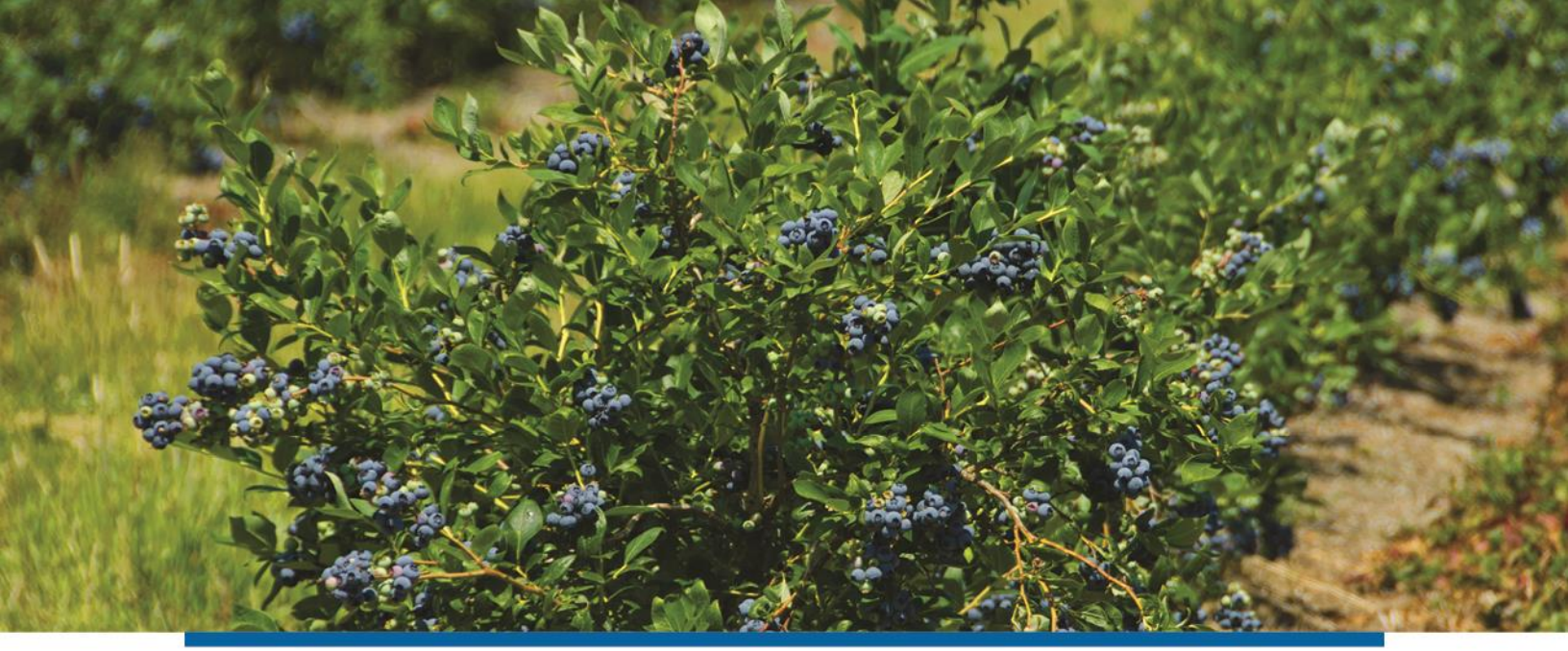

Crop Profile for Highbush Blueberry in Canada, 2017

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Agriculture and Agri-Food Canada

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Preface

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

Information on pest 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 this crop, the reader is referred to provincial crop production guides and provincial ministry websites listed in the Resources Section at the end of the profile.

Every effort has been made to ensure that the information in this publication is complete and accurate. Agriculture and Agri-Food Canada does not assume liability for errors, omissions, or representations, expressed or implied, contained in any written or oral communication associated with this publication. Errors brought to the attention of the authors will be corrected in subsequent updates.

Agriculture and Agri-Food Canada gratefully acknowledges the contributions of provincial crop specialists, industry specialists and growers in the gathering of information for this publication.

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Crop Profile for Highbush Blueberry in Canada

The highbush blueberry, *Vaccinium corymbosum*, is a perennial, deciduous, woody shrub in the Ericaceae or Heath family. It was developed by selective breeding from the native lowbush blueberry by the United States Department of Agriculture (USDA) in the first half of the 20th century.

The health benefits of blueberries, particularly due to their high antioxidant levels, have positively influenced consumers and the market for blueberries has grown. Blueberries are considered as ‘superfruits’ packed with antioxidants, Vitamins A and C, minerals and fibre. Most highbush blueberries are consumed fresh or frozen.

Crop Production

Industry Overview

Canada is a major producer and exporter of blueberries in the world. Canada exported $410 million of blueberries in 2017, a 4% drop compared to the previous year. The United States, Japan and Germany are the top markets for Canada's exports. Highbush blueberries accounted for nearly half of all blueberry exports, including both fresh (25%) and frozen (22%) blueberries in 2016. Highbush blueberry had a farm gate value of $156 million or 77% of the total farm gate value of all blueberries produced in Canada (Table 1) in 2017.

Table 1. General production information, 2017

	Highbush blueberry
Canadian production[1]	65,043 metric tonnes 11,428 hectares
Farm gate value[1]: **Highbush blueberry** **Total blueberries[2]**	 $155.9 Million (77%) $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

In Canada, highbush blueberry is grown primarily (90%) in British Columbia (Table 2). Most of the commercial highbush blueberry production in British Columbia is located in the Lower Mainland region, with the remainder on Vancouver Island.

The balance of national production is in Quebec, Ontario and Nova Scotia. In Nova Scotia, production is located in the Annapolis Valley, and there is growing interest in production on the extensive peat bogs located in the mild, western end of the province. Production in Quebec is located in the regions of Monteregie, Quebec City and Chaudiere-Appalaches. In Ontario, most of the highbush blueberry production is concentrated in the south-western region of the province where mild winters provide a more ideal growing environment.

Table 2. Distribution of total production in Canada, 2017

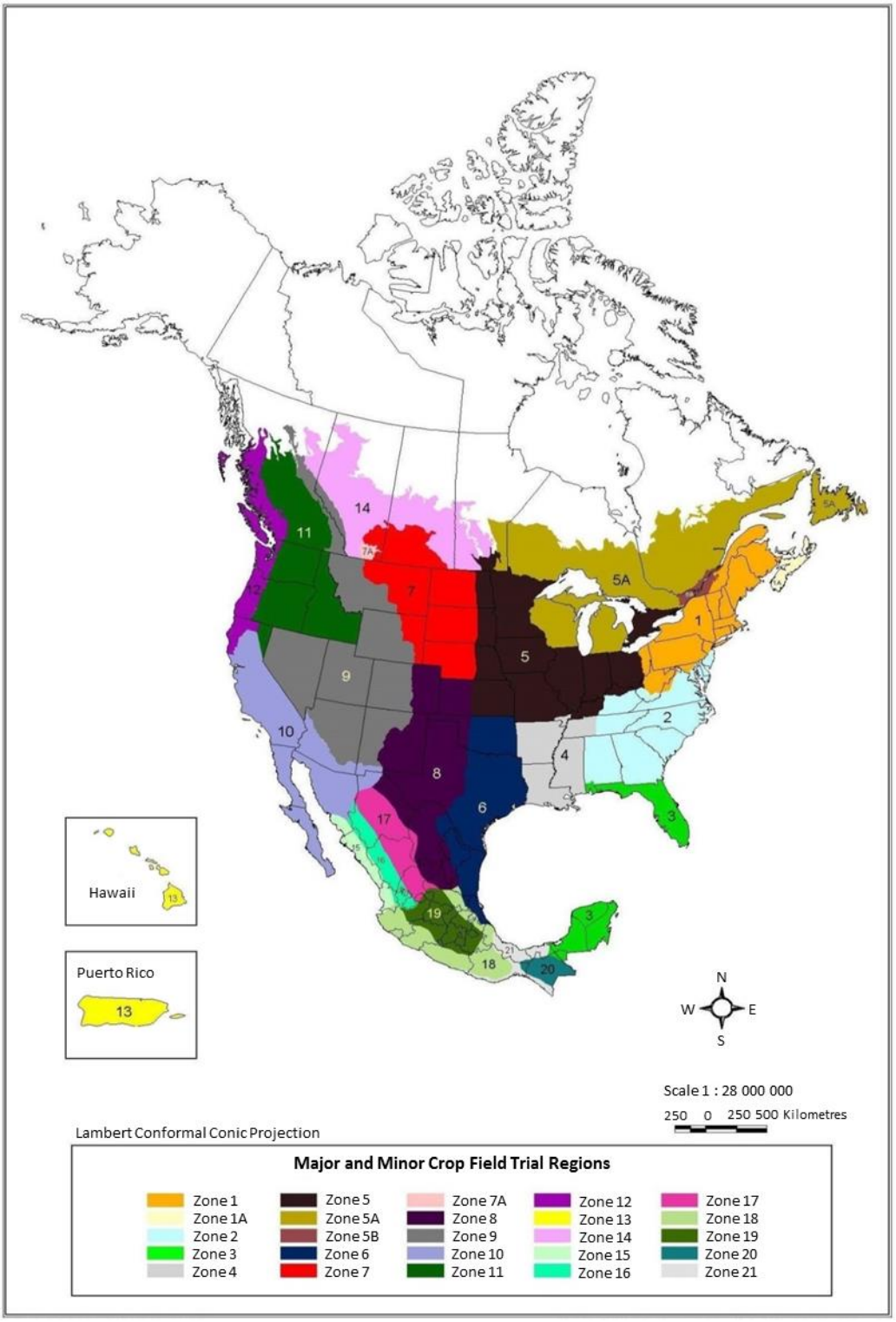
Production Regions	Cultivated area[1] (hectares) and percentage ( )	Marketed production[1] (metric tonnes)	Farm gate value[1] ($)
	Highbush Blueberry		
British Columbia	10,068 ha (88%)	61,510 m. t.	$136.5 Million
Quebec	560 ha (5%)	1,027 m. t.	$5.8 Million
New Brunswick	11 ha (<1%)	x	x
Nova Scotia	202 ha (2%)	1,131 m. t.	$6.2 Million
Canada	**11,428 ha**	**65,043 m. t.**	**$155.9 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 (Figure 1) 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

