white)
Information regarding the practice for this pest is unknown. (grey)

[1]Source: Lowbush blueberry stakeholders in reporting provinces (Quebec, New Brunswick, Nova Scotia and Prince Edward Island); the data reflect the 2017, 2016 and 2015 production years.

Botrytis Blight (*Botrytis cinerea*)

Pest Information

Damage: Botrytis blight, also known as grey mould can be a serious problem during prolonged wet conditions. Blossoms, fruit and leaves may be affected. Affected leaves turn brown and entire flower clusters may become blighted. Under humid conditions, infected tissues can become covered with grey mould. Frost and herbicide damage increase the susceptibility of the weeds and the blueberry bushes to the disease. Botrytis blight can also develop during storage if fruit is contaminated or mis-handled at harvest. Postharvest losses can result if diseased and injured berries are stored together.

Life cycle: The fungus overwinters on infected weeds. In the spring the pathogen produces spores that are blown by wind to blueberry blossoms, which they infect, and in which new spore production occurs.. Spores produced blossoms are blown by wind to other susceptible tissues where they cause new infections. The number of disease cycles and the severity of infection is associated with the frequency of cool, wet periods during bloom and shortly thereafter. Early-blooming blueberry clones are the first to be infected and they are the source of spores for later flowering clones.

Pest Management

Cultural controls: Pruning by burning every second or third crop cycle may reduce some overwintering inoculum of *B. cinerea*. The control of weeds in and around blueberry fields will eliminate the overwintering sources of disease. Potential host weeds include bunchberry, sheep sorrel, goldenrod, pearly everlasting, *Potentilla* spp. and some grasses. Monitoring of early flowering clones for infections of *B. cinerea* helps to determine if sprays are necessary. Modified atmosphere packaging, , following rapid removal of field heat from the fruit after harvest can reduce the growth of grey mould rot in storage. Additional management practices for botrytis blight are listed in *Table 5. Adoption of disease management practices in lowbush blueberry production in Canada.*

Issues for Botrytis Blight

1. The development of biological products or low residue products that are safe for pollinators is required for the management of botrytis blight.
2. Further investigation is required to establish the potential for novel application methods such as bee vectoring of biological fungicides for the management of botrytis blight.
3. The development of a forecasting model to improve timing of treatments for botrytis blight would be of benefit to growers.

Godronia (Fusicoccum) Canker (*Fusicoccum putrefaciens*)

Pest Information

Damage: The fungus only infects new wood. Infected branches are killed, reducing lowbush blueberry yields.

Life cycle: The fungus overwinters as mycelium in living stems and crowns. Pycnidia (fungal spore producing bodies) develop in cankers and release spores during rainy periods. Lesions develop at leaf scars and in the axils of buds and eventually girdle stems, causing wilting and death. Most infections occur in spring and fall.

Pest Management

Cultural controls: Practices for godronia canker include pruning-out and destroying infected branches. Pruning will also promote good air movement around plants and facilitate foliar drying.

Issues for Godronia Canker

None identified.

Leaf Rust (*Naohidemyces vaccinii*)

Pest Information

Damage: Severe outbreaks of leaf rust can cause extensive defoliation in sprout (non-fruiting) fields. Infected leaves develop small, reddish spots on the upper leaf surface that may coalesce into larger spots. Small, water-soaked spots appear on the lower leaf surface, with yellow-orange pustules of spores appearing in these lesions. Premature defoliation from rust impacts fruit bud development and is of greatest concern when it occurs in sprout fields. Leaves begin to fall in response to rust infection in late summer and early fall and is most important in sprout fields.

Life cycle: Leaf rust produces a number of different spore types and requires two hosts to complete its life cycle. In the spring, aeciospores produced on eastern hemlock needles, are wind-blown to lowbush blueberry fields where they infect new foliage. Rust pustules develop in leaf lesions by mid-season and release urediniospores that can re-infect blueberry leaves. The pathogen overwinters as teliospores (dormant spores) in leaf lesions on blueberry plants; these germinate in spring producing basidiospores that re-infect hemlock.

Pest Management

Cultural controls: Burn pruning of blueberry fields is beneficial to reduce inoculum source, and removing nearby hemlock trees, the secondary host is also a good practice to reduce disease pressure. Over fertilization may increase leaves' susceptibility to leaf rust. Additional management practices for leaf rust blight are listed in *Table 5. Adoption of disease management practices in lowbush blueberry production in Canada.*

Issues for Leaf Rust

1. There is a need for improved understanding of the yield impact of leaf rust and the mitigating effects of cultural practices such as pruning and adjustment of fertilisation.
2. There is a need for the development of an integrated approach to the management of leaf rust. The development of a forecasting model based on rust levels on secondary hosts would allow the improved timing of rust control treatments.

Monilinia Blight or Mummy Berry (*Monilinia vaccinii-corymbosi*)

Pest Information

Damage: The development of monilinia blight or mummy berry disease is favoured by extended wet periods. The fungus infects blossoms, leaves and fruits, resulting in foliar wilting and shrivelling of flower clusters. Infected fruit shrivel and harden several weeks before harvest, becoming black fungal masses known as ‘mummy berries’.

Life cycle: The fungus overwinters in mummy berries and can survive for many years. During bud break, mummy berries give rise to apothecia, structures that release ascospores. Under cool and wet conditions, these spores infect the vegetative and floral buds, with disease symptoms appearing in 10 to 20 days. Exposure to frost increases the susceptibility of buds to infection. Conidia are produced on diseased shoots that germinate and grow near flowers and infect maturing berries. Fruits developing from infected blossoms remain symptom-less until they are almost mature, at which time they drop to the ground as mummy berries and the fungus completes its life cycle.

Pest Management

Cultural controls: Pruning by intense burning helps destroy mummy berries. Measures to improve drainage and air circulation in a field can also help reduce the susceptibility of lowbush blueberry plants to monilinia blight. Spreading a mulch of straw or wood chips, can help to prevent the spread of monilinia blight by covering the mummy berries. A management strategy that improves drainage and air flows can also help to prevent this disease. Additional management practices for monilinia blight are listed in *Table 5. Adoption of disease management practices in lowbush blueberry production in Canada.*

Issues for Monilinia Blight

1. Fine-tuning of existing monitoring models is needed to allow for field specific forecasting.
2. New fungicides from classes other than the demethylation inhibitors (DMI’s) are required for the management of monilinia blight and as fungicide resistance management tools. The availability of effective biopesticides would be of great benefit to the industry to help respond to market demands.

3. Newly registered products must have maximum residue limits (MRLs) established which are acceptable for key export markets (European Union, Asia), as well as domestic markets.

Powdery Mildew (*Microsphaera vaccinii*)

Pest Information

Damage: Powdery mildew may cause premature leaf drop in both fruiting and sprout fields. Some clones show irregular, reddish patches on the leaves, while others show abundant, white, mycelial growth. Early leaf drop may cause poor fruit bud development in sprouts and reduced yields in crop fields.

Life cycle: The fungus overwinters in infected tissues. First symptoms appear in early July, resulting from infections that took place two to three weeks previously. Spores (conidia) are produced within the white mycelia on the leaf surfaces and are spread by wind to new tissues throughout the growing season. Powdery mildew tends to be more serious in fields on light, sandy and gravelly soils and during hot, dry summers. Phosphorous deficiency may increase powdery mildew severity.

Pest Management

Cultural controls: The susceptibility of lowbush blueberry clones may vary.

Issues for Powdery Mildew

None identified.

Red Leaf (*Exobasidium vacinii*)

Pest Information

Damage: Plants infected with red leaf develop conspicuous red foliage in June and July. The pathogen grows systemically throughout the plant and reduces plant vigour and yield. Infected plants may fail to flower and do not produce much fruit. By midsummer, infected leaves drop and the disease becomes inconspicuous. Symptoms reappear on the same plants each year until the plants weaken and die.

Life cycle: The fungus overwinters in the shoots and rhizomes of blueberry plants, infecting new sprouts as they arise from the mother plant. Infected leaves turn red and the fungus develops spore-bearing structures on their lower surface. The role of the spores in spreading the disease is unknown. It is assumed that spore-mediated field infections occur only under extended wet conditions.

Pest Management

Cultural controls: The practice of burn pruning or burying mowed prunings does not control rhizome infections as plants are systemically invaded by the pathogen. However, it may destroy new infections in the shoots that have not yet progressed into the rhizome.

Issues for Red Leaf

1. The industry-wide impact of this disease is minor, but yield reduction does occur in some production regions. Further studies on the biology, yield impact and effective management, including potential benefits of improved soil nutrition, are required. Monitoring of this disease to track its severity and occurrence is also required.
2. More information is needed on the potential of fungicides to control red leaf.

