Crop Profile for Highbush Blueberry in Canada, 2020

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Preface

National crop profiles are developed by the Pest Management Program of Agriculture and Agri-Food Canada (AAFC). The crop profiles provide baseline information on production and pest management practices and document growers' needs to address pest management gaps and issues for specific crops grown in Canada. This information is developed through extensive consultation with stakeholders and data collected from reporting provinces. Reporting provinces are selected based on their acreage of the target crop (>10 % of the national production) and provide qualitative data on pest occurrence and integrated pest management practices used by growers in those provinces. For highbush blueberry production, the reporting provinces are British Columbia and Quebec.

Information on pest issues and management practices is provided for information purposes only. For detailed information on growing highbush blueberries the reader is referred to provincial crop production guides and provincial ministry websites listed in the Resources Section at the end of the profile. For guidance about crop protection products registered for pests on highbush blueberry, the reader is referred to provincial crop production guides and Health Canada's Pesticide label database.

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

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

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The 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 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. Most highbush blueberries are consumed fresh or frozen.

Crop Production

Industry Overview

In 2020, blueberry (highbush and lowbush) ranked as the number two fruit crop in Canada, behind apples with respect to total production. In 2020, highbush blueberry had a farm gate value of $162 million, 59 percent of the total farm gate value of all blueberries produced in Canada (Table 1).

Table 1. General production information, 2020

Canadian production[1]	75,333 metric tonnes 11,652 hectares
Farm gate value[1] Highbush blueberry	$162 Million
Farm gate value[1] Total blueberries	$274 Million
Food available in Canada[3]	1.38 kg/ person (fresh blueberries) 0.74 kg/ person (frozen blueberries)

…continued

Table 1. General production information, 2020 (continued)

Exports[4]	$179.7 million
Imports[4]	$329.1 million

[1]Source: Statistics Canada. Table 32-10-0456-01 Area, production and farm gate value of marketed fruits (Accessed 2021-07-06).

[2]Includes both lowbush and highbush blueberries.

[3]Source: Statistics Canada. Table 32-10-0054-01 Food available in Canada (Accessed: 2021-07-06).

[4]Source: Statistics Canada. Canada International Merchandise Trade Database (accessed 2021-06-28): HS # 081040-Cranberries, bilberries and other fruits of the genus Vaccinium, fresh.

Production Regions

In Canada, highbush blueberry is grown primarily in British Columbia (92 percent), followed by Quebec (4 percent), Nova Scotia (2 percent) and Ontario (1 percent) (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. 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.

Table 2. Distribution of total production in Canada, 2020[1]

Production Regions	Cultivated area (percentage national area)	Production	Farm gate value
British Columbia	10,705 ha (92%)	72,876 metric tonnes	$146.4 million
Quebec	483 ha (4%)	1,077 metric tonnes	$6.2 million
Ontario	158 ha (1%)	605 metric tonnes	$3.7 million
Nova Scotia	281 ha (2%)	679 metric tonnes	$4.9 million
Canada	11,652 ha	75,333 metric tonnes	$161.8 million

[1]Source: Statistics Canada. Table 32-10-0456-01 Area, production and farm gate value of marketed fruits (Accessed 2021-07-06).

Cultural Practices

Highbush blueberries are best grown on organic-rich sandy loam soils but can tolerate a wide range of soils from peat (organic) soils to sandy loam, silt loam and clay loam. In general, highbush blueberries perform well in acidic soils with a pH from 4.5 to 5.5. Minor to severe iron deficiency symptoms can be observed when soil pH is greater than 5.5. Irrigation is essential in highbush blueberry production and is primarily done through drip irrigation.

Pollination is an important aspect of highbush blueberry production. In addition to native pollinators, honeybee hives are placed in blueberry fields while the crop is in bloom. Insecticides are not applied when blueberries are in bloom and when pesticides are applied, they are selected and applied in ways to best protect pollinators and natural predators.

Perennial cover crops such as fescue and rye grass mixes 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.