Highbush blueberries are grown on a wide variety of soils ranging from peat (organic) soils to sandy loam, silt loam and clay loam. Highbush blueberries generally produce well in acidic soils with a pH from 4.5 to 6.5. Minor iron deficiency symptoms can be observed when soil pH is greater than 6.5. Both overhead and trickle irrigation is used in blueberry production and systems vary by region.

Pollination is an important aspect of highbush blueberry production. Honeybee hives are placed in the fields while the crop is in bloom in April and May for pollination. Insecticide selection to avoid harming pollinators and natural insect predators, which are essential to lower production costs, is critical in growing blueberries.

Perennial cover crops such as fescue are often established between rows in blueberry plantations. Sawdust mulches are used to aid in water conservation, maintain a lower soil pH, increase organic matter in the soil, improve soil structure and help control annual weeds.

Blueberry varieties most commonly grown in British Columbia are cv. Bluecrop which matures mid-season, Duke which matures early and Elliott which is late maturing. There are also new cultivars planted in British Columbia, including Draper, Liberty and Aurora. In Quebec, cultivars used must be adapted to Zones 3 and 4. Patriot is currently the leading cultivar; however, its acreage is in decline due to disease issues. Many different cultivars are grown in Ontario, due to regional differences in weather where highbush blueberry is grown. Varieties grown include cvs. Bluecrop (the leading cultivar by acreage), Blueray, Duke, Patriot, Bluejay, Northland, Elliot, Nelson and Northblue. In Nova Scotia, all of the above varieties are planted to some extent but the major varieties in terms of acreage are Bluecrop, Jersey, Coville, Berkeley, Burlington, and Brigitta.

The following table 3 describes typical production practices and worker activities for highbush blueberry throughout the season.

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

Time of Year	Activity	Action
January and February Plants dormant	Plant care	BC and ON: pruning
	Disease management	BC: spraying for disease control
	Weed management	BC: weed control
March BC: Buds start to swell; QC, ON & NS: Plants dormant	Plant care	BC: planting
		ON and NS: pruning
	Disease management	BC and ON: spraying for disease control
	Weed management	BC: weed control
Late March to late April BC: Leaf and flower bud break; QC: Slight bud break; ON & NS: Buds swell	Plant care	BC and ON: planting, fertilizing
		ON, NS and QC: pruning
	Weed management	NS: weed control
	Disease management	BC and ON: spraying for disease control
	Insect and mite management	BC and ON: spraying for insect control
Late April and May BC: Blossoming; QC: bud break; ON & NS: Leaf and flower bud break, blossoming	Weed management	BC and ON: weed control
	Plant care	BC, ON and NS: honeybees are set out when flowering begins
		QC: pruning, fertilizing; ON and NS: planting, fertilizing
	Disease, insect and mite and weed management	BC, ON and NS: spraying, if needed, weed control
June Fruit development	Plant care	Installing bird control devices; fertilizer application
	Disease, insect and mite and weed management	Spraying if needed; weed control
July Fruit development and ripening	Plant care	Harvesting, irrigation if necessary, installing bird control devices
	Disease, insect and mite, and weed management	Spraying as needed

…continued

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

Time of Year	Activity	Action
July to September Harvest	Plant care	Harvesting, irrigation if necessary; removing bird control devices
		QC: foliar feeding if necessary
	Disease, insect and mite and weed management	Spraying as needed
September Post-harvest growth	Plant care	Harvesting, irrigation if necessary; removing bird control devices
		QC: fertilizing for winter hardening
	Disease, insect and mite and weed management	Spraying as needed
October Post-harvest growth	Plant care	BC: pruning
		ON: application of sawdust mulch if needed
		NS: Harvesting; irrigation for frost protection
	Disease and insect and mite management	BC: spraying
	Weed management	BC and ON: weed control
November and December Plants dormant	Plant care	BC, ON and NS: sawdust mulch applied if needed
	Disease, insect and mite and weed management	BC: spraying

Abiotic Factors Limiting Production

Nutrients

Highbush blueberry plants that are nitrogen deficient are reduced in size, have poor leaf colour and weak, stunted growth. Plants that have an excess of nitrogen show excessive vegetative growth, restricted flower bud formation and delayed fruit maturity.

Iron Deficiency

Iron deficiency causes a yellowing of new leaves and often develops when the soil pH is too high. Short-term control of iron deficiencies is obtained through foliar sprays of chelated iron. Soil pH can be lowered with sulphur applications over several years.

Water

A uniform, adequate moisture supply is essential for good berry production. Under drought conditions, berry cracking can occur. The skin of the berry toughens and when water becomes available again, the berry swells rapidly, splitting the skin. Fruit may also shrivel under drought stress. Poor drainage promotes the development of root rot in low-lying areas.

Cold Temperatures

Frost injury predisposes blueberries to pseudomonas bacterial blight in the spring, and can be more severe if bacterial blight is already established. Cold weather in the winter often causes freezing of stems not covered by snow, limiting subsequent growth and production from the stems. However, heavy snow and ice can damage branches and buds.

Diseases

Key Issues

- The registration of biofungicides and other reduced risk fungicides is required for the management of blueberry anthracnose.
- The resistance of botrytis to fungicides is a primary concern in British Columbia. There is a need for the registration of fungicides with novel modes of action. The development of fungicide use patterns that minimize the potential for resistance development in pathogen populations and maximize the duration of efficacy of currently available fungicides is required.
- Improved diagnostic testing is required for virus diseases to enable growers to better manage these diseases.
- International standardization of Maximum Residue Levels (MRLs) for commonly used highbush blueberry pesticides would be helpful to the industry.

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

Disease	British Columbia	Quebec
Alternaria fruit rot		
Blueberry anthracnose and ripe rot		
Botrytis blight and fruit rot		
Mummy berry		
Virus diseases		
Blueberry scorch		
Blueberry shock		
Tomato ringspot		
Stunt disease		
Witches broom		
Godronia canker/ fusicoccum canker		
Root and crown rot (oomycetes)		
Fruit rots		

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: Highbush blueberry stakeholders in reporting provinces (British Columbia and Quebec); 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 highbush blueberry production in Canada[1]

	Practice / Pest	Blueberry scorch	Mummy berry	Botrytis blight and fruit rot	Blueberry anthracnose and ripe rot	Godronia canker
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					

...continued

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

	Practice / Pest	Blueberry scorch	Mummy berry	Botrytis blight and fruit rot	Blueberry anthracnose and ripe rot	Godronia canker
Monitoring	Scouting / spore trapping					
	Maintaining records to track diseases					
	Soil analysis for the presence of pathogens					
	Weather monitoring for disease forecasting					
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of diseases					
Decision making tools	Economic threshold					
	Use of predictive model for management decisions					
	Crop specialist recommendation or advisory bulletin					
	Decision to treat based on observed disease symptoms					
	Use of portable electronic devices in the field to access pathogen / disease identification / management information					

...continued

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

Practice / Pest		Blueberry scorch	Mummy berry	Botrytis blight and fruit rot	Blueberry anthracnose and ripe rot	Godronia canker
Suppression	Use of diverse product modes of action for resistance management					
	Soil amendments and green manuring involving soil incorporation as biofumigants to reduce pathogen populations					
	Use of bio-pesticides (microbial and non-conventional pesticides)					
	Controlled atmosphere storage					
	Targeted pesticide applications (banding, spot treatments, use of variable rate sprayers, etc.)					
	Selection of pesticides that are soft on beneficial insects, pollinators and other non-target organisms					
Crop specific practices	Use of wind machines for frost protection to reduce infection sites					

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: Highbush blueberry stakeholders in British Columbia; the data reflect the 2017, 2016 and 2015 production years.