Septoria Leaf Spot (*Septoria* spp.)

Pest Information

Damage: Symptoms of septoria leaf spot develop on the lower leaf surface and appear as small water-soaked lesions similar to early rust symptoms. The lesions later coalesce to produce irregular, brown blotches. Septoria leaf spot may cause defoliation in both crop and sprout fields. This may affect fruit bud development in the sprout year and reduce yield in the crop year.

Life cycle: The fungus overwinters on infected leaves and twigs. In the spring and early summer, infected litter from the previous year can cause the development of lesions on lower stem portions. Spores are released from late spring to early summer and rain splashing of spores contributes to the next infection cycle. Infected leaves drop prematurely in August and secondary infection can start on dead leaves. The severity of septoria leaf spot depends on the number of wet periods in a growing season.

Pest Management

Cultural controls: Pruning by intensive burning or mowing reduce the inoculum source during the non-fruiting year of a biennial production cycle. Additional management practices for septoria leaf spot are listed in *Table 5. Adoption of disease management practices in lowbush blueberry production in Canada.*

Issues for Septoria Leaf Spot

1. Further studies are required to establish the yield impact of septoria leafspot and the efficacy and economic value of practices, including burning and chemical treatments, for the management of this disease.
2. The development of a reduced input management approach that includes biological and other organic products is required for septoria leafspot.

Valdensinia Leaf Spot (*Valdensinia heterodoxa*)

Pest Information

Damage: Valdensinia leaf spot causes the development of large, reddish-brown circular spots on foliage. Infected leaves drop soon after symptom development. This disease may cause severe defoliation in both crop (fruit) and sprout fields during very wet years.

Life cycle: The fungus overwinters as sclerotia (resting bodies) in infected leaves. In the spring, large spores (conidia) are produced on the sclerotia. After two to three days of high wetness, spores are released and infect leaves causing large lesions. Another generation of spores is produced after another period (one to two days) of wetness and spread in the foliage canopy where they cause new infections. The fungus can readily spread from field to field on equipment, footwear, etc. Other hosts of the valdensinia fungus include wild raspberry, birch saplings, bunchberry, maple saplings and wild strawberry.

Pest Management

Cultural controls: Cleaning equipment and boots between fields will help reduce spread. Cleaning and sanitizing boxes and bins used during harvest before re-use will help to limit the spread of the pathogen. If infection is on a small scale, pruning by burning with a hand held weed burner under dry conditions will reduce inoculum during a sprout year. Avoiding over fertilisation will help to reduce susceptibility of foliage to the pathogen. Additional management practices for valdensinia leaf spot are listed in *Table 5. Adoption of disease management practices in lowbush blueberry production in Canada.*

Issues for Valdensinia Leaf Spot

1. Further studies are required on the impact of production practices such as fertilization and pruning by mowing on the incidence and spread of valdensinia leaf spot.
2. The registration of control products that can be used in alternate years to burning (pruning) is required for the management of valdensinia leaf spot.
3. Further information is required by growers on the identification and management of this disease.

Exobasidium Fruit and Leaf Spot (*Exobasidium* spp.)

Pest Information

Damage: Exobasidium fruit and leaf spot is an emerging disease of lowbush blueberry that has the potential to reduce yield and quality of the fruit. The pathogen causes round, white to pale green spots on the leaves and fruit. Infected berries become unmarketable.

Life cycle: Little is known about the life cycle of this pathogen in lowbush blueberry in Eastern Canada.

Pest Management

Cultural controls: None identified

Issues for Exobasidium Leaf and Fruit Spot

1. Work is required to determine the life cycle of the pathogen, impact of the disease and control options in the lowbush blueberry production cycle,

Witches' Broom (*Pucciniastrum goeppertianum*)

Pest Information

Damage: Plants infected with witch's broom develop broom-like masses of shoots with few or no leaves, and which do not produce fruit. Symptoms appear the year following infection and persist for many years.

Life cycle: The witches' broom fungus has a complex life cycle, similar to the leaf rust fungus. Its alternate host is the balsam fir (rather than the eastern hemlock which is the alternate host for leaf rust fungus). From mid-May to late June, rust spores develop on infected shoots and germinate to produce another type of spore (basidiospore). These spores are carried by wind to balsam fir where they attack young needles where aeciospores are produced. Aeciospores are carried by wind back to blueberry plants where they cause new infections, stimulating the production of lateral buds that develop into the characteristic, broom-like swollen shoots. Finally, teliospores are formed on the swollen, broom-like shoots of blueberry plants and overwinter there. The brooms are perennial and produce new growth each spring, serving as sources of the fungus for many years.

Pest Management

Cultural controls: Because infections are systemic and remain present in rhizomes, burning or flail mowing will not control this disease. Infected plants are removed to eliminate this source of inoculum. Removal of the alternate host (balsam fir) within 400 to500 metres of blueberry fields may break the disease cycle, but often may not be practical.

Issues for Witches' Broom

None identified.

Fungicides, bactericides and biofungicides registered in Canada for disease management in lowbush blueberry production

Active ingredients registered for the management of **diseases** in lowbush blueberry are listed below in Table 6 *Fungicides, bactericides and biofungicides registered for disease management in lowbush blueberry production in Canada*. This table also provides registration numbers for **products registered on lowbush blueberry as of December 12, 2018** for each active ingredient, in addition to information about chemical family and re-evaluation status. For guidance about active ingredients registered for specific **diseases**, the reader is referred to individual product labels available on the PMRA label database https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management.html and to provincial crop production guides.

Table 6. Fungicides, bactericides and biofungicides registered for disease management in lowbush blueberry in Canada

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
Agrobacterium radiobacter	21106	biological	N/A	unknown	unknown	R
Aureobasidium pullulans DSM 14940 and DSM 14941	31248	biological	N/A	unknown	unknown	R
Bacillus subtilis strain QST 713	28549, 31666, 33035	microbial: *Bacillus* spp. and the fungicidal lipopeptides they produce	44	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	R
Streptomyces lydicus strain WYEC 108	28672	biological	N/A	unknown	unknown	R
azoxystrobin + propiconazole	28328, 32878	methoxy-acrylate + triazole	11 + 3	C3: respiration + G1: sterol biosynthesis in membranes	complex III: cytochrome bc1 (ubiquinol oxidase) at Q0site (cyt b gene)C14- demethylase in sterol biosynthesis (erg11/cyp51)	R + R
benzovindiflupyr	31522, 31981	pyrazole-4- carboxamide	7	C2: respiration	complex II: succinate dehydrogenase	R
boscalid	30141	pyridine-carboxamide	7	C2: respiration	complex II: succinate-dehydrogenase	R

...continued

Table 6. Fungicides, bactericides and biofungicides registered for disease management in lowbush blueberry in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
Boscalid + pyraclostrobin	27985	pyridine-carboxamide + methoxy-carbamate	7 + 11	C2: respiration + C3: respiration	complex II: succinate-dehydrogenase + complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	R + R
canola oil	32408, 32819	diverse	N/C	not classified	unknown	R
captan	4559, 9582, 23691, 24613, 26408, 31949	phthalimide (electrophile)	M04	multi-site contact activity	multi-site contact activity	R (RVD2018-12)
chlorothalonil	28900, 29225, 29306, 29355, 29356	chloronitrile (phthalonit+C41:O41rile)	M05	multi-site contact activity	multi-site contact activity	R (RVD2018-11)
copper octanoate	31825	inorganic (electrophile)	M01	multi-site contact activity	multi-site contact activity	R
cyprodinil + difenoconazole	30827	anilino-pyrimidine + triazole	9 + 3	D1: amino acids and protein synthesis + G1:sterol biosynthesis in membranes	methionine biosynthesis (proposed) (cgs gene) + C14-demethylase in sterol biosynthesis (erg11/cyp51)	RE + RE