The most common blueberry cultivars grown in British Columbia are early-maturing Bluecrop, early-maturing Duke and late-maturing Elliott. New cultivars planted in British Columbia include Draper, Liberty, Aurora, Calypso, Valor, Top Shelf and Last Call. In addition, Reka and Hardyblue are important processing cultivars. Cultivars planted in Quebec must be adapted to growing zones 3 and 4. Patriot is currently the most widely grown cultivar, although acreage is declining due to disease problems. Other popular cultivars include Bluecrop, Duke and Blueray. In colder regions, hardy cultivars such as Patriot and Northland remain popular. In Ontario, several cultivars are used due to climatic differences between growing regions. Varieties grown include Bluecrop (the leading cultivar by acreage), Blueray, Duke, Patriot, Bluejay, Northland, Elliot, Nelson and Northblue. In Nova Scotia, all of the above varieties are grown to some extent with the following representing the largest acreage: Bluecrop, Jersey, Coville, Berkeley, Burlington, and Brigitta.

The following table (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
	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: pesticide application 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
	Weed management	BC and NS: weed control
	Disease management	BC and ON: spraying for disease control
	Insect and mite management	BC and ON: pesticide applications for insect control
Late April and May BC: Blossoming; QC: bud break and flowering; ON & NS: Leaf and flower bud break, blossoming	Weed management	BC, ON and QC: weed control
	Plant care	BC, ON and NS: honeybees are set out when flowering begins
		QC: pruning, fertilizing, irrigating; BC, ON and NS: planting, fertilizing
	Disease, insect and mite and weed management	BC, ON, QC and NS: pesticide application, if needed, weed control
June Fruit development	Plant care	Installing bird control devices and netting; irrigation if necessary, fertilizer application
	Disease, insect and mite and weed management	Pesticide application, if needed; weed control
July Fruit development and ripening, harvest (BC)	Plant care	Irrigation if necessary, installing bird control devices; Harvesting in BC.
	Disease, insect and mite, and weed management	Pesticide application 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; removal of netting
	Disease, insect and mite and weed management	Pesticide application as needed
September Post-harvest growth	Plant care	Harvesting, irrigation, if necessary
	Disease, insect and mite and weed management	Pesticide application as needed, BC: weed control
October Post-harvest growth	Plant care	BC: pruning
		ON: application of sawdust mulch, if needed
		QC: winter protection, weed control
		NS: Harvesting; irrigation for frost protection
	Disease and insect and mite management	BC: pesticide application, if needed
	Weed management	BC and ON: weed control
November and December Plants dormant	Plant care	BC, ON and NS: sawdust mulch applied, if needed; pruning
	Disease, insect and mite and weed management	BC: pesticide application, if needed

Abiotic Factors Limiting Production

Nutrients

Nitrogen deficient highbush blueberry plants are reduced in size, have poor leaf colour and 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 alkaline. Foliar sprays of chelated iron can provide short-term control of iron deficiency. 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 bacterial blight (*Pseudomonas syringae* pv. *syringae*) in the spring. 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 also cause damage to branches and buds.

Diseases

Key Issues

- New conventional and non-conventional pest control products are required for the management of blueberry anthracnose.
- In British Columbia, the resistance of *Botrytis cinerea* to fungicides is a concern. Fungicides with novel modes of action and fungicide application programs that minimize resistance development and maximize the duration of efficacy of currently available fungicides are required.
- Improved diagnostic testing is required for viral diseases to enable growers to better manage these diseases. Development of in-field detection kits for diseases that can be used by agronomists, consultants and advisors would be beneficial.
- International standardization of maximum residue levels 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		
Bacterial blight		
Anthracnose fruit rot		
Botrytis blight and fruit rot		
Mummy berry		
Virus diseases		
Blueberry scorch		
Blueberry shock		
Tomato ring spot		
Stunt disease		
Witches' broom		
Canker diseases		
Godronia canker		
Phomopsis canker		
Phytophthora root rot		

Widespread yearly occurrence with high pest pressure.