Alternaria Fruit Rot (*Alternaria alternata* and other species)

Pest information

Damage: Fruit rot and leaf spot caused by *Alternaria* spp. is usually only a problem during cold, wet periods when infections may occur. Infected fruit becomes soft with a flat, fuzzy greenish mould containing many spores. Fruit can rot before or after harvest. Leaf spots are small and are light brown to grey with a brownish red border.

Life cycle: The fungi overwinter on the ground, on twigs and on debris, as spores and mycelium. Spores produced in infected tissues in the spring are dispersed to the fruit and foliage by wind and moisture. Infection penetrates through berry injury and natural openings.

Pest management

Cultural controls: Timely harvest to avoid over-ripening and cooling the fruit immediately after harvest will reduce fruit rot. The crop is monitored for leaf infections in the spring and for fruit infections at harvest to determine the potential for disease the following spring.

Resistant Cultivars: None available.

Issues for Alternaria Fruit Rot

1. There is a need for the registration of reduced risk fungicides for alternaria fruit rot control.
2. Although alternaria fruit rot is of secondary importance in Quebec, reports of this disease have increased in recent years. There is a need to determine the prevalence and actual field losses caused by alternaria in highbush blueberry.

Anthracnose and Ripe Rot (*Colletotrichum gloeosporioides* and *C. acutatum*)

Pest information

Damage: Ripe berries develop sunken and shrivelled areas. Salmon coloured spore masses are eventually produced within these areas. Berries infected with anthracnose are unmarketable.

Life cycle: The fungus overwinters as mycelium in infected twigs and spent fruit trusses, and in the spring produces spores that are splashed onto the developing flowers and fruit. Infected fruit develop sunken lesions that ooze bright orange spores as the disease develops. Spores are spread by berry contact at harvest or via water. Fruit rot usually develops on ripe berries after harvest. Spores can also be spread on containers, flats and harvesting machines.

Pest management

Cultural controls: Practices that encourage rapid drying of the canopy such as pruning to allow good air circulation, avoiding overhead irrigation and irrigating during the early morning, will help reduce anthracnose. It is important to cool berries as soon as possible after harvest and to monitor the crop during harvest for disease. Avoiding the movement of containers and flats between farms and the transfer of unwashed harvesters from infected to healthy fields will reduce disease spread. Additional management practices for anthracnose and ripe rot are listed in *Table 5. Adoption of disease management practices in highbush blueberry production in Canada.*

Resistant Cultivars: None available.

Issues for Anthracnose and Ripe Rot

1. Management approaches for blueberry anthracnose and ripe rot that include preventative methods and the use of a predictive model for improved timing of fungicide treatments, are required.

Botrytis Blight and Grey Mould Fruit Rot (*Botrytis cinerea*)

Pest information

Damage: Botrytis attacks primarily blossoms and fruit but also causes stem blight. Infected blossoms turn brown and wilt, while infected berries shrivel and soften. Grey sporulation is often visible around the site of infection. It can develop during storage if fruit is contaminated or damaged by handling at harvest. Storage losses can result if diseased and injured berries are stored together with sound fruit.

Life cycle: Botrytis cinerea overwinters as mycelium or sclerotia in infected plant material. In the spring, numerous spores are produced in infected tissues and are wind dispersed to blossoms where primary infections occur. Cool temperatures and periods of high relative humidity favour infections. Senescing blossoms are especially susceptible to infection. Spores are spread to ripening fruit later in the season where they cause infections.

Pest management

Cultural controls: Cultural controls involve minimizing periods of wetness in the crop canopy by managing irrigation and increasing air circulation through pruning and plant spacing. The removal of infected tissues during pruning, and cooling fruit as quickly as possible after harvest will reduce the potential for disease development. Weather and field history are good indicators for infection and can be used in conjunction with monitoring for blossom infections. Modified atmosphere packaging, including managed carbon dioxide and oxygen concentrations, following rapid cooling of temperatures can reduce the growth of grey mould rot in storage. Additional management practices for botrytis blight and grey mould fruit rot are listed in *Table 5. Adoption of disease management practices in highbush blueberry production in Canada*.

Resistant Cultivars: None available.

Issues for Botrytis Blight and Grey Mold Fruit Rot

1. The resistance of Botrytis to fungicides is a primary concern in British Columbia. There is a need for the development of fungicide use patterns that minimize the potential for resistance development in pathogen populations and maximize the duration of efficacy of currently available fungicides.
2. There is a need for the registration of fungicides in new chemical groups for resistance management in Botrytis.

Monilinia Blight or Mummy Berry Disease (*Monilinia vacinii-corymbosi*)

Pest information

Damage: Mummy berry is a serious problem in highbush blueberry produced in South-coastal British Columbia. Early infection causes a wilting and discolouration of young leaves. Infected shoots wilt and turn brown. Berries discolour, dry-out and drop before harvest.

Life cycle: The fungus overwinters in mummified or '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. A secondary infection starts with the formation of conidiophores on diseased shoots which produce conidia 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: Cultural controls are aimed at burying or destroying the mummified fruit and apothecia. In early spring, mummy berries can be destroyed by raking or surface cultivating the soil around the base of the bushes. Rotovating or frequent harrowing after raking also destroys apothecia and helps bury mummies. Straw, wood chips and sawdust mulch are also used to bury mummies. Since disease is most severe where air circulation is poor, in low-lying and moist areas or beside windbreaks, creating openings in windbreaks may reduce infections; however, care must be taken with this approach as it may result in increased winter injury. Bud development and the presence of primary infections, mummy berries and apothecia, can be monitored to predict the need and timing for sprays. Additional management practices for monilinia blight or mummy berry disease are listed in *Table 5. Adoption of disease management practices in highbush blueberry production in Canada.*

Resistant Cultivars: None available.

Issues for Mummy Berry

1. The registration of biological and reduce risk chemical products suitable for use in organic systems is required for mummy berry control.
2. Almost all fungicides registered for mummy berry belong to a single classification group (Group 3). While resistance development has not been a concern to date, the registration of new chemistries is required to reduce this risk.

Godronia (Fusicoccum) Canker (*Fusicoccum putrefaciens*)

Pest information

Damage: Godronia canker affects new wood. Infected branches are killed, reducing highbush 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 management or avoidance of godronia canker include pruning-out and destroying infected branches. Pruning will also promote good air movement around plants and facilitate foliar drying. Practices that minimize the duration of foliar wetness such as avoiding evening over-head irrigation in infected fields or timing irrigation during early morning so plants can dry quickly, will minimize infections and godronia spread. Additional management practices for godronia canker are listed in *Table 5. Adoption of disease management practices in highbush blueberry production in Canada*.

Resistant Cultivars: Rubel and Rancoccas are resistant cultivars.

Issues for Godronia Canker

1. There is a need to promote good cultural practices that reduce the incidence of the disease.
2. There is a need to register fungicides for the control of godronia canker.

Phytophthora Root and Crown Rot (*Phytophthora cinnamomi*)

Pest information

Damage: Phytophthora spp. destroy plant roots and eventually causes crown death. Leaves of infected plants become yellow or scorched and stunted. This disease is often seen in patches corresponding to areas where the soil is poorly drained. Disease severity can be compounded by secondary soil pathogens such as *Pythium* species.

Life cycle: Phytophthora spp. can persist for many years as chlamydospores (resting spores) or oospores (sexual spores) which, under wet conditions and poor soil drainage, give rise to motile zoospores that swim on moisture films and infect plant roots.

Pest management

Cultural controls: It is important that disease-free nursery stock be planted to prevent the introduction of *Phytophthora* spp. into the field. Good soil drainage will prevent the development of phytophthora root rot. In new plantings, the installation of subsurface drainage where needed and avoidance of deep planting will minimize the development of phytophthora diseases. In established plantings, careful management of irrigation to avoid excessive soil moisture and preventing other stresses such as fertilizer or herbicide burn can reduce disease development. Removal of infected plants from the field can also help.

Resistant Cultivars: None available.

Issues for Phytophthora Root and Crown Rot

None identified.

Blueberry Scorch Virus (BlScV)

Pest information

Damage: Blueberry scorch virus causes blighting and dieback of shoots and blossoms in the spring, a reduction in fruit production and eventual death of the plant in highly susceptible varieties. Infected bushes can remain symptomless for one to two years. In some varieties, fruit production can drop drastically three years after infection.

Life cycle: Both symptomatic and asymptomatic plants can be a source of virus. Aphids, primarily the blueberry aphid, are the main vectors of this disease. The disease can also be spread in cuttings used for vegetative propagation taken from infected plants and through the movement of infected nursery stock. There are several strains of BlScV and at least five strains have been identified in British Columbia.

Pest management

Cultural controls: The planting of virus-free stock will prevent the introduction of the disease into the field. Lady beetles will provide some control of aphids which vector the virus, and this may reduce the disease spread. Monitoring blueberry fields starting at bloom for symptoms of blueberry scorch and laboratory testing of plants with suspicious symptoms will enable growers to remove and destroy infected plants. This practice does not provide complete protection since infected plants are symptomless the first year or two of infection. Additional management practices for blueberry scorch virus are listed in *Table 5. Adoption of disease management practices in highbush blueberry production in Canada.*

Resistant Cultivars: All highbush blueberry cultivars are susceptible to blueberry scorch, however, cvs. Duke and Bluecrop have subtle, relatively minor symptoms when infected.