...continued

Table 6. Fungicides, bactericides and biofungicides registered for disease management in lowbush blueberry in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
cyprodinil + fludioxonil	28189, 30185	anilino-pyrimidine + phenylpyrrole	9 + 12	D1: amino acids and protein synthesis + E2: signal transduction	methionine biosynthesis (proposed) (cgs gene) + MAP/histidine-kinase in osmotic signal transduction (os-2, HoG1)	RE + R (RVD2018-04)
fenhexamid	25900	hydroxyanilide	17	G3: sterol biosynthesis in membranes	3-keto reductase, C4-demethylation (erg27)	RE
ferbam	2,013,620,536	dithiocarbamate and relatives (electrophile)	M03	multi-site contact activity	multi-site contact activity	PO (RVD2018-37)
fluazinam	27517	2,6-dinitro-aniline	29	C5: respiration	uncouplers of oxidative phosphorylation	R
fluopyram	30509, 32108	pyridinyl-ethyl-benzamide	7	C2: respiration	complex II: succinate-dehydrogenase	R
fluopyram + pyrimethanil	30510	pyridinyl-ethyl-benzamide + anilino-pyrimidine	7 + 9	C2: respiration + D1: amino acid and protein synthesis	complex II: succinate-dehydrogenase + methionine biosynthesis (proposed) (cgs gene)	R + R
fluxapyroxad	30565, 31697	pyrazole-4-carboxamide	7	C2: respiration	complex II: succinate-dehydrogenase	R
hydrogen peroxide + peroxyacetic acid	32907	inorganic	N/A	unknown	unknown	R (RVD2018-09, RVD 2018-10)
isofetamid	31555, 31758	phenyl-oxo-ethyl thiophene amide	7	C2: respiration	complex II: succinate-dehydrogenase	R

…continued

Table 6. Fungicides, bactericides and biofungicides registered for disease management in lowbush blueberry in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
mandestrobin	32286, 32288	methoxy-acetamide	11	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	R
metconazole	30401, 30402, 33081	triazole	3	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	R
methyl bromide	9564, 19498	alky halide[4]	8A[4]	miscellaneous non-specific (multi-site) inhibitor[4]	miscellaneous non-specific (multi-site) inhibitor[4]	PO[5]
mineral oil	33099	diverse	N/C	not classified	unknown	R
myclobutanil	22399	triazole	3	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	R
oriental mustard seed meal (oil) (*Brassica juncea*)	30263	diverse	N/C	not classified	unknown	R
penthiopyrad	30331	pyrazole-4-carboxamide	7	C2: respiration	complex II: succinate-dehydrogenase	R
phosphites (mono and dibasic sodium, potassium and ammonium phosphite)	30449	not classified	N/A	unknown	unknown	R
phosphorous acid (mono and di-potassium salts of phosphorous acid	30648, 30650	ethyl phosphonate	P07	P7: host plant defence induction	phosphonate	R

…continued

Table 6. Fungicides, bactericides and biofungicides registered for disease management in lowbush blueberry in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	**Chemical Group**[2]	**Resistance Group**[2]	**Mode of Action**[2]	**Target Site**[2]	**Re-evaluation Status (Re-evaluation Decision Document)**[3]
polyoxin D zinc salt	32688, 32918	polyoxin	19	H4: cell wall biosynthesis	H4: chitin synthase	R
propiconazole	numerous products	triazole	3	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	R
prothioconazole	28359	triazolinthione	3	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	R
pyraclostrobin	27323	methoxy-carbamate	11	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	R
pyrimethanil	28011	anilino-pyrimidine	9	D1: amino acids and protein synthesis	methionine biosynthesis (proposed) (cgs gene)	R
tea tree oil (*Melaleuca alternifolia*)	30910	terpene hydrocarbons and terpene alcohols	46	F7: lipid synthesis and membrane integrity	cell membrane disruption (proposed)	R
thiophanate-methyl	12279, 25343, 27297, 31784, 32096	thiophanate	1	B1: cytoskeleton and motor proteins	ß-tubuline assembly in mitosis	RE

…continued

Table 6. Fungicides, bactericides and biofungicides registered for disease management in lowbush blueberry in Canada (continued)

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

[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 December 12, 2018.** While every effort has been made to ensure all fungicides, bactericides and biofungicides registered in Canada on lowbush blueberry have been included in this list, some active ingredients or products may have been inadvertently omitted. 'Numerous products' is entered where there are more than ten products for an active ingredient. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The product label is the final authority on pesticide use and should be consulted for application information. The information in this table should not be relied upon for pesticide application decisions and use.

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

[3]PMRA re-evaluation status as published in Re-evaluation Note REV2018-06 Pest Management Regulatory Agency Re-evaluation and Special Review Work Plan 2018-2023, Re-evaluation Note REV2018-17 Initiation of Cumulative Health Risk Assessment-N-Methyl Carbamates **and other re-evaluation documents**: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review. Other codes include: DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

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

[5]As published by Government of Canada: *Notice to anyone engaged in the use of methyl bromide: June 2017*. *https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/notice-use-methyl-bromide-june-2017.html*

Insects and Mites

Key issues

- Given the high potential for damage, it is important to continue to monitor for the presence of spotted wing drosophila in lowbush blueberry. Improved monitoring approaches and treatment thresholds need to be developed.
- Grower education is required on approaches to monitoring and scouting to enable improved management of a number of blueberry pests.
- There is a need for the development of alternative, integrated programs for blueberry maggot that provide comparable levels of control to conventional approaches for the management of this insect.
- There is a need for the development of an integrated approach to blueberry flea beetle management, including the development of a forecasting model and measures to be implemented in the sprout year.
- A protocol for equipment sanitization is required to help growers reduce the spread of insect pests when moving between lowbush blueberry fields.
- It is critical that pre-harvest intervals of all new product registrations be set so as to enable the crop to meet Maximum Residue Limits (MRLs) for export as well as domestic markets, to ensure the marketability of the crop.
- There is a need for the registration of reduced risk, pollinator friendly, insecticides that target common pests faced by lowbush blueberry producers.

Table 7. Occurrence of insect pests in Canadian lowbush blueberry production[1,2]

Insect and mite	Quebec	New Brunswick	Nova Scotia	Prince Edward Island
Blueberry case beetle				
Blueberry flea beetle				
Blueberry gall midge				
Blueberry tip midge				
Blueberry leaftier				
Blueberry maggot				
Spotted wing drosophila				
Blueberry sawfly				
Spanworms (general)				
Blueberry spanworm				
Blueberry stem gall wasp				
Blueberry thrips (general)				
Blueberry thrips (Catinathrips spp.)				
Blueberry thrips (Frankliniella spp.)				
Plant bugs				
Redstriped fireworm				

Widespread yearly occurrence with high pest pressure.

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

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

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

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

Pest not present.

Data not reported.

[1]Source: Lowbush blueberry stakeholders in reporting provinces (Quebec, New Brunswick, Nova Scotia and Prince Edward Island); the data reflect the 2017, 2016 and 2015 production years.

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

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

Practice / Pest		Blueberry flea beetle	Blueberry leaftier	Blueberry maggot	Blueberry spanworm	Spotted wing drosophila
Avoidance	Varietal selection / use of resistant or tolerant varieties					
	Planting/ harvest date adjustment					
	Rotation with non-host crops					
	Choice of planting site					
	Optimizing fertilization for balanced growth					
	Minimizing wounding to reduce attractiveness to pests					
	Reducing pest populations at field perimeters					
	Use of physical barriers (e.g. mulches, netting, floating row covers)					
	Use of pest-free propagative materials (seed, cuttings or transplants)					

…continued

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

Practice / Pest		Blueberry flea beetle	Blueberry leaftier	Blueberry maggot	Blueberry spanworm	Spotted wing drosophila
Prevention	Equipment sanitation					
	Canopy management (thinning, pruning, row or plant spacing, etc.)					
	Manipulating seeding / planting depth					
	Irrigation management (timing, duration, amount) to manage plant growth					
	Management of soil moisture (improvements to drainage, use of raised beds, hilling, mounds, etc.)					
	End of season or pre-planting crop residue removal / management					
	Pruning out / removal of infested material throughout the growing season					
	Tillage / cultivation to expose soil insects					
	Removal of other hosts (weeds/ wild plants / volunteers) in field and vicinity					
Monitoring	Scouting/ trapping					
	Maintaining records to track pests					
	Soil analysis for pests					
	Weather monitoring for degree day modelling					
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of pests					

…continued

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

Practice / Pest		Blueberry flea beetle	Blueberry leaftier	Blueberry maggot	Blueberry spanworm	Spotted wing drosophila
Decision making tools	Economic threshold					
	Use of predictive model for management decisions					
	Crop specialist recommendation or advisory bulletin					
	Decision to treat based on observed presence of pest at susceptible stage of life cycle					
	Use of portable electronic devices in the field to access pest identification / management information					
Suppression	Use of diverse pesticide modes of action for resistance management					
	Soil amendments and green manuring involving soil incorporation as biofumigants, to reduce pest populations					
	Use of biopesticides (microbial and non-conventional pesticides)					
	Release of arthropod biological control agents					
	Preservation or development of habitat to conserve or augment natural controls (e.g. preserve natural areas and hedgerows, adjust crop swathing height, etc.)					
	Mating disruption through the use of pheromones					
	Mating disruption through the release of sterile insects					
	Trapping					
	Targeted pesticide applications (banding, spot treatments, use of variable rate sprayers, etc.)					
	Selection of pesticides that are soft on beneficial insects, pollinators and other non-target organisms					

…continued

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

Practice / Pest		Blueberry flea beetle	Blueberry leaftier	Blueberry maggot	Blueberry spanworm	Spotted wing drosophila
Crop specific practices	Pruning by mowing or burning					
	Monitoring in sprout / vegetative year					

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: Lowbush blueberry stakeholders in reporting provinces (Quebec, New Brunswick, Nova Scotia and Prince Edward Island); the data reflect the 2017, 2016 and 2015 production years.