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

Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high 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 2018, 2019 and 2020 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	Anthracnose fruit rot	Godronia canker
Avoidance	Varietal selection / use of resistant or tolerant varieties					
	Planting / harvest date adjustment					
	Rotation with non-host crops					
	Choice of planting site					
	Optimizing fertilization for balanced growth and to minimize stress					
	Minimizing wounding and insect damage to limit infection sites					
	Use of disease-free propagative materials (seed, cuttings or transplants)					
Prevention	Equipment sanitation					
	Canopy management (e.g., thinning, pruning, row or plant spacing)					
	Manipulating seeding / planting depth					
	Irrigation management (timing, duration, amount) to minimize disease infection periods and manage plant growth					
	Management of soil moisture (e.g., improvements in drainage, use of raised beds, hilling, mounds)					
	End of season or pre-planting crop residue removal / management					

...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	Anthracnose fruit rot	Godronia canker
Prevention	Pruning out / removal of infected material throughout the growing season					
	Removal of other hosts (weeds / volunteers / wild plants) in field and vicinity					
Monitoring	Scouting / spore trapping					
	Maintaining records to track diseases					
	Soil analysis for the presence of pathogens					
	Weather monitoring for disease forecasting					
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of diseases					
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	Anthracnose fruit 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 biopesticides (microbial and non-conventional pesticides)					
	Controlled atmosphere storage					
	Targeted pesticide applications (e.g., banding, spot treatments, use of variable rate sprayers)					
	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 in the province.

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

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

Information regarding the practice for this pest is unknown.

[1]Source: Highbush blueberry stakeholders in reporting provinces (British Columbia); the data reflect the 2018, 2019 and 2020 production years.

Alternaria Fruit Rot (*Alternaria* spp.)

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. Leaf spots are small, light brown to gray with a brownish red border. Infected fruit becomes soft with a flat, fuzzy greenish mold containing many spores, and fruit can rot before or after harvest.

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. New conventional and non-conventional pest control products are required for the management of Alternaria fruit rot. Alternative management methods to chemical controls must be discovered and promoted (e.g., preventive management, biological products, etc.).
2. Although Alternaria fruit rot is of secondary importance in Quebec, reports of this disease continue to increase. There is a need to better understand the prevalence and actual field losses caused by this disease.
3. There is a need to determine the efficacy of fungicides registered for other diseases in highbush blueberry to determine if there is an opportunity to expand the use pattern to include Alternaria fruit rot.

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

Pest information

Damage: Ripe berries infected with *Colletotrichum* spp. develop sunken and shrivelled areas with salmon coloured spore masses 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. In the spring spores are produced 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.

Resistant Cultivars: None available.

Issues for Anthracnose Fruit Rot

1. New management approaches for this disease are required. These approaches include preventative methods and the use of a predictive model for improved timing of fungicide treatments.
2. Research is needed into potential resistance issues to currently available fungicides.

Bacterial Blight (*Pseudomonas syringae* pv. *syringae*)

Pest information

Damage: Bacterial blight can cause significant economic damage in new plantings. Stem lesions may result in girdling and death of young plants. When associated with late spring frosts, flower buds may be killed. Symptoms first appear in late winter as water soaked lesions that range in size from several millimetres to the length of an entire branch. Only one-year old shoots are affected.

Life cycle: Pseudomonas syringae pv. *syringae* overwinters on diseased twigs and spreads during cool wet weather in the spring and fall. Infection occurs through wounds, natural openings such as leaf scars, or on frost or winter injured tissues.

Pest management

Cultural controls: Pruning diseased wood out before fall will remove a source of inoculum. Avoiding over application of nitrogen is important to prevent overly vigorous growth, which is very susceptible to fall infection. Field history, spring weather and the severity of the disease at winter pruning, can be used to forecast infection levels.

Resistant Cultivars: None available.

Issues for Bacterial Blight

1. There is a need for alternative products to copper bactericides for the management of bacterial blight. Copper resistant strains of the pathogen have been reported in the Pacific Northwest.
2. New management approaches are required as an alternative to copper applications for the control of bacterial blight. Approaches to be considered include preventative management, forecasting models, new bactericides, etc.