Issues for Blueberry Scorch Virus

1. Effective controls to minimize the spread of blueberry scorch virus are available, but further research on disease diagnosis is needed.
2. It is important that all nursery stock available to growers be certified free of virus diseases to prevent the introduction of viruses into new fields.

Blueberry Shock Virus (BlShV)

Pest information

Damage: Blueberry shock virus (BlShV) causes flowers and new shoots of affected plants to blight rapidly in the spring. Affected plants produce a second flush of foliage and appear normal by the end of the growing season although they do not produce fruit. Blueberries infected with shock virus display dramatic symptoms for one to four years, after which they appear to recover. However, the virus remains in the plant, and the bush continues to serve as a source of viral inoculum.

Life cycle: The virus spreads rapidly via contaminated planting stock, and insects carrying infected pollen to healthy plants.

Pest management

Cultural controls: Planting only certified, virus-free stock in new areas will prevent the introduction of the virus, and avoiding the establishment of blueberry bushes next to virus-infected fields will minimize the likelihood of disease spread to new plantings. Laboratory testing for correct diagnosis of the virus is available, and can be used on plants showing suspicious symptoms to differentiate between plants infected with blueberry scorch virus. Management of bees used for pollination to ensure they are not being moved from infected to clean fields will minimize this possible route of disease spread.

Resistant Cultivars: None available.

Issues for BIShV

1. Shock virus is a cause for concern for blueberry growers as it appears to spread rapidly in the field. The long-term effect of BlShV on yield and plant vigour needs to be determined.

Tomato Ringspot Virus (ToRSV)

Pest information

Damage: Highbush blueberry bushes infected with the ToRSV virus show a gradual decline in productivity and eventually may die. Foliage of infected plants develops symptoms similar to mosaic virus disease.

Life cycle: ToRSV is spread by soilborne nematodes, *Xiphinema* spp. *(*dagger nematode*).* These parasites transmit the virus by piercing the wall of root cells to feed. This viral infection tends to spread very slowly as nematodes move in water films around soil particles.

Pest management

Cultural controls: The use of virus-free planting stock is the foundation of practices to avoid introduction of the disease into blueberry fields. The removal of infected plants and symptomless plants in the immediate vicinity of the infected plants, along with soil treatment (fumigation) to control nematodes can help limit the spread of this disease. Avoiding new plantings near an infested field and testing of soil for the presence of dagger nematodes in areas selected for new plantings to avoid areas of potential for the development of this viral disease are good practices.

Resistant Cultivars: Varieties vary in their susceptibility to ToRSV.

Issues for ToRSV

1. Studies are required on the identification and management of vectors of ToRSV.
2. It is important that all planting stock available to growers be certified free of viruses to prevent the introduction of virus diseases into the field.
3. Further information is required on the identification and management of virus diseases in the field.

Blueberry Stunt Disease (Phytoplasma)

Pest information

Damage: Blueberry plants infected with blueberry stunt develop shortened internodes which give the plant a bushy appearance. Leaves develop interveinal and marginal yellowing and slight downward cupping. By fall, yellowed leaves become bright red. Ripening of fruit on infected bushes is delayed or does not occur.

Life cycle: The phytoplasma is present in sapwood and once infected the blueberry bush remains permanently infected. The phytoplasma is spread through infected cuttings and by leafhoppers, primarily sharp-nosed leafhoppers (*Scaphytopius* spp.). The leafhopper is present throughout the growing season with peak numbers occurring after harvest.

Pest management

Cultural controls: The planting of blueberry bushes certified free of the phytoplasma will minimize the chances of introduction of the phytoplasma into the field. The presence of sharp-nosed leafhoppers can be monitored throughout the growing season with the use of yellow sticky traps and leafhopper controls can be implemented to eliminate disease spread. Infected bushes are typically removed and destroyed.

Resistant Cultivars: None identified. Cultivars differ in their susceptibility.

Issues for Blueberry Stunt

1. It is important that all blueberry planting stock available to growers be certified free of phytoplasma diseases.
2. Additional information is needed on the identification and management of the disease in the field.

Witches' Broom (*Pucciniastrum geoppertianum*)

Pest information

Damage: Broom-like masses of thickened, spongy shoots with few leaves develop on branches and crowns of affected plants in the spring. Affected shoots do not produce fruit. The bark of affected shoots eventually becomes dry and cracked.

Life cycle: The pathogen has a complex life cycle that involves blueberry and balsam fir. Rust spores produced on balsam fir are wind-blown to blueberry in mid to late summer and infect leaves and stems. The fungus overwinters as teliospores (resting spores) produced on infected blueberry shoots ('witches' brooms') within a blueberry field. In the spring, different spore types are produced on the brooms, germinate and are transported by wind to balsam fir where they attack young needles. During the summer, more spores are blown back to blueberry plants where they attack the epidermis of blueberry stems. The witches' broom is a perennial blueberry disease and its spores can only attack balsam fir.

Pest management

Cultural controls: The removal of balsam fir within the vicinity of the plantation will help to break the life cycle of the pathogen but may not be practical in some locations. Infected blueberry plants are typically removed and destroyed.

Resistant Cultivars: None are truly resistant but less susceptible cultivars exist.

Issues for Witches' Broom

None identified.

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

Active ingredients registered for the management of **diseases** in highbush blueberry are listed below in Table 6 *Fungicides, bactericides and biofungicides registered for disease management in highbush blueberry production in Canada*. This table also provides registration numbers for **products registered on highbush blueberry as of December 11, 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 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 highbush blueberry production in Canada

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
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 oxisdase) at Q0site (cyt b gene)C14-demethylase in sterol biosynthesis (erg11/cyp51)	R + R
benzovindiflupyr	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 bio-fungicides registered for disease management in highbush 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	15723, 28900, 29306, 29355, 29356	chloronitrile (phthalonit+C41:O41rile)	M05	multi-site contact activity	multi-site contact activity	R (RVD2018-11)
copper (present as copper oxychloride)	13245, 19146	inorganic (electrophile)	M01	multi-site contact activity	multi-site contact activity	R
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 bio-fungicides registered for disease management in highbush 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)
fenbuconazole	27294	triazole	3	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	R
fenhexamid	25900	hydroxyanilide	17	G3: sterol biosynthesis in membranes	3-keto reductase, C4-demethylation (erg27)	RE
ferbam	20136, 20536	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	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

… continued

Table 6. Fungicides, bactericides and bio-fungicides registered for disease management in highbush 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]
fluxapyroxad	30565, 31697	pyrazole-4-carboxamide	7	C2: respiration	complex II: succinate-dehydrogenase	R
fosetyl-Al	24458, 27688	ethyl phosphonate	P07	P7: host plant defence induction	phosphonate	RE
hydrogen peroxide + peroxyacetic acid	32907	inorganic	N/A	unknown	unknown	R (RVD2018-09, RVD 2018-10)
isofetamid	31758	phenyl-oxo-ethyl thiophene amide	7	C2: respiration	complex II: succinate-dehydrogenase	R
lime sulphur (calcim polysulphide)	16465	inorganic	M02	multi-site contact activity	multi-site contact activity	R
metalaxyl-M and S-isomer	25384, 28474	acylalanine	4	A1: nucleic acids synthesis	RNA polymerase I	R
metam-sodium	6453, 19421, 25103, 28247, 29128, 29142	methyl isothiocyanate generator	8F[4]	miscellaneous non-specific (multi-site) inhibitor[4]	miscellaneous non-specific (multi-site) inhibitor[4]	R (RVD2018-33)
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

… continued

Table 6. Fungicides, bactericides and bio-fungicides registered for disease management in highbush 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]
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
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

…continued

Table 6. Fungicides, bactericides and bio-fungicides registered for disease management in highbush 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]
Reynoutria sachalinensis (extract)	30199	complex mixture, ethanol extract (anthraquinones resveratrol)	P05	P5: host plant defence induction	anthraquinone elicitors	R
sulphur	16465	inorganic (electophiles)	M02	multi-site contact activity	multi-site contact activity	R
tea tree oil (*Melaleuca alternifolia*)	30910	terpene hydrocarbons and terpene alcohols	46	F7: lipid synthesis and membrane integrity	cell membrane disruption (proposed)	R
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 11, 2018.** While every effort has been made to ensure all fungicides, bactericides and biofungicides registered in Canada on highbush 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

- Spotted wing drosophila (SWD) can cause significant crop losses in blueberry. The development of effective management strategies that integrate sprays for SWD with those for other pests such as aphids, to reduce the overall frequency of insecticide sprays, is required.
- The registration of new chemistries is required for spotted wing drosophila control and to reduce the potential for the development of resistance to available insecticides within the pest population.
- There is a need to develop reduced risk approaches to the management of spotted wing drosophila including exclusion netting, mass trapping, attract and kill technologies and the introduction of sterile males, etc.
- International standardization of Maximum Residue Levels (MRLs) for commonly used highbush blueberry pesticides would be helpful to the industry.