Blueberry Case Beetle (*Neochlamisus cribripennis*)

Pest Information

Damage: Both adults and larvae of the blueberry case beetle feed on leaves, causing severe defoliation if present in large numbers. Adults feeding on the bark of stems cause the most serious damage, resulting in drying and winter kill. Damage is most serious in sprout fields or second crop fields in a three-year production cycle, where a major portion of the crop can be lost during large outbreaks. Damage is not serious during the crop year in a two-year rotation, as plants are pruned.

Life cycle: The pest overwinters as adults in leaf litter under blueberry plants. Adult beetles emerge in May and lay eggs in mid-June. The eggs hatch in about ten days and emerging larvae feed mainly on the leaves of blueberries. Larvae go through three instars (stages) and pupate from late July to early August. The egg, larva and pupa are each enclosed in a bell-shaped case. The pupal stage lasts from four to five weeks and emerging adults of the second generation remain active until November.

Pest Management

Cultural controls: Pruning by burning may reduce populations. Several species of wasp are parasitoids of the pest. Usually pest populations are kept low by these parasitoids and chemical sprays are not necessary. Weekly sampling with an insect sweep net is most important in sprout fields, where adult activity in the fall can cause severe damage.

Issues for Blueberry Case Beetle

None identified.

Blueberry Flea Beetle (*Altica sylvia*)

Pest Information

Damage: The blueberry flea beetle can cause severe defoliation if it is present in large numbers. Both adults and larvae feed on blueberry foliage. Outbreaks develop in late May or early June and can occur in the crop or sprout year. If not controlled, these outbreaks can cause severe losses in plant emergence and growth in the sprout year.

Life cycle: The eggs of the flea beetle overwinter in leaf litter and hatch in May when the leaves begin to unfold. The larvae develop through three instars (stages) before pupating in the soil. Adults emerge from pupae in late June, lay eggs in late July and are present until late August.

Pest Management

Cultural controls: Fall or spring burning will help control the flea beetle population, as the eggs overwinter in the leaf litter. Most outbreaks occur in mechanically pruned fields. A sweep net can be used for weekly sampling. Additional management practices for blueberry flea beetle are listed in *Table 8. Adoption of insect pest management practices in lowbush blueberry production in Canada.*

Issues for Blueberry Flea Beetle

1. Further studies are required on integrated management approaches for blueberry flea beetle including controls for implementation in the sprout year. The impact of this insect industry-wide is minor, but it can be severe in specific areas.
2. The registration of reduced risk, pollinator friendly, insecticides including *Bacillus thuringiensis* (Bt) based products is required for the control of blueberry flea beetle.
3. A model developed to predict the emergence of blueberry flea beetle requires additional verification.

Blueberry Maggot (Currant Fruit Fly) (*Rhagoletis mendax*)

Pest Information

Damage: The blueberry maggot is the most serious insect threat for the blueberry industry in Quebec. It is recognized as the most important insect pest of lowbush blueberry. The pest consumes the inner parts of the berry, resulting in shrivelling and premature dropping from the plant. Although direct losses of fruit are of minimal economic importance, there is a zero tolerance for fruit fly larvae in some export markets. The presence of larvae at low levels in harvested fruit greatly reduces the commercial value of the crop.

Life cycle: Most pupae spend one winter in the ground. Others can prolong their diapause for a second or third year. Adult flies emerge from soil from late June to early August, and live for approximately 30 days. Females lay eggs in fruit as it begins to ripen. Each female can lay up to 100 eggs, usually deposited under the epidermis of the fruit. Larvae develop inside the berries and when full grown, drop to the soil and tunnel a few centimetres deep where they pupate and overwinter. There is one generation per year.

Pest Management

Cultural controls: Since the majority of flies emerge during the non-crop year in a two-year cropping system, it is important that crop and non-crop (sprout) fields remain isolated from one another to reduce new infestations. Sanitation practices such as destroying fallen fruits rather than composting them, and picking and removing infested berries will help to reduce re-infestation. Controlling weeds that provide shelter for adult flies can also be helpful. Adult flies may be monitored using yellow sticky traps placed in the outer margin of the field. The action threshold has been set at one captured fly due to the intolerance for this pest in export markets. Phytosanitary requirements prohibit the domestic movement of crops infested with blueberry maggot under the *Federal Plant Protection Act* (*(*http://www.inspection.gc.ca/plants/plant-pests-invasive-species/domestic-measures/eng/1523384657071/1523384657601), in order to prevent the introduction or spread of this pest to pest-free areas in Canada. These requirements are also part of the Blueberry Certification Program (BCP) (http://www.inspection.gc.ca/plants/plant-pests-invasive-species/directives/horticulture/d-02-04/eng/1320046578973/1320046655958. Additional management practices for blueberry maggot are listed in maggot are listed in *Table 8. Adoption of insect pest management practices in lowbush blueberry production in Canada.*

Issues for Blueberry Maggot

1. Effective control of blueberry maggot is critical for the marketability of this crop given that this pest is a regulated insect in some export markets and that there is close to zero tolerance of insects in the fruit in "direct to consumer" sales.
2. Monitoring is required to prevent the introduction of blueberry maggot into non-infested areas.
3. The need for insecticide sprays late in the production cycle for the management of blueberry maggot increases the difficulties in exporting the crop to foreign markets that have specific residue import tolerances. It is important that export tolerances be taken into consideration when registering new insecticides and when extending the registration of older products.
4. There is a need for the development of alternative, integrated approaches that provide comparable levels of control to conventional approaches for the management of blueberry maggot.
5. New, "pollinator-friendly" products are required for the management of blueberry maggot.

Blueberry Leaftier (*Croesia curvalana*)

Pest information

Damage: Young larvae of the blueberry leaftier can cause severe damage by feeding on developing flower buds, with up to 20 percent of the buds being affected. Older larvae damage blueberry by feeding on leaves and flowers. Defoliation can be close to 100 percent if the outbreak is severe.

Life cycle: The pest overwinters as eggs in leaf litter around blueberry plants. Eggs hatch from April to May. Larvae feed on buds, young leaves and flowers and form a protective shelter of leaves and silk when molting. Larvae pupate within these shelters during June. Adult moths emerge from the pupae in early to late July and lay eggs on the leaf litter from late July to early August.

Pest Management

Cultural controls: Burning in the sprout year can help reduce pest numbers for the following crop year. Additional management practices for blueberry leaftier are listed in *Table 8. Adoption of insect pest management practices in lowbush blueberry production in Canada*.

Issues for Blueberry Leaftier

1. Information on scouting and monitoring is required to help establish the degree of damage caused by the blueberry leaftier.

Blueberry Gall Midge (cranberry tip worm, blueberry tip midge) (*Dasineura oxycoccana*)

Pest Information

Damage: Blueberry gall midge larvae feed on the terminal growth of vegetative shoots causing deformed foliage, premature break of secondary buds and excessive branching. As a result of this shoot growth, the development of flower buds for the following season's crop may be delayed and rendered more susceptible to winter injury.

Life Cycle: The blueberry gall midge overwinters in the soil as pupae, and emerges as adult flies in the spring. First generation females mate and lay eggs in buds. Following hatching, larvae feed within buds for up to 10 days. Larvae develop through three instars and, when mature, drop to the ground to pupate. The next generation adults emerge soon after. There can be several generations per year.

Pest Management

Cultural Controls: It is important to apply balanced fertilizers that do not stimulate the excessive growth that is attractive to this insect. The presence of gall midge can be detected by visual examination of blackened shoot tips when leaf buds unfold in the spring. Monitoring through scouting and tracking can help to determine if economic threshold levels have been reached and controls are warranted. Pruning by intense burning is effective against this pest.