Botrytis Blight and Fruit Rot (*Botrytis cinerea*)

Pest information

Damage: Botrytis cinerea primarily attacks blossoms and fruit but can also cause stem blight. Infected blossoms turn brown and wilt, while infected berries shrivel and soften. Gray 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 healthy 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 disease progression in storage. Additional management practices for Botrytis blight and fruit rot are listed in Table 5.

Resistant Cultivars: None available.

Issues for Botrytis Blight and Fruit Rot

1. The resistance of *Botrytis cinerea* 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*.

Mummy Berry (*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 asymptomatic 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 blueberry bushes. Rotovating or frequent harrowing after raking also destroys apothecia and helps bury mummy berries. Straw, wood chips and sawdust mulch are also used to bury mummy berries. 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 mummy berry are listed in Table 5.

Resistant Cultivars: None available.

Issues for Mummy Berry

1. The registration of conventional and non-conventional pest control products, including biopesticides suitable for use in organic systems, is required for mummy berry control.
2. Alternative methods to fungicide control should be researched including preventative management practices and biological products.
3. Almost all fungicides available for mummy berry management belong to a single fungicide group (Group 3). While resistance development has not been reported, there is a need for new cost effective chemistries that can be used in rotation with Group 3 products.

Godronia 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 and prevention of Godronia canker include pruning-out and destroying infected branches. Pruning also promotes good air movement around plants and facilitates 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 disease spread. Additional management practices for Godronia canker are listed in Table 5.

Resistant Cultivars: Resistant cultivars are available.

Issues for Godronia Canker

1. There is a need to document and promote good cultural practices that reduce the incidence of the disease.
2. Currently, no fungicides are available for Godronia canker management in highbush blueberries. There is a need to evaluate the effectiveness of different active ingredients and move forward with the registration of effective products.
3. There is a need to understand the lifecycle of *Fusicoccum putrefaciens*, especially the conditions needed for infections.

Phomopsis Canker (*Phomopsis vaccinii*)

Pest information

Damage: Phomopsis cankers develop on stems that are one to three years old. The fungus invades through flower buds and grows into the stem. The resulting cankers progress downwards and can girdle the stems, causing reddening of foliage and wilting and dieback of shoots.

Life cycle: The fungus overwinters in infected stems. Spore producing structures (pycnidia) develop in infected tissues, giving rise to conidia. The conidia are spread by rain and cause new infections from blossom bud swell until late August.

Pest management

Cultural controls: Cultural management practices for Phomopsis canker include pruning out and destroying infected branches.

Resistant Cultivars: None available.

Issues for Phomopsis Canker

None identified.

Phytophthora Root Rot (*Phytophthora cinnamomi*)

Pest information

Damage: Phytophthora cinnamomi destroys 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 cinnamomi 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 the pathogen into the field. Good soil drainage will prevent the development of the disease. In new plantings, the installation of subsurface drainage, where needed, and avoidance of deep planting, will minimize the development of Phytophthora root rot. In established plantings, careful management of irrigation to avoid excessive soil moisture and

prevention of other stresses such as fertilizer or herbicide burn can reduce disease development. Removal of infected plants from the field can also help.

Resistant Cultivars: Varieties with moderate resistance are available, including Patriot and Reka.

Issues for Phytophthora Root Rot

None identified.

Witches' Broom (*Pucciniastrum goeppertianum*)

Pest information

Damage: In the spring, broom-like masses of thickened, spongy shoots with few leaves develop on branches and crowns of affected plants. 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

1. Witches' broom is an issue in Quebec highbush blueberry production. A better understanding of the lifecycle of *Pucciniastrum goeppertianum* is needed, including an understanding of the conditions and periods of sporulation in host plants (balsam fir and blueberry).

Blueberry Scorch Virus (BlScV, genus *Clarlavirus*)

Pest information

Damage: Blueberry scorch virus causes blighting and dieback of shoots and blossoms in the spring, as well as 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 with at least five strains identified in British Columbia.