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

Insect and mite	British Columbia	Quebec
Aphids (general)		
Blueberry aphid		
Heath spittlebug		
Leafhoppers		
Blueberry Thrips		
Brown marmorated stinkbug		
Blueberry gall midge (Cranberry tipworm)		
Blueberry maggot		
Spotted wing drosophila		
Cherry fruitworm		
Spring feeding caterpillars		
Bruce spanworm		
Winter moth		
Obliquebanded leafroller		
European leafroller		
Obliquebanded leafroller (summer generation)		
Black vine weevil		
Rose chafer		
European chafer		
Japanese beetle		

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: Highbush blueberry stakeholders in reporting provinces (British Columbia and Quebec); 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 highbush blueberry production in Canada[1]

	Practice / Pest	Aphids	Blueberry gall midge (cranberry tip worm)	Spring feeding caterpillars	Spotted wing drosophila	Root weevils
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)					
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					

…continued

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

Practice / Pest		Aphids	Blueberry gall midge (cranberry tip worm)	Spring feeding caterpillars	Spotted wing drosophila	Root weevils
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					
Decision making tools	Economic threshold					
	Use of predictive model for management decisions					
	Crop specialist recommendation or advisory bulletin					
	Decision to treat based on observed presence of pest at susceptible stage of life cycle					
	Use of portable electronic devices in the field to access pest identification / management information					

…continued

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

Practice / Pest		Aphids	Blueberry gall midge (cranberry tip worm)	Spring feeding caterpillars	Spotted wing drosophila	Root weevils
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					

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: Highbush blueberry stakeholders in British Columbia; the data reflect the 2017, 2016 and 2015 production years.

Aphids: Blueberry Aphids (*Ericaphis fimbriata*) and Other Species

Pest information

Damage: Aphids feed on new shoots by sucking plant sap. Feeding by high populations may cause deformities and wilting or make the fruit unmarketable because of honeydew and associated sooty mould. Aphids are vectors of blueberry scorch virus.

Life cycle: Aphids overwinter as eggs near buds on stems. The eggs hatch from late February to the end of March in the Fraser Valley of British Columbia and in May throughout Eastern Canada. Young, wingless aphids (nymphs) begin to feed on blossoms and growing shoots. Throughout the season, aphids bear live, female young without mating. Males develop in the fall and after mating, the females produce the overwintering eggs.

Pest management

Cultural controls: The avoidance of excessive vegetative growth favourable for aphids can be managed by reducing nitrogen applications. In fields at low risk of viral infection, insecticides are not generally applied for aphids because natural enemies usually provide adequate control. A number of native, beneficial insects feed on or parasitize aphids including ladybeetles (*Hippodamia convergens),* lacewings (Neuroptera), syrphid flies (*Episyrphus balteatus)* and small parasitic wasps (*Aphelinus mali).* Scouting and trapping and assessment for economic thresholds can help decision-making for timely treatment application, should this become necessary. Additional management practices for aphids are listed in *Table 8. Adoption of insect pest management practices in highbush blueberry production in Canada1*.

Resistant Cultivars: None identified.

Issues for Blueberry Aphid

1. The effect of sprays for spotted wing drosophila on aphid populations needs to be determined so that treatments for these pests may be combined. The goal is to reduce the overall number of sprays.

Blueberry (Heath) Spittlebug (*Clastoptera saintcyri*)

Pest information

Damage: The spittlebug feeds by sucking plant sap. Larvae secrete a white foam-like substance (spittle) which provides a protective covering as they feed. Adults do not produce spittle. Plant vigour can be reduced if populations are high. Feeding wounds can be an entry site for pathogens. The insect can also be a nuisance during harvest.

Life cycle: The spittlebug has one generation per year and it overwinters as eggs in the bark of the host plant. Eggs hatch in the spring and the young nymphs secrete the spittle and begin to feed. The nymphs develop through five larval stages after which the adult emerges.

Pest management

Cultural controls: Natural control agents exist and are effective. Economic thresholds for blueberry spittle bugs have not been determined, however chemical control is rarely needed.

Resistant Cultivars: None available.

Issues for Blueberry Spittlebug

None identified.

Leafhoppers: Sharp-nosed Leafhoppers (*Scaphytopius spp.*) and Other Species

Pest information

Damage: Leafhoppers feed by sucking plant sap. During feeding, leafhoppers may pick up the blueberry stunt phytoplasma from infected plants and transmit it to healthy ones. Sharp-nosed leafhoppers (*Scaphytopius spp.*) are key vectors of the blueberry stunt phytoplasma but other species including the potato leafhopper (*Empoasca fabae*), *Limotettix corniculus* and the aster leafhopper (*Macrosteles quadrilineatus*) may also transmit the pathogen.

Life cycle: Sharp-nosed leafhoppers overwinter as eggs in leaf tissue. They develop from egg through five nymphal stages (instars) to adult and have one to two generations per year. Adults of the aster leafhopper and potato leafhopper overwinter in the United States and are carried by winds to Canada in the spring. They may have three to five and two to four generations per year respectively.

Pest management

Cultural controls: Leafhoppers may be monitored through the use of yellow sticky traps. Economic thresholds have not been established for leafhoppers. It is important to identify the leafhopper species present in a field and to establish whether it is a vector of blueberry stunt phytoplasma, to determine whether controls are necessary.

Resistant Cultivars: None available.

Issues for Leafhoppers

None identified.

Blueberry Gall Midge (Cranberry Tipworm) (*Dasineura oxycoccana*)

Pest information

Damage: Blueberry gall midge larvae feed on vegetative and floral buds. Feeding on buds of shoot tips may cause unwanted branching of new growth. This is particularly a problem in young plantings, as they may take longer to reach suitable heights for machine harvesting.

Life cycle: The adult is a very small fly that lays its eggs on the growing tips of plants. The larvae feed within the buds and when fully grown, at the third instar, they drop to the soil to pupate. They overwinter as pupae and emerge as adult flies in the spring. There can be several generations per year.

Pest management

Cultural controls: Monitoring through scouting and tracking can help to determine if the pest reaches economic threshold levels. Targeted pesticide applications are sometimes used by growers. Additional management practices for blueberry gall midge are listed in *Table 8. Adoption of insect pest management practices in highbush blueberry production in Canada.*

Issues for Blueberry Gall Midge

1. Blueberry gall midge remains of concern in British Columbia.

Blueberry Maggot (*Rhagoletis mendax*)

Pest information

Damage: The blueberry maggot is present only in Eastern Canada. The larvae of the blueberry maggot develop within the fruit making it unmarketable. If left uncontrolled, almost all of the fruit in a field may be infested. There is zero tolerance for blueberry maggots in most fresh markets.

Life cycle: The adult is a medium-sized fly that inserts its eggs directly into ripening fruit. The larvae feed and develop within the fruit. Infested berries usually drop prematurely. Larvae exit the fruit and pupate in the soil, where they overwinter. There is one generation per year.

Pest management

Cultural controls: Cultural controls include completely harvesting the crop (clean picking), eliminating all crop debris, and controlling weeds that provide shelter for adult flies. Yellow sticky boards and pheromone traps may be used to monitor for the presence of blueberry maggot adults and to establish whether sprays are needed. 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 in pest-free areas within 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.

Resistant Cultivars: None available.

Issues for Blueberry Maggot

1. Preventative measures must continue to be implemented to prevent the introduction of this pest into non-infested areas.

Spotted Wing Drosophila (*Drosophila suzukii*)

Pest information

Damage: The spotted wing drosophila (SWD) can attack many types of berries and stone fruits. 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.

Life cycle: SWD overwinters as adult flies. The flies become active in the spring when they mate and lay eggs in mature fruits. Unlike other fruit flies, female SWD have a serrated ovipositor that enables them to lay eggs in unblemished, ripening fruit. After hatching, larvae feed internally within fruit. Pupation takes place within or outside the fruit. There can be up to five overlapping generations 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 also the removal of nearby, wild, alternate hosts, will help to reduce the SWD populations. Flies can be monitored through the use of apple cider vinegar baited traps which can also be used to monitor earlier fruiting hosts in the vicinity of the blueberry field for signs of SWD attack. Additional practices used for the management of SWD include: mulching and mowing alley ways; pruning out of infested material; weather monitoring for degree-day modelling of population; scouting, trapping and the use of economic thresholds for making spray decisions. Additional management practices for spotted wing drosophila are listed in *Table 8. Adoption of insect pest management practices in highbush blueberry production in Canada.*

Resistant Cultivars: None available.

Issues for Spotted Wing Drosophila

1. SWD can cause significant crop losses in blueberry. Effective management strategies that minimize the frequency of chemical sprays are required.
2. The registration of new chemistries is urgently required for control of SWD and for resistance management.

Cherry Fruitworm (*Grapholitha packardii*)

Pest information

Damage: The cherry fruitworm feeds on blueberry fruit. This fruitworm feeds inside the fruit with one larva damaging one to two berries.