Issues for Blueberry Gall Midge

1. Additional research is required on the biology of the blueberry gall midge and its impact on growth and yield of lowbush blueberry.
2. The development of an integrated approach that includes improved monitoring methods, and implementation of economic thresholds and reduced risk insecticides is required to enable growers to effectively manage the blueberry gall midge.

Blueberry Sawfly (*Neopareophora litura*)

Pest Information

Damage: Blueberry sawfly larvae feed on leaves and may cause defoliation if present in large numbers. Infestations are usually confined to isolated areas within a field.

Life cycle: Adult sawflies lay eggs in May inside developing leaf whorls. Larvae feed on foliage until late June, when they move to the ground litter, spin cocoons and overwinter. Pupation takes place the next spring and adults emerge within two weeks.

Pest Management

Cultural controls: Pruning by burning does not have a huge effect on sawfly as pupae are often deeper in the soil than other insect pests and are thus more protected. Several parasitic wasps (family Ichneumonidae) are active in blueberry fields and help to keep the populations of sawfly low. However, parasites may not control an outbreak early enough to prevent economic damage. It is important to monitor crop fields weekly using sweep net. The blueberry sawfly is usually kept in check by treatments for other insects such as the blueberry flea beetle or spanworm.

Issues for Blueberry Sawfly

None identified.

Blueberry Spanworm (*Speranza argillacearia*) and other Spanworms

Pest Information

Damage: Caterpillars of several species of spanworm moths feed on the foliage of lowbush blueberry. Plants can be completely defoliated if the outbreak is severe. In sprout fields, the new shoots may be completely consumed. These insects are more problematic in fields that are pruned by mowing as opposed to burning.

Life cycle: Adult moths of *Speranza argillacearia,* formerly named *Itame argillacearia*, are present in mid-summer and lay overwintering eggs in litter at the base of plants. The eggs hatch when plant growth resumes in the spring. The larvae feed most actively on leaves and buds at night, hiding in leaf litter on the ground during the day. Larvae complete their feeding by early summer at which time they drop to the soil to pupate, with adults emerging in mid-summer.

Pest Management

Cultural controls: Burning can reduce the number of spanworms in the field by killing overwintering eggs. Several species of parasitic wasp attack the blueberry spanworm and help to control the population. The pest can be monitored once a week, starting from early May until June, using a sweep net and remedial treatments can be applied when threshold levels have been reached. Additional management practices for blueberry spanworm are listed in *Table 8. Adoption of insect pest management practices in lowbush blueberry production in Canada.*

Issues for Blueberry Spanworm

1. Improved monitoring methods and thresholds are required for more targeted treatments for the blueberry spanworm.

Blueberry Stem Gall Wasp (*Hemadas nubilipennis*)

Pest Information

Damage: The blueberry stem gall wasp causes the formation of galls (irregular growths) on the stems of the plant in response to egg laying and larval feeding on blueberry. Tissue at the tip of the stem is destroyed, stopping the formation of fruit buds on affected stems. If this damage occurs during the vegetative year, yield can be reduced the following year. Galls can also break off the stem during harvesting, pass through the processing line and end up as foreign objects in the finished product. Field infestations can be high in fields which have been exclusively mechanically pruned for an extended number of years.

Life cycle: Adults are almost all females. They emerge from galls from May to June before the buds break and lay eggs in developing shoots. The process of egg laying induces abnormal tissue growth, resulting in a chamber being formed around each egg. Eggs hatch in two weeks and larvae feed inside the chamber, further stimulating the undifferentiated growth of the plant tissue. Eventually a gall is formed around several feeding larvae. The larvae overwinter inside the gall and pupate and emerge as adults the following spring.

Pest Management

Cultural controls: Burn pruning of the plants may have some effect in decreasing gall wasp populations.

Issues for Blueberry Stem Gall

1. Grower education on the need and approach to equipment sanitation is important to minimize the spread of the blueberry gall wasp.

Blueberry Thrips (*Frankliniella vaccinii* and *Catinathrips kainos*)

Pest Information

Damage: These two thrip species feed on leaves of lowbush blueberry plants, causing them to curl tightly and wrap around the stem. In sprout fields, damage is only visible in spring on leaves that remain attached to the plant. In crop fields, expanding leaves do not unfold normally and resemble enlarged buds. Most infestations are localized, but sometimes large infestations of several hectares can occur. Infested plants are more susceptible to winter injury and produce less fruit.

Life cycle: The two species attacking lowbush blueberries have a similar appearance and life cycle. Adult females overwinter in the soil and emerge from the ground in April and May. Females lay eggs in leaf tissues from May to June. Emerging larvae feed on blueberry leaves by sucking sap, causing the leaves to curl. *F. vaccinii* pupates within the curled leaves and *C. kainos* often drops to the soil to pupate and complete its development. Adults appear in late July.

Pest Management

Cultural controls: Fields are inspected for the presence of thrips and damage beginning in early June. Infested areas can be treated the following spring, when the plants are small and the overwintered adults first appear. In some areas, delayed pruning by mowing or burning in mid-June, after thrips colonization during a sprout year has shown to be effective in controlling thrips populations.

Issues for Thrips

1. The true impact of blueberry thrips on the crop needs to be determined. Work is needed on alternative management approaches due to the narrow window for use of chemical controls.

Red-Striped Fireworm (*Aroga trialbamaculella*)

Pest Information

Damage: The red-striped fireworm is most prevalent in sprout fields but can also be found in crop fields. The larvae web stems and leaves together and feed within the webbed leaves. They may also web together fruit, which may affect fruit size and interfere with harvest. The caterpillars are considered to be harvest contaminants on field equipment and processing lines.

Life cycle: The red-striped fireworm overwinters as mature larvae in ground litter. Pupation occurs in the spring and adults begin to emerge in late June. Adults lay eggs under bark and in axils of leaves of blueberry plants. Eggs hatch in 9 to 16 days and larvae begin feeding on the blueberry plants. In September, larvae move back in the leaf litter.

Pest Management

Cultural controls: Due to the importance of this pest as a harvest contaminant, monitoring is carried out for this insect.

Issues for Red-Stripped Fireworm

1. Studies are required on the impact of red-striped fireworm feeding in the sprout year on yields the following year.
2. Continued work to determine ecological factors resulting in outbreak conditions and identification of behavioral attractants would be of benefit.

Spotted Wing Drosophila (*Drosophila suzukii*)

Pest Information

Damage: The spotted wing drosophila (SWD) attacks wild and cultivated lowbush blueberry, other berry crops and also stone fruit crops. Feeding by larvae within the fruit turns the flesh of the fruit brown and soft. Damage can provide entry sites for infection by secondary fungi and bacteria causing further deterioration of the fruit. This injury results in unmarketable fruit and economic loss to growers.

Life cycle: SWD overwinter as adult flies. The flies become active in the spring and move into commercial crops once fruit begins to ripen. Female SWD have a serrated ovipositor that enables them to lay eggs in ripening fruit. Following egg hatch, larvae feed internally within fruit. Pupation takes place within or outside the fruit. With warm summer temperatures, the time required for one generation can be as short as ten days, and as a result there can be multiple, overlapping generations in a year. The insect can be dispersed by wind or moved into new areas through the movement of infested fruit.

Pest Management

Cultural controls: Sanitation practices such as the removal of over-ripe and fallen fruit, the elimination of old fruit in processing areas and in equipment, and the removal of nearby, wild, hosts, will help to reduce the SDW population. Fields and earlier fruiting hosts in the vicinity of the blueberry field are closely monitored through the use of apple cider vinegar baited traps for the presence of SWD. Treatments are initiated when the first male fly is detected. Additional management practices for spotted wing drosophila are listed in *Table 8. Adoption of insect pest management practices in lowbush blueberry production in Canada.*

Issues for Spotted Wing Drosophila

1. Studies are required to understand the biology of this insect in eastern Canada. The development of a growing degree day model for first emergence would be very helpful for the management of this pest.
2. Improved monitoring approaches and treatment thresholds are required for SWD in lowbush blueberry.
3. Effective control options are required for SWD. New insecticides must be “pollinator friendly” and meet pre-harvest interval (PHI) and maximum residue limit (MRL) requirements of domestic and export markets to ensure the marketability of the crop.
4. Efficient methods of insecticide application need to be developed for use during the harvest period for the management of SWD.

Plant Bugs: Tarnished Plant Bug (*Lygus lineolaris*) and other *Lygus* spp.

Pest Information

Damage: Plant bugs feed and injure fruits and leaf buds. Late season damage may occur anywhere on the fruit. The tarnished plant bug has a wide range of hosts, feeding on weeds, vegetables, fruits, flowers and shrubs. It punctures the fruit skin and sucks the sap, resulting in fruit deformation. They prefer floral buds and immature fruits.