Pest management

Cultural controls: The planting of virus-free stock will prevent the introduction of the disease into the field. Ladybird beetles will provide some control of aphids which vector the virus, and this may reduce the disease spread. Monitoring blueberry fields 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.

Resistant Cultivars: All highbush blueberry cultivars are susceptible to blueberry scorch; however, 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 commercial nursery stock be certified virus-free to prevent the introduction of viruses into new fields.
3. The detection and uprooting of affected plants should be encouraged.

Blueberry Shock Virus (BlShV, genus *Ilavirus*)

Pest information

Damage: Blueberry shock virus (BlShV) causes necrosis of flowers and new shoots of affected plants in the spring during bloom. 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, honey bees and other insects that transfer 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 is available and can be used to identify if the virus is present in plants with suspicious symptoms. 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 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, genus *Nepovirus*)

Pest information

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

Life cycle: ToRSV is vectored and spread by the dagger nematode (*Xiphinema* spp.), a soilborne nematode. These parasitic nematodes transmit the virus by piercing the wall of root cells to feed. ToRSV 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 soil testing 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. Research on how to control dagger nematodes is needed. Further, control methods must be tested for efficacy in highbush blueberry fields.
2. It is important that all commercial planting stock be certified virus-free to prevent the introduction of viral diseases into the field.
3. The detection and uprooting of affected plants should be encouraged.

Blueberry Stunt Disease (Candidatus Phytoplasma asteris)

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 after harvest.

Pest management

Cultural controls: The planting of blueberry bushes certified free of the phytoplasma will minimize 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 Disease

1. It is important that all commercial blueberry planting stock available be certified free of phytoplasma diseases.

Insects and Mites

Key Issues

- Spotted wing drosophila can cause significant crop losses in blueberry. The development of effective management strategies that integrate insecticide sprays for spotted wing drosophila with those for other pests (e.g., aphids, blueberry maggot and beetles) to reduce the overall frequency of insecticide sprays, is required.
- New chemistries are needed for control and resistance management of spotted wing drosophila.
- There is a need to develop additional management tactics including exclusion netting, mass trapping, attract and kill technologies and the introduction of sterile males for spotted wing drosophila.
- International standardization of maximum residue levels for commonly used pesticides in highbush blueberry production would benefit the industry.

Table 6. Occurrence of insect pests in highbush blueberry production in Canada[1,2]

Insect and mite	British Columbia	Quebec
Aphids		
Blueberry aphid		
Heath spittlebug		
Leafhoppers		
Brown marmorated stinkbug		
Blueberry gall midge (Cranberry tipworm)		
Blueberry maggot		
Spotted wing drosophila		
Cherry fruitworm		
Cranberry fruitworm		
Spring feeding caterpillar complex		
Bruce spanworm		
Winter moth		
Obliquebanded leafroller		
European leafroller		
Plum curculio		
Root weevils		
Black vine weevil		
Obscure weevil		
Strawberry root weevil		
European chafer		
Japanese beetle		
Rose chafer		
June 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 2018, 2019 and 2020 production years.
[2]Refer to Appendix 1 for a detailed explanation of colour coding of occurrence data.

Table 7. Adoption of insect pest management practices in highbush blueberry production in Canada[1]

Practice / Pest		Aphids	Blueberry gall midge	Cherry fruitworm	Spring feeding caterpillar complex	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 (seeds, 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 (e.g., improvements to drainage, use of raised beds, hilling, mounds)						
	End of season or pre-planting crop residue removal / management						

…continued

Table 7. Adoption of insect pest management practices in highbush blueberry production in Canada[1] (continued)

Practice / Pest		Aphids	Blueberry gall midge	Cherry fruitworm	Spring feeding caterpillar complex	Spotted wing drosophila	Root weevils
Prevention	Pruning out / removal of infested material throughout the growing season						
	Tillage / cultivation to expose soil insect pests						
	Removal of other hosts (weeds / wild plants / volunteer crops) in field and vicinity						
Monitoring	Scouting / trapping						
	Maintaining records to track pests						
	Soil analysis for pests						
	Weather monitoring for degree day modelling						
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of pests						
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 7. Adoption of insect pest management practices in highbush blueberry production in Canada[1] (continued)

Practice / Pest		Aphids	Blueberry gall midge	Cherry fruitworm	Spring feeding caterpillar complex	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)						
	Mating disruption through the use of pheromones						
	Mating disruption through the release of sterile insects						
	Trapping						
	Targeted pesticide applications (e.g., banding, spot treatments, use of variable rate sprayers)						
	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 in the province.