Life cycle: Mature larvae of the cherry fruitworm overwinter under bark. The cherry fruitworm adult lays eggs on the leaves around blossom time. Once the eggs hatch, the larvae feed within the berries but remain hidden. This fruitworm has one generation per year.

Pest management

Cultural controls: Pheromone traps are used to monitor adult activity and to time insecticide sprays. Fruit and leaves may be monitored for eggs beginning in mid-May. Treatments are timed in order to make contact with the larvae before it enters the fruit. Other practices used to manage fruitworms are perimeter spraying and targeted pesticide applications, pruning out and removal of infested material.

Resistant Cultivars: None identified. However, early maturing highbush blueberry cultivars are more vulnerable to fruitworm infestation compared to late maturing ones.

Issues for Cherry Fruitworm

1. The impact of fruitworms on crop yields needs to be determined.

Spring Feeding Caterpillars: Bruce Spanworm (*Operophthera bruceata*) and Winter Moth (*O. brumata*)

Pest information

Damage: The Bruce spanworm and winter moth are present at the same time and cause similar damage. These early-season caterpillars feed on developing blossoms and leaves and can cause complete defoliation and significant yield loss if infestations are severe.

Life cycle: Eggs hatch in the early spring and larvae feed from late March to early June, then drop to the soil and pupate. Moths emerge in the late fall and lay eggs in crevices and under the bark of host plants.

Pest management

Cultural controls: Practices to manage this pest include thinning and pruning out of infested material, perimeter spraying, equipment sanitation, and removal of alternate hosts. Scouting, trapping, and economic thresholds can help timing of treatment application. Additional management practices for spring feeding caterpillars are listed in *Table 8. Adoption of insect pest management practices in highbush blueberry production in Canada.*

Resistant Cultivars: None available.

Issues for Winter Moth and Spanworm

1. There is a need for suitable IPM friendly insecticides.

Leafrollers: Obliquebanded Leafroller (*Choristoneura rosaceana*) and European Leafroller (*Archips rosana*)

Pest information

Damage: Leafrollers feed on foliage, buds, flowers and berries throughout the growing season. Larvae feed within protective shelters made by rolling or tying leaves together with silken strands. Heavy feeding on young bushes can result in defoliation, weakening of bushes and excessive branching when growing points are damaged. Damage to the fruit itself is minimal, but leafrollers may fall into picking pails and contaminate the harvested berries.

Life cycle: The obliquebanded leafroller has two generations per year. Larvae overwinter under the bark of blueberry plants and pupate in the spring. Adult moths emerge in early summer and lay eggs on leaves. After hatching, larvae disperse by crawling or hanging on silken threads and being carried by winds to un-infested plants. When full-grown, larvae pupate and emerge as adults that lay eggs on foliage. Larvae of the second generation overwinter. The European leafroller has one generation per year. This insect overwinters as eggs on bark of the host plant. After hatching, larvae feed and when full grown, pupate within rolled leaves. Adults emerge to lay the overwintering eggs.

Pest management

Cultural controls: Pruning plantings helps to reduce numbers of leafrollers by removing over-wintering sites.

Resistant Cultivars: None identified.

Issues for Leafrollers

1. There is a need for suitable IPM friendly insecticides for management of leafrollers.

Root Weevils: Black Vine Weevil (*Otiorynchus sulcatus*) and Other Species

Pest information

Damage: Root weevil larvae feed on roots, rootlets and the basal crown area. They can be a serious problem on young blueberry plants. Adults feed on new growth and cause notching on the leaf edges. Affected bushes may become stunted, yield poorly and die.

Life cycle: Weevils have four life stages: egg, larva, pupa and adult. Larvae and adults overwinter in soil and emerge in large numbers in late June. Adult weevils do not fly, but are strong walkers and invade new plantings in July and August. Adult beetles begin to lay their eggs on the soil in June and continue until mid-September. Immediately following hatch, the larvae work through the soil and begin feeding on blueberry roots. Adults can live for more than one year.

Pest management

Cultural controls: Use of planting stock that is free of weevils will prevent the introduction of root weevils to a field. In infested fields, growing a non-host crop such as a cereal cover crop for 12 to 16 months before planting blueberries will reduce weevil numbers. A multi-year approach may be required to reduce populations of these pests once they are established. Controlling weevils in vegetation and ornamentals adjacent to the blueberry field will reduce problems due to migrating weevils. Additional practices used in the management of weevils are perimeter spraying, equipment sanitation, mowing and mulching alley ways. Tillage and cultivation of perimeter can help to reduce infestation from alternate hosts. Scouting, trapping and spraying only when economic threshold levels have been reached can minimize the number of control applications.

Resistant Cultivars: None available.

Issues for Weevils

1. The registration of control products that are effective against the larval stage is required.
2. The presence of weevils is increasing in highbush blueberry. Visual scouting is time consuming and not always reliable as adult weevils can be difficult to detect in highbush blueberry unless numbers are high and their presence may be missed if weevils are feeding on nearby, alternate host plants. Monitoring approaches that reliably detect adult emergence are required for improved timing of sprays.

White Grubs: European Chafer (*Rhizotrogus majalis*) and Japanese Beetle (*Popillia japonica*)

Pest information

Damage: The larval stages of the European chafer and the Japanese beetle commonly called white grubs, feed on the roots of blueberry. Although losses in productivity due to white grub feeding are hard to measure, they can ultimately affect the planting for many years. Damage in the early years of the planting can be particularly devastating. Chronic, sub-lethal levels of white grub feeding injury can result in an annual 50 to 80 percent crop loss on affected bushes. It is assumed that plants damaged by white grubs will eventually recover although this may take a number of years. Adult Japanese beetles begin feeding on foliage and fruit prior to harvest and can be a fruit contaminant at harvest.

Life cycle: Adult beetles lay their eggs in soil in close proximity to host plants. After hatching, larvae begin feeding on roots. The insects overwinter as larvae in the soil. Adult beetles emerge in the spring and summer and following mating, lay their eggs in the soil. European chafer and Japanese beetle have one generation per year.

Pest management

Cultural controls: Monitoring sites prior to planting, and avoiding planting blueberries where white grubs are present will reduce the likelihood of problems with these pests.

Resistant Cultivars: None available.

Issues for White Grubs

1. Effective controls for white grubs are required.
2. Japanese beetles are a big concern in the southern region of Québec, and they are spreading slowly to the eastern and northern regions. The most common management strategy used involves insecticides targeting the adults; however, the development and promotion of alternatives to the use of pesticides such as entomophagous nematodes, mass trapping, etc. is required and is a priority for growers.

Rose Chafer (*Macrodactylus subspinosus*)

Pest information

Damage: Adults feed on flower buds, growing fruits and leaves of many hosts such as grape, apple, peach, roses, blueberries and other fruits. Heavy infestation can destroy the foliage and photosynthetic capacity.

Life cycle: Larvae overwinter in the soil and adults emerge from their pupal case in late May or early June in Eastern Canada. Adults mate and feed for three to four weeks before they pupate. Females lay their eggs preferentially in a sandy soil, and they hatch in one to three weeks. Larvae feed on the roots of grasses and weeds before they burrow deep into the soil to overwinter. Rose chafer has one generation per year.

Pest management

Cultural controls: Traps baited with floral scents can be used to trap adults. Surface cultivation or harrowing around plants expose larvae. Removing weeds near blueberry plants can decrease the potential for damage to the roots of blueberry plants. Avoiding the placement of new blueberry plantations in sandy soils will reduce rose chafer reproduction and population levels.

Resistant Cultivars: None available.

Issues for Rose Chafer

None identified.

Brown Marmorated Stink Bug (*Halyomorpha halys*)

Pest information

Damage: The brown marmorated stink bug (BMSB) is an invasive alien insect, and has caused significant crop injury in the Mid-Atlantic States where large populations have become established in agricultural crops. Although the insect is present in parts of Canada, infestations have not yet been detected on a large scale in Canadian commercial agricultural settings. This insect has a broad host range including tree fruit, berries, grapes, ornamentals, grain crops, tomatoes, peppers and sweet corn. Injury is caused by feeding of adults and nymphs. BMSB injects saliva with digestive enzymes into the plant and ingests the liquefied plant material. Each feeding puncture results in crop injury. In blueberries, feeding on fruit can result in sunken brown lesions, decreasing its value for the fresh market.

Life cycle: BMSB spreads through natural means and also as a “hitchhiker” in cargo and vehicles. It is known to readily move among host crops throughout the growing season. BMSB overwinters as adults. In the spring, adults mate and lay eggs on host plants. Both nymphs and adults feed on host plants. Adults are long-lived and females may lay several hundred eggs over an extended period of time. In the fall, adults move back to protected overwintering sites. They have frequently entered structures in the fall where they are a nuisance pest.

Pest management

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

Resistant Cultivars: None available.

Issues for BMSB

1. There is a need for an increased understanding of the biology and the behaviour of the BMSB.
2. There is a need for the registration of effective control products and the development of integrated management approaches for BMSB.