Life cycle: Adult tarnished plant bugs overwinter under leaf and weed litter. In late spring, they migrate to weeds and wild flowers where they lay their eggs into stems and stalks. Nymphs hatch in seven to ten days and develop through three to five stages over a 15 to 30-day period, before they become adults. There can be several overlapping generations per year.

Pest Management

Cultural controls: Keeping neighbouring fields free of weeds and mowing field borders can help to reduce attractiveness of the area to plant bugs.

Issues for Plant Bugs

None identified.

Insecticides, miticides and bioinsecticides registered in Canada for the management of insect and mite pests in lowbush blueberry production

Active ingredients registered for the management of **insects and mites** in lowbush blueberry are listed below in Table 9 *Insecticides, miticides and bioinsecticides registered for the management of insect and mite pests in lowbush blueberry production in Canada*. This table also provides registration numbers for **products registered on lowbush blueberry as of December 12, 2018** for each active ingredient in addition to information about chemical family and re-evaluation status. For guidance about active ingredients registered for specific **insects and mites**, the reader is referred to individual product labels on the PMRA label database https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management.html and to provincial crop production guides.

Table 9 Insecticides, miticides and bioinsecticides registered for insect management in lowbush blueberry production in Canada

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Re-evaluation Status (re-evaluation decision document)[3]
acetamiprid	27128	neonicotinoid	4A	nicotinic acetylcholine receptor (nAChR) competitive modulator	R
Bacillus thuringiensis subsp. *kurstaki* strain ABTS-351	24978, 26508	*Bacillus thuringiensis* and the insecticidal proteins they produce	11A	microbial disruptor of insect midgut membranes	R
Bacillus thuringiensis subsp. *kurstaki* strain EVB113-19	26854, 27750, 32425	*Bacillus thuringiensis* and the insecticidal proteins they produce	11A	microbial disruptor of insect midgut membranes	R
canola oil	32408, 32819	not classified	N/A	unknown	R
carbaryl	17534, 22339, 27876	carbamate	1A	acetylcholinesterase (AChE) inhibitor	RE (REV2018-17)
chlorantraniliprole	28981	diamide	28	ryanodine receptor modulator	R
cyantraniliprole	30895	diamide	28	ryanodine receptor modulator	R
deltamethrin	22478, 25573, 32446	pyrethroid, pyrethrin	3A	sodium channel modulator	R (RVD2018-27)
dimethoate	8277, 9382, 9807, 25651	organophosphate	1B	acetylcholinesterase (AChE) inhibitor	R
ferric phosphate	27085, 27096, 30025	not classified	N/A	unknown	R (RVD2018-23)

…continued

Table 9. Insecticides, miticides and bioinsecticides registered for insect management in lowbush blueberry production in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Re-evaluation Status (re-evaluation decision document)[3]
ferric sodium ethylenediamine tetra acetic acid (EDTA)	28774	not classified	N/A	unknown	R
flonicamid	29796	flonicamid	29	chlordotonal organ modulator - undefined target site	R
flupyradifurone	31452	butenolide	4D	nicotinic acetylcholine receptor (nAChR) competitive modulator	R
imidacloprid	24094	neonicotinoid	4A	nicotinic acetylcholine receptor (nAChR) competitive modulator	RES*
imidacloprid + deltamethrin	29611	neonicotinoid + pyrethroid, pyrethrin	4A	nicotinic acetylcholine receptor (nAChR) competitive modulator + sodium channel modulator	RES* + RE
malathion	8372	organophosphate	1B	acetylcholinesterase (AChE) inhibitor	R
metaldehyde	26650, 32149	not classified	N/A	unknown	R
methoxyfenozide	27786	diacylhydrazine	18	ecdysone receptor agonist	R
methyl bromide	9564	alkyl halide	8A	miscellaneous non-specific (multi-site) inhibitor	PO[5]
mineral oil	27666, 33099	not classified	N/A	unknown	R
permethrin	14882, 16688, 28877	pyrethroid, pyrethrin	3A	sodium channel modulator	RE

…continued

Table 9. Insecticides, miticides and bioinsecticides registered for insect management in lowbush blueberry production in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Re-evaluation Status (re-evaluation decision document)[3]
phosmet	23006, 29064	organophosphate	1B	acetylcholinesterase (AChE) inhibitor	RE
potassium salts of fatty acids	14669, 27886, 28146, 31433	not classified	N/A	unknown	R
pyrethrins	30164	pyrethroid, pyrethrin	3A	sodium channel modulator	RE
spinetoram	28777, 28778	spinosyn	5	nicotinic acetylcholine receptor (nAChR) allosteric modulator - site 1	R
spinosad	26835, 27825, 28336, 30382	spinosyn	5	nicotinic acetylcholine receptor (nAChR) allosteric modulator - site 1	RE
spirodiclofen	28051	tetronic and tetramic acid derivative	23	inhibitor of acetyl CoA carboxylase	R
spiromesifin	28905	tetronic and tetramic acid derivative	23	inhibitor of acetyl CoA carboxylase	R
spirotetramat	28953	tetronic and tetramic acid derivative	23	inhibitor of acetyl CoA carboxylase	R
tebufenozide	24503	diacylhydrazine	18	ecdysone receptor agonist	RE
thiamethoxam	28408	neonicotinoid	4A	nicotinic acetylcholine receptor (nAChR) competitive modulator	RES*
Storage Treatment					
methyl bromide	9564	alkyl halide	8A	miscellaneous non-specific (multi-site) inhibitor	PO[5]

…continued

Table 9. Insecticides, miticides and bioinsecticides registered for insect management in lowbush blueberry production in Canada (continued)

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Re-evaluation Status (re-evaluation decision document)[3]
Pheromone					
none					

[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 December 12, 2018.** While every effort has been made to ensure all insecticides, miticides and biopesticides registered in Canada on lowbush blueberry have been included in this list, some active ingredients or products may have been inadvertently omitted. 'Numerous products' is entered where there are more than ten products for an active ingredient. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The product label is the final authority on pesticide use and should be consulted for application information. The information in this table should not be relied upon for pesticide application decisions and use.

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

[3]PMRA re-evaluation status as published in Re-evaluation Note REV2018-06 Pest Management Regulatory Agency Re-evaluation and Special Review Work Plan 2018-2023, Re-evaluation Note REV2018-17 Initiation of Cumulative Health Risk Assessment-N-Methyl Carbamates **and other re-evaluation documents**: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review. Other codes include: DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

[4]Source: Fungicide Resistance Action Committee. *FRAC Code List 2017: Fungicides sorted by mode of action (including FRAC code numbering)* (www.frac.info/) (accessed September 13, 2017).

[5]As published by Government of Canada: *Notice to anyone engaged in the use of methyl bromide: June 2017 https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/notice-use-methyl-bromide-june-2017.html*.

Weeds

Key Issues

- There is a need for the registration of selective, reduced-risk herbicides active against a targeted range of weeds to reduce reliance on applications of broad-spectrum, pre-emergent herbicides.
- There is a need for the registration of post-emergent herbicides active against grass weed species, and of chemical groups other than Group 1, in order to facilitate resistance management within these weed populations.
- It is critical that pre-harvest intervals of all new product registrations be set so as to enable the crop to meet Maximum Residue Limits (MRLs) for export as well as domestic markets, to ensure the marketability of the crop.
- A protocol for equipment sanitization is required for transfer to industry to help growers reduce the spread of weeds among blueberry fields.
- There is a need for further research on the effect of soil nutrition and pH on the growth of perennial weeds.

Table 10. Occurrence of weeds in Canadian lowbush blueberry production[1,2]

Weeds	Quebec	New Brunswick	Nova Scotia	Prince Edward Island
Annual broadleaf weeds				
Annual grass weeds				
Perennial broadleaf weeds				
Perennial grass weeds				
Woody plants				
Widespread yearly occurrence with high pest pressure.				
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.				
Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pest pressure.				
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.				
Pest not present.				
Data not reported.				

[1]Source: Lowbush blueberry stakeholders in reporting provinces (Quebec, New Brunswick, Nova Scotia and Prince Edward Island); the data reflect the 2017, 2016 and 2015 production years.

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

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

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

...continued

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

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

green	**This practice is used to manage this pest by at least some growers.**
red	**This practice is not used by growers to manage this pest.**
white	**This practice is not applicable for the management of this pest.**
grey	**Information regarding the practice for this pest is unknown.**

[1]Source: Lowbush blueberry stakeholders in reporting provinces (Quebec, New Brunswick, Nova Scotia and Prince Edward Island); the data reflect the 2017, 2016 and 2015 production years.

All Weeds

Pest Information

Damage: Weeds compete for space, moisture and nutrients and can reduce blueberry plant vigour and yield. Weeds may shade the crop resulting in poor bud formation, and can act as alternate hosts for insects and diseases. The presence of weeds can also cause harvesting challenges.

Life cycle: ***Annual weeds*****:** Annual weeds complete their life cycle, from seed germination, through vegetative growth and flowering to seed production in one year. They produce large numbers of seeds that can remain viable in the soil for many years, and germinate when conditions are suitable.

Biennial weeds: Biennial weeds germinate in the spring and remain vegetative during the first season. They overwinter as rosettes and in the second growing season, flower and produce seed and die.

Perennial weeds*:* Perennial weeds are herbaceous or woody plants that live for many years. They can reproduce and spread by means of seed as well as through the expansion of various types of root systems and other vegetative means.

Pest Management

Cultural controls: Equipment sanitation when moving between fields, the use of weed-free straw for prune-burning and controlling weeds along roadsides and at field perimeters, is important to prevent the introduction of weeds into blueberry fields. Weed pulling and cutting prior to seed set, can prevent seed dispersal. Avoiding excessive fertilizer applications and reducing soil pH can improve the competitiveness of the crop. Eliminating bare areas in a field by interplanting young blueberry plants will eliminate sites prone to weed establishment. Pruning by burning will destroy weed top-growth and seeds; however, pruning by burning or mowing may only suppress perennial weeds as these practices do not completely destroy the root systems, allowing these weeds to re-grow. Additional management practices for weeds are listed in *Table 11. Adoption of weed management practices in lowbush blueberry production in Canada.*

Issues for Annual Weeds

1. There is a need for improved understanding of the impact of fertilization and soil nutrient levels on the growth and vigour of annual broadleaf weeds.
2. There is a need for the registration of post-emergent grass weed herbicides in groups other than Group 1, for resistance management.
3. Witch grass is an emerging annual grass problem.
4. Biological control options are required for weed control in lowbush blueberry.

Issues for Perennial Weeds

1. There is a need for a clearer understanding of the spectrum of weeds controlled by currently available herbicides for improved treatment decisions.
2. Additional information is required on the best timing of herbicide applications and the combining of herbicide treatments for perennial broadleaf weed control.

3. There is a need for the registration of reduced risk products which control a more targeted range of weeds, to allow for more precise herbicide applications and reduce the need for broad spectrum pre-emergent herbicides.
4. St. John's wort (*Hypericum perforatum*), spreading dogbane (*Apocynum androsaemifolium*), barrenberry (*Photinia* spp.), spreading blackberry (*Rubus* spp.), vetch (*Vicia spp.*), sheep sorrel (*Rumex acetosella*), hawkweed (*Hieracium* spp.), bulrush, sweet fern (*Comptonia* spp.) are weed species that are particularly challenging to control.
5. The development of a protocol for equipment sanitation is required to help growers reduce the spread of weeds between fields in lowbush blueberry. In addition, an effective approach to inform producers of sanitation protocols is required.
6. There is a need for further research on the effect of soil nutrition and pH on the growth of perennial weeds.
7. Perennial grasses, including poverty oat grass (*Danthonia spicata*) and fescues (*Festuca* spp.) are an increasing problem in lowbush blueberry. The registration of additional reduced risk products is needed to enable product rotation and reduce the likelihood of resistance development in these weeds.
8. It is critical that all new product registrations have pre-harvest intervals that enable the crop to meet MRLs for domestic and export markets to ensure the marketability of the crop.
9. Alternative approaches to weed control including organic methods and different application timings that break weed cycles are required.

Herbicides and bioherbicides registered in Canada for weed management in lowbush blueberry production

Active ingredients registered for the management of **weeds** in lowbush blueberry are listed in *Table 12 Herbicides and bioherbicides registered for weed management in lowbush blueberry production in Canada*. This table also provides registration numbers for **products registered on lowbush blueberry as of December 12, 2018** for each active ingredient, in addition to information about chemical family and re-evaluation status. For guidance about active ingredients registered for specific **weeds**, the reader is referred to individual product labels available on the PMRA label database, https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management.html and to provincial crop production guides.

Table 12 Herbicides and bioherbicides registered for weed management in lowbush blueberry production in Canada

Active Ingredient[1]	Product Registration Numbers	Chemical Family[2]	Resistance Group[2]	Site of Action[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
ammonium soap of fatty acids	30012, 30515	not classified	N/A	not classified	R
bentazon (bendioxide)	12221	benzothiadiazinone	6	inhibition of photosynthesis at photosystem II site B	R
carfentrazone-ethyl	28573	triazolinone	14	inhibition of protoporphyrinogen oxidase (Protox, PPO)	R
clopyralid	23545, 30620	pyridine carboxylic acid	4	synthetic auxin	R
dicamba	18837, 23957, 26772, 28761, 28966, 29223, 31536, 31745, 31896, 31998, 32220	benzoic acid	4	Synthetic auxin	R
dichlobenil	12533	nitrile	20	inhibition of cell wall synthesis site A	R
fluazifop-P	21209	aryloxyphenoxy-propionate 'FOP'	1	inhibition of acetyl CoA carboxylase (ACCase)	R
flumioxazin	29231, 29235	N-phenylphthalimide	14	inhibition of protoporphyrinogen oxidase (Protox, PPO)	R
foramsulfuron	27424	sulfonylurea	2	inhibition of acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS)	R

…continued

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

Active Ingredient[1]	Product Registration Numbers	Chemical Family[2]	Resistance Group[2]	Site of Action[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
glufosinate ammonium	23180, 28532	phosphinic acid	10	inhibition of glutamine synthetase	R
glufosinate ammonium + glyphosate	25795, 26625	phosphinic acid + glycine	10 + 9	inhibition of glutamine synthetase + inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	R + R
glyphosate (present as dimethylamine salt)	28840, 28977, 29774, 29775, 30319, 30516, 31090	glycine	9	inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	R
glyphosate (present as isopropylamine salt)	numerous products	glycine	9	inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	R
glyphosate (present as isopropylamine salt and potassium salt)	29888, 31316, 32228, 32532, 33029, 33030	glycine	9	inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	R
glyphosate (present as potassium salt	numerous products	glycine	9	inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	R
hexazinone	14163, 18197, 21390, 25225	triazinone	5	inhibition of photosynthesis at photosystem II site A	RES
mesotrione	27833, 32958	triketone	27	inhibition of 4-hydroxyphenyl-pyruvate-dioxygenase (4-HPPD)	R
napropamide	25230, 25231, 31081, 31688	acetamide	15	inhibition of mitosis	R
nicosulfuron + rimsulfuron	24736, 32709	sulfonylurea	2	inhibition of acetolactate synthase (ALS) or acetohydroxyacid synthase (AHAS)	R

…continued

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

Active Ingredient[1]	**Product Registration Numbers**	**Chemical Family**[2]	**Resistance Group**[2]	Site **of Action**[2]	**Re-evaluation Status (Re-evaluation Decision Document)**[3]
propyzamide (pronamide)	25595, 30264	benzamide	3	microtubule assembly inhibition	R
sethoxydim	24835	cyclohexanedione 'DIM'	1	inhibition of acetyl CoA carboxylase (ACCase)	R
simazine and related triazines	16370	triazine	5	inhibition of photosynthesis at photosystem II site A	R
sulfentrazone	29012, 32846	triazolinone	14	inhibition of protoporphyrinogen oxidase (Protox, PPO)	R
terbacil	10628, 30082	uracil	5	inhibition of photosynthesis at photosystem II site A	R
tribenuron methyl	25475, 29653	sulfonyurea	2	inhibition of acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS)	R
triclopyr	21053, 28434, 28945, 29334, 29960	pyridine carboxylic acid	4	synthetic auxin	R

…continued

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

Active Ingredient[1]	Product Registration Numbers	Chemical Family[2]	Resistance Group[2]	Site of Action[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
Plant Growth Regulators (PGR)					
ethephon	11580	plant growth regulator	N/A	plant growth regulator to accelerate fruit colouring and maturity	R

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

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

[3]PMRA re-evaluation status as published in Re-evaluation Note REV2018-06 Pest Management Regulatory Agency Re-evaluation and Special Review Work Plan 2018-2023, Re-evaluation Note REV2018-17 Initiation of Cumulative Health Risk Assessment-N-Methyl Carbamates **and other re-evaluation documents**: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review. Other codes include: DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

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

[5]As published by Government of Canada: *Notice to anyone engaged in the use of methyl bromide: June 2017*. *https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/notice-use-methyl-bromide-june-2017.html.*

Vertebrate Pests

Birds

Birds feed on ripening fruit and are an increasing concern. Their feeding can significantly reduce crop yield before harvest. The most important birds include seagulls, crows, robins and blackbirds, with gulls being of particular concern in the Atlantic coastal regions. Many producers use propane bangers, electronic noisemakers, balloons or other noise making devices to reduce fruit damage from birds. Some species become accustomed to these deterrents and will still cause significant reductions in crops. Small acreage producers with heavy bird pressure can use netting to stop birds from reaching the plants.