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

Active ingredients registered for the management of **insects and mites** in highbush blueberry are listed below in Table 9 *Insecticides, miticides and bioinsecticides registered for the management of insect pests in highbush blueberry production in Canada*. This table also provides registration numbers for **products registered on highbush blueberry as of December 11, 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 the management of insect pests in highbush 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
bifenthrin	31396	pyrethroid, pyrethrin	3A	sodium channel modulator	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

…continued

Table 9. Insecticides, miticides and bioinsecticides registered for the management of insect pests in highbush 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]
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)
ferric sodium EDTA	28774	not classified	N/A	unknown	R
flupyradifurone	31452	butenolide	4D	nicotinic acetylcholine receptor (nAChR) competitive modulator	R
imidacloprid	24094, 28475, 28726, 29048	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
lime sulphur or calcium polysulphide	16465	not classified	N/A	unknown	R
malathion	8372	organophosphate	1B	acetylcholinesterase (AChE) inhibitor	R

…continued

Table 9. Insecticides, miticides and bioinsecticides registered for the management of insect pests in highbush 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]
methoxyfenozide	27786	diacylhydrazine	18	ecdysone receptor agonist	R
methyl bromide	9564	alkyl halide	8A	miscellaneous non-specific (multi-site) inhibitor	PO[5]
mineral oil	9542, 14981, 27666, 33099	not classified[4]	N/A	unknown	R
novaluron	28515, 28881	benzoylurea	15	inhibitor of chitin biosynthesis affecting CHS1	R
permethrin	14882, 16688, 28877	pyrethroid, pyrethrin	3A	sodium channel modulator	RE
phosmet	23006, 29064	organophosphate	1B	acetylcholinesterase (AChE) inhibitor	RE
potassium salts of fatty acids	14669, 27886, 28146, 31433	not classified	N/A	unknown	R
pymetrozine	27274	pyridine azomethine derivative	9B	chlorodontal organ TRPV channel modultor	RES
pyrethrin	30164	pyrethroid, pyrethrin	3A	sodium channel modulator	RE
spinetoram	28777, 28778	spinosyn	5	nicotinic acetylcholine receptor (nAChR) allosteric modulator - site 1	R

…continued

Table 9. Insecticides, miticides and bioinsecticides registered for the management of insect pests in highbush 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]
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
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 the management of insect pests in highbush 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					
(Z,Z)-3,13-octadecadien-1-yl acetate + (E,Z)-2,13-octadecadien-1-yl acetate + (Z,Z)-3,13-octadecadien-1-ol + (E,Z)-2,13-octadecadien-1-ol	30589	not classified	N/A	pheromone - mating disruption for dogwood borer (*Synanthedon scitula*)	R (RVD2018-28)

[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 11, 2018.** While every effort has been made to ensure all insecticides, miticides and biopesticides registered in Canada on highbush 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

- The development of bioherbicides and non-chemical approaches to weed control for organic highbush blueberry production is needed.
- There is a need for the dissemination of information on the use of mulches and mechanical tillers for weed management.
- International standardization of Maximum Residue Levels (MRLs) for commonly used highbush blueberry pesticides would be helpful to the industry.

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

Weeds	British Columbia	Quebec
Annual broadleaf weeds		
Annual grass weeds		
Perennial broadleaf weeds		
Perennial grass weeds		
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: Highbush blueberry stakeholders in reporting provinces (British Columbia and Quebec); 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 highbush blueberry production in Canada[1]

Practice / Pest		Annual broadleaf weeds	Annual grass weeds	Perennial broadleaf weeds	Perennial grass weeds
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 highbush blueberry production in Canada[1] (continued)

Practice / Pest		Annual broadleaf weeds	Annual grass weeds	Perennial broadleaf weeds	Perennial grass weeds
Decision making tools	Economic threshold				
	Crop specialist recommendation or advisory bulletin				
	Decision to treat based on observed presence of weed at susceptible stage of development				
	Decision to treat based on observed crop damage				
	Use of portable electronic devices in the field to access weed identification / management information				
Suppression	Use of diverse herbicide modes of action for resistance management				
	Soil amendments and green manuring involving soil incorporation as biofumigants to reduce weed populations				
	Use of biopesticides (microbial and nonconventional pesticides)				
	Release of arthropod biological control agents				
	Mechanical weed control (cultivation / tillage)				
	Manual weed control (hand pulling, hoeing, flaming)				
	Use of stale seedbed approach				
	Targeted pesticide applications (banding, spot treatments, use of variable rate sprayers, etc.)				
	Selection of herbicides that are soft on beneficial insects, pollinators and other non-target organisms				
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: Highbush blueberry stakeholders in British Columbia; the data reflect the 2017, 2016 and 2015 production years.

Weeds

Pest information

Damage: Annual and perennial grasses and broadleaf weeds compete with blueberries for nutrients, water and light and serve as alternate hosts for insects and diseases. They also interfere with irrigation and harvest operations. Flowering weeds compete with the crop for bee visitations. In addition, weeds reduce air circulation, thus increasing the likelihood of cane, fruit and foliar diseases. Many weeds are also hosts to nematode species, a number of which are vectors to virus diseases.

Life cycle: **Summer annual** weeds germinate in the spring, flower and set seed in the summer or fall, and die before the onset of winter. **Winter annual** weeds germinate in the fall, overwinter in a vegetative state, flower in the spring, form seeds and die.
Simple perennials regenerate each year from a root or crown tissues and reproduce by flowering and setting seed. **Creeping perennials** can regenerate from roots, shoots and other structures and can also reproduce by flowering. Broken root pieces, tubers and rhizomes can give rise to a new weed.

Pest management

Cultural controls: By managing **annual weeds** in headlands and other non-productive areas and by preventing them from setting seed on crop land, growers can gradually decrease the reservoir of weed seeds in their fields. Hand weeding, hoeing and mulches can be used to control weeds within the row. Materials that can be used for mulching include sawdust, wood shavings, grass clippings, weed-free hay, clean straw and chicken manure. Tillage will help control weeds between the rows but must be shallow to avoid damaging blueberry roots. Cover crops may be grown between rows to reduce weed growth, as well as to provide leaching and erosion protection. Control of **perennial weeds** before planting will help to reduce the pressure from these weeds over time. Prior to planting new fields, perennial weeds may be controlled by cultivation and herbicide treatments. Herbicides and cultural practices used in rotational crops will help manage perennial weeds in blueberries. Serious perennial infestations require persistent control for many years. Following strict sanitation procedures will reduce the spread of perennial roots, tubers or rhizomes in soil and water and on field equipment. Additional management practices for weeds are listed in *Table 11. Adoption of weed management practices in highbush blueberry production in Canada*.

Issues for Weeds

1. The further development of non-chemical approaches to weed management, including bioherbicides, is required.

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

Active ingredients registered for the management of **weeds** in highbush blueberry are listed in *Table 12 Herbicides and bioherbicides registered for weed management in highbush blueberry production in Canada*. This table also provides registration numbers for **products registered on highbush blueberry as of December 11, 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 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 the management of weeds in highbush 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]
2,4-D	5931, 17511	phenoxy-carboxylic-acid	4	synthetic auxin	R (REV2017-08)
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
clethodim	22625, 27598, 28224, 29277, 31496	cyclohexanedione 'DIMs'	1	inhibition of acetyl CoA carboxylase (ACCase)	R
clopyralid	23545, 30620	pyridine carboxylic acid	4	synthetic auxin	R
dichlobenil	12533	nitrile	20	inhibition of cell wall synthesis site A	R
fluazifop-P	21209	aryloxyphenoxy-propionate 'FOP'	1	inhibition of acetyl CoA carboxylase (ACCase)	R

…continued

Table 12. Herbicides and bioherbicides registered for the management of weeds in highbush 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]
flumioxazin	29231, 29235	N-phenylphthalimide	14	inhibition of protoporphyrinogen oxidase (Protox, PPO)	R
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
halosulfuron-methyl	31209	sulfonylurea	2	inhibition of acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS)	R

…continued

Table 12. Herbicides and bioherbicides registered for the management of weeds in highbush 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]
indaziflam	30220, 30221, 30451	not specified	29	Inhibition of cell wall synthesis site C	R
mesotrione	27833, 32958	triketone	27	inhibition of 4-hydroxyphenyl-pyruvate-dioxygenase (4-HPPD)	R
metam-sodium	6453, 19421, 25103, 28247, 29128, 29142	methyl isothiocyanate generator	8F[5]	miscellaneous non-specific (multi-site) inhibitor[4]	R (RVD2018-33)
metribuzin	17242, 20968, 32081	triazinone	5	inhibition of photosynthesis at photosystem II site A	R
napropamide	25230, 25231, 31081, 31688	acetamide	15	inhibition of mitosis	R
oxyfluorfen	24913	diphenylether	14	inhibition of protoporphyrinogen oxidase (Protox, PPO)	R
paraquat	8661, 33125	bipyridylium	22	photosystem-I-electron diversion	R

…continued

Table 12. Herbicides and bioherbicides registered for the management of weeds in highbush 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]
rimsulfuron	23983, 30057	sulfonylurea	2	inhibition of acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS)	R
s-metolachlor and R-enantiomer	25728, 25729, 29347	chloroacetamide	15	inhibition of mitosis	RE
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

…continued

Table 12. Herbicides and bioherbicides registered for the management of weeds in highbush 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 accelerates apple 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 active ingredients registered as of December 11, 2018.** While every effort has been made to ensure all herbicides, bioherbicides and plant growth regulators registered in Canada on highbush 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*.

Mollusc Pests

Slugs and Snails

Snails and slugs cause problems when they are present on bushes, as they can contaminate harvested fruit particularly when mechanical harvesting is used. Snails that are the same size as blueberries cannot be removed mechanically. Berries harbouring contaminants can be downgraded or rejected by buyers. Snails climb into the blueberry bushes and eat moss and lichens on their branches. Occasionally they eat the leaves and berries. Their protective shells allow them to stay in the bushes during the day.

Weed control can help to reduce slug and snail populations. When slug and snail populations are high, they are typically controlled through the use of baits before they climb into the plants.

Vertebrate Pests

Birds (starlings, crows, robins, songbirds and blackbirds)

Pest information

Damage: Birds are a significant concern to the industry, because they feed on berries close to harvest. The amount of bird damage each year is variable and unpredictable. Starlings are the most common bird pests of British Columbia blueberry fields and crows are also a major concern in some areas. As the berries ripen, incoming flocks of starlings eat the fruit before it is harvested. Starlings learn the locations of good feeding sites and return repeatedly.

Cultural controls: In most blueberry fields, a variety of control methods are used to deter birds including netting over the bushes, visual scare devices (scarecrows, balloons, streamers, flash tape, model predators) and noisemakers (propane cannons, distress calls and predator calls). Netting is the most effective way to keep birds out of the field; however, it is not always cost-effective. Visual scaring devices are most effective when used together with noise scaring devices. The use of predatory birds such as falcons has been successful on a few farms in Ontario to minimize bird nesting and feeding on blueberries.

Issues for Birds

None identified.

Voles

Vole numbers can fluctuate widely, but when numerous, can cause severe damage. Voles (also known as field mice) chew the stems and roots of blueberries, often girdling the stems. Plant vigour and yields may be reduced and plants may be killed. The damage occurs most commonly from fall to early spring. Below ground injury is not noticeable until poor growth becomes apparent in the spring.

Vole injury can be reduced by management of vegetation along field borders and within the blueberry row. Poison baits may be used if preventative control measures are ineffective. Covered bait stations are used to protect bait from weather and to prevent accidental poisoning of other animals.

Issues for Voles

None identified.

Resources

Integrated pest management / integrated crop management resources for highbush blueberry production in Canada

Agri-Réseau, Québec.
www.agrireseau.qc.ca

British Columbia Ministry of Agriculture and Lands. *Berry information*.
www2.gov.bc.ca/gov/content/industry/agriculture-seafood/animals-and-crops/crop-production/berries

British Columbia Ministry of Agriculture and Lands. 2012-2013 Berry Production Guide, *Beneficial Management Practices for BC Berry Growers*.
www2.gov.bc.ca/gov/content/industry/agriservice-bc/production-guides

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

Centre de référence en agriculture et agroalimentaire du Québec (CRAAQ).
www.craaq.qc.ca

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. Publication 360, *Guide to Fruit Production, 2018-19*.
www.omafra.gov.on.ca/english/crops/pub360/p360toc.htm

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

Provincial Crop Specialists and Minor Use Coordinators in Highbush Blueberry Producing Provinces

Province	Ministry	Crop Specialist	Minor Use Coordinator
British Columbia	British Columbia Ministry of Agriculture www.gov.bc.ca/agri	Carolyn Teasdale Industry Specialist, Berries carolyn.teasdale@gov.bc.ca	Caroline Bédard caroline.bedard@gov.bc.ca
Ontario	Ontario Ministry of Agriculture and Food www.omafra.gov.on.ca	Erica Pate Fruit Crop Specialist erica.pate@ontario.ca	Jim Chaput jim.chaput@ontario.ca
Québec	Ministère d'Agriculture, Pêcheries et Alimentation du Québec www.mapaq.gouv.qc.ca	Christian Lacroix Agronome christian.lacroix@mapaq.gouv.qc.ca Caroline Turcotte Fruit Crop Specialist caroline.turcotte@mapaq.gouv.qc.ca	Mathieu Coté mathieu.cote@mapaq.gouv.qc.ca
Nova Scota	Nova Scotia Department of Agriculture www.novascotia.ca/agri/	Jennifer Haverstock Perennia (www.perennia.ca) jhaverstock@perennia.ca	Jason Sproule jason.sproule@novascotia.ca

National and Provincial Fruit Grower Organizations

Provincial:

BC Blueberry Council
www.bcblueberry.com

North American Blueberry Council
www.nabcblues.org

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

The Association of Producers of Highbush Blueberries: Valley of Upper St. Lawrence (Quebec)
http://bleuetsdelavallee.ca/en/the-blueberry/health/

National:

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>Colour Code</th></tr>
<tr><td rowspan="12">Present</td><td rowspan="9">Data available</td><td>Frequency</td><td>Distribution</td><td>Pressure</td><td></td></tr>
<tr><td rowspan="5">**Yearly** - Pest is present 2 or more years out of 3 in a given region of the province.</td><td rowspan="3">**Widespread** - The pest population is generally distributed throughout crop growing regions of the province. In a given year, outbreaks may occur in any region.</td><td>**High** - If present, potential for spread and crop loss is high and controls must be implemented even for small populations.</td><td>Red</td></tr>
<tr><td>**Moderate** - If present, potential for spread and crop loss is moderate: pest situation must be monitored and controls may be implemented.</td><td>Orange</td></tr>
<tr><td>**Low** - If present, the pest causes low or negligible crop damage and controls need not be implemented.</td><td>Yellow</td></tr>
<tr><td rowspan="3">**Localized** - The pest is established as localized populations and is found only in scattered or limited areas of the province.</td><td>**High** - see above</td><td>Orange</td></tr>
<tr><td>**Moderate** - see above</td><td>White</td></tr>
<tr><td>**Low** - see above</td><td>White</td></tr>
<tr><td rowspan="6">**Sporadic** - Pest is present 1 year out of 3 in a given region of the province.</td><td rowspan="3">**Widespread** - as above</td><td>**High** - see above</td><td>Orange</td></tr>
<tr><td>**Moderate** - see above</td><td>Yellow</td></tr>
<tr><td>**Low** - see above</td><td>White</td></tr>
<tr><td rowspan="3">**Localized** - as above</td><td>**High** - see above</td><td>Yellow</td></tr>
<tr><td>**Moderate** -see above</td><td>White</td></tr>
<tr><td>**Low** - see above</td><td>White</td></tr>
<tr><td rowspan="2">Data **not** available</td><td colspan="3">**Not of concern:** The pest is present in commercial crop growing areas of the province but is causing no significant damage. Little is known about its population distribution and frequency in this province; however, it is not of concern.</td><td>White</td></tr>
<tr><td colspan="3">**Is of concern:** The pest is present in commercial crop growing areas of the province. Little is known about its population distribution and frequency of outbreaks in this province and due to its potential to cause economic damage, is of concern.</td><td>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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Agri-Réseau. 2017. *Fiche technique du Scarabée du rosier (Rose Chafer).* https://www.agrireseau.net/documents/Document_97157.pdf

Bristow, P.R., R.R. Martin, and G.E. Windom. 2000. *Transmission, Field Spread, Cultivar Response and Impact on Yield in Highbush Blueberry Infected with Blueberry Scorch Virus.* Phytopathology. 90: 474-479. Online.

British Columbia Ministry of Agriculture. *Berries Production Guide online: Blueberries*. http://productionguide.agrifoodbc.ca/guides/14

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https://www.agrireseau.net/documents/Document_92828.pdf

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http://www.omafra.gov.on.ca/english/crops/pub360/notes/bluestunt.htm.

Ontario Ministry of Agriculture, Food and Rural Affairs. *Blueberry maggot in Ontario*
http://www.omafra.gov.on.ca/english/crops/pub360/notes/bluemaggot.htm (accessed April 8, 2019)

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University of California. Division of Agriculture and Natural Resources. Online: *Postharvest Center Information.*
http://postharvest.ucdavis.edu/Commodity_Resources/Fact_Sheets/

University of Vermont, Extension. Brattleboro, VT. USA. *Health and History of Highbush Blueberries.*
http://www.uvm.edu/vtvegandberry/factsheets/blueberrie.html

Washington State University Whatcom County Extension. *Integrated Pest Management for Blueberries: Leafroller, Obliquebanded leafroller (Choristoneura rosaceana) and others*. Insects and Invertebrates.
http://whatcom.wsu.edu/ipm/manual/blue/leafroller.html

Wild Blueberry Production Guide 36. *Blueberry spittlebug.*
http://perlebleue.ca/images/documents/amenagement/guideanglais/e036.pdf