Bear

Bears cause most of their damage during the bloom period in June. Honeybee hives that are used to increase pollination in the fields can attract bears. Bears can severely damage or destroy hives and colonies. This damage can be very costly to both the blueberry grower and the beekeeper. Bears also feed on mature fruit and destroy plants when sitting or lying in fields.

Fencing of beehives is a must in most fields to reduce the damage from bears. Properly installed fencing systems are usually very effective.

Coyote

When populations are high, coyotes can consume significant quantities of blueberry fruits. The presence of coyotes will reduce the damage caused by deer.

Deer

Deer can cause significant crop losses where populations are high and blueberry fields are small and isolated. Deer feed on leaves throughout the summer and on fruits as they mature. Most importantly, in the early spring of the fruiting year, deer migrate to the center of the fields where snow has disappeared and graze on the blueberry twigs, chewing off the tops of the vines that carry most of the fruit buds that would otherwise develop into the current year’s crop.

The use of deer deterrents sprayed around the perimeters of fields has met with spotty success only. In a very few cases fences have been erected, but this is expensive and, in most fields, not practical.

Resources

Integrated Pest Management / Integrated Crop Management Resources for Production of Lowbush Blueberry in Canada

Agriculture and Agri-Food Canada. Horticulture sector reports. Statistical Overview of the Canadian Fruit Industry 2017.

http://www.agr.gc.ca/eng/industry-markets-and-trade/canadian-agri-food-sector-intelligence/horticulture/horticulture-sector-reports/statistical-overview-of-the-canadian-fruit-industry-2017/?id=1526403930297

Agri-Réseau. Centre de référence en agriculture et agroalimentaire du Québec. www.agrireseau.qc.ca/petitsfruits/

Canadian Food Inspection Agency. Online Plant Protection Policy Directives – Horticulture. D-02-04: *The Blueberry Certification Program and domestic phytosanitary requirements to prevent the spread of blueberry maggot (Rhagoletis mendax) within Canada* (Effective date: October 24, 2017)

http://www.inspection.gc.ca/plants/plant-pests-invasive-species/directives/horticulture/d-02-04/eng/1320046578973/1320046655958#cha3

Lambert, L., G. H. Laplante, O. Carisse and C. Vincent. 2013. *Diseases, Pests and |Beneficial Organisms of Strawberry, Raspberry and Blueberry.* Centre de référence en agriculture et agroalimentaire du Québec. ISBN 978-2-7649-0230-1. 343 pp.

Ontario Ministry of Agriculture, Food and Rural Affairs. *Berry information*. http://www.omafra.gov.on.ca/english/crops/hort/berry.html

Perennia : Wild Blueberries
https://www.perennia.ca/portfolio-items/wild-blueberries/?portfolioCats=87

Wild Blueberry Network Information Centre.
https://www.dal.ca/sites/wild-blueberry.html

Provincial Crop Specialists and Provincial Minor Use Coordinators

Province	Ministry	Crop Specialist	Minor Use Coordinator
Ontario	Ontario Ministry of Agriculture and Food www.omafra.gov.on.ca/english	Erica Pate erica.pate@ontario.ca	Jim Chaput jim.chaput@ontario.ca
Quebec	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec www.mapaq.gouv.qc.ca	André Gagnon andre.gagnon@mapaq.gouv.qc.ca Andrée Tremblay andree.tremblay@mapaq.gouv.qc.ca	Mathieu Coté mathieu.cote@mapaq.gouv.qc.ca
New Brunswick	New Brunswick Department of Agriculture, Aquaculture and Fisheries https://www2.gnb.ca/content/gnb/en/departments/10.html	Michel Melanson michel.melanson@gnb.ca	Gavin Graham gavin.graham@gnb.ca
Nova Scotia	Nova Scotia Department of Agriculture www.gov.ns.ca/agri/	N/A	Jason Sproule jason.sproule@novascotia.ca
	N/A	Peter Burgess Perennia (www.perennia.ca) pburgess@perennia.ca	
Prince Edward Island	Prince Edward Island Department of Agriculture and Forestry www.gov.pe.ca/af/	Chris Jordan chriswjordan@gov.pe.ca	Sebastian Ibarra sibarra@gov.pe.ca

Provincial Lowbush Blueberry Grower Organizations

Bleuets NB Blueberries: www.nbwildblue.ca

Ontario Berry Growers Association: http://ontarioberries.com/

PEI Wild Blueberry Growers Association: http://peiwildblueberries.com/

Syndicat des producteurs de bleuets du Québec: http://perlebleue.ca/

Wild Blueberry Producers Association of Nova Scotia: www.nswildblueberries.com

National Lowbush Blueberry Grower Organizations

Canadian Horticultural Council: www.hortcouncil.ca/

Appendix 1

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

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

<table>
<tr><th>Presence</th><th colspan="4">Occurrence information</th><th rowspan="2">Colour Code</th></tr>
<tr><td rowspan="16">Present</td><td rowspan="14">Data available</td><th>Frequency</th><th>Distribution</th><th>Pressure</th></tr>
<tr><td rowspan="6">Yearly - Pest is present 2 or more years out of 3 in a given region of the province.</td><td rowspan="3">Widespread - The pest population is generally distributed throughout crop growing regions of the province. In a given year, outbreaks may occur in any region.</td><td>High - If present, potential for spread and crop loss is high and controls must be implemented even for small populations.</td><td>Red</td></tr>
<tr><td>Moderate - If present, potential for spread and crop loss is moderate: pest situation must be monitored and controls may be implemented.</td><td>Orange</td></tr>
<tr><td>Low - If present, the pest causes low or negligible crop damage and controls need not be implemented.</td><td>Yellow</td></tr>
<tr><td rowspan="3">Localized - The pest is established as localized populations and is found only in scattered or limited areas of the province.</td><td>High - see above</td><td>Orange</td></tr>
<tr><td>Moderate - see above</td><td>White</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="6">Sporadic - Pest is present 1 year out of 3 in a given region of the province.</td><td rowspan="3">Widespread - as above</td><td>High - see above</td><td>Orange</td></tr>
<tr><td>Moderate - see above</td><td>Yellow</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="3">Localized - as above</td><td>High - see above</td><td>Yellow</td></tr>
<tr><td>Moderate -see above</td><td>White</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="2">Data not available</td><td colspan="3">Not of concern: The pest is present in commercial crop growing areas of the province but is causing no significant damage. Little is known about its population distribution and frequency in this province; however, it is not of concern.</td><td>White</td></tr>
<tr><td colspan="3">Is of concern: The pest is present in commercial crop growing areas of the province. Little is known about its population distribution and frequency of outbreaks in this province and due to its potential to cause economic damage, is of concern.</td><td>Blue</td></tr>
<tr><td>Not present</td><td colspan="4">The pest is not present in commercial crop growing areas of the province, to the best of 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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Agriculture and Agri-Food Canada. 2017. Commodity Innovation Series: *Blueberries in Food, Drink, and Pet Food.* Market Access Secretariat. Global Analysis Report. 15 pp.
https://search-recherche.gc.ca/rGs/s_r?q=commodity+innovation+series&cdn=aacaafc&st=s&num=10&s5bm3ts21rch=x&st1rt=0&langs=eng

Centre de référence en agriculture et agroalimentaire du Québec (CRAAQ*). 2016. Guide de production du bleuet sauvage…dans une perspective de développement durable.* Pub. No. PAUT0108-PDF. 245 p. (also available in English)

https://www.craaq.qc.ca/Publications-du-CRAAQ/guide-de-production-du-bleuet-sauvage/p/PAUT0108-PDF

Centre de référence en agriculture et agroalimentaire du Québec (CRAAQ). 2016. *Wild Blueberry Production Guide…in a context of sustainable development.* Pub. No. PAUT0108-PDF. 245 pp.

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University of Maine. 1994. Cooperative Extension: Maine Wild Blueberries. Insects – 205-*Red-Striped Fireworm (Aroga trialbamaculella Cham.).* Fact Sheet No. 205.
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