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

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

Information regarding the practice for this pest is unknown.

[1]Source: Highbush blueberry stakeholders in reporting provinces (British Columbia); the data reflect the 2018, 2019 and 2020 production years.

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

Pest information

Damage: Aphids feed on new shoots by sucking plant sap. Feeding by large populations may cause deformities and wilting or make the fruit unmarketable because of honeydew and associated sooty mold. 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 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 ladybird beetles, lacewings, syrphid flies and small parasitic wasps. Scouting, trapping and assessments for economic thresholds can help decision making for timely treatment application, should this become necessary. Additional management practices for aphids are listed in Table 7.

Resistant Cultivars: None identified.

Issues for Blueberry Aphid

1. The impact of pesticide applications for spotted wing drosophila management on aphid populations needs to be investigated, so that treatments for both pests can be combined and the overall number of applications reduced.
2. There is a need for pollinator-safe management strategies to control aphid populations during the bloom period.

Blueberry (Heath) Spittlebug (*Clastoptera saintcyri*)

Pest information

Damage: The spittlebug feeds by sucking plant sap. Larvae secrete a white foam-like substance (spittle) that 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. It overwinters as eggs in the bark of the host plant. Eggs hatch in the spring and young nymphs secrete the spittle and begin to feed.

Pest management

Cultural controls: Natural control agents exist and are effective. Economic thresholds for blueberry spittlebugs 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 to other plants during feeding. Sharp-nosed leafhoppers (*Scaphytopius* spp.) are key vectors of the blueberry stunt phytoplasma. Other leafhopper 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 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

1. Some growers apply insecticides against leafhopper populations with the intent of reducing possible vectors of blueberry phytoplasma. The efficacy of this management strategy needs to be assessed.

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 (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 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 7.

Issues for Blueberry Gall Midge

None identified.

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 can be used to monitor for the presence of adults. Phytosanitary requirements prohibit the domestic movement of crops infested with blueberry maggot under the *Federal Plant Protection Act* to prevent the spread of this pest within Canada. These requirements are also part of the Blueberry Certification Program.

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: 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 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 the fruit. Pupation takes place within or outside of 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 SWD populations. Flies can be monitored through the use of apple cider vinegar baited traps. These traps can also be used to monitor earlier fruiting hosts in the vicinity of blueberry fields for signs of potential future SWD infestations. 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 populations, scouting, trapping and the use of economic thresholds for making spray decisions. Additional management practices for spotted wing drosophila are listed in Table 7.

Resistant Cultivars: None available.

Issues for Spotted Wing Drosophila

1. Effective management strategies that minimize the frequency of insecticide applications are required. Alternative methods to chemical controls must be researched and shared with growers (e.g., preventive management, biological products, sterile flies, exclusion nets).
2. New insecticide chemistries are urgently required for control and resistance management of SWD. These chemistries need to have appropriate re-entry and pre-harvest intervals and maximum residue limits to allow their use.
3. Easily installable and affordable exclusion net technology is needed.

Green Fruit Larvae: Cherry Fruitworm (*Grapholitha packardii*), Plum Moth (*G. prunivora*) and Cranberry Fruitworm (*Acrobasis vaccinii*)

Pest information

Damage: The cherry fruitworm, plum moth and cranberry fruitworm feed inside blueberries. Individual larva can damage multiple berries.

Life cycle: Mature larvae of the cherry fruitworm overwinter under bark. Cranberry fruitworm overwinters as larvae or pre-pupae in a silken structure in the soil. The plum moth, also known as the lesser appleworm, overwinters as larvae in debris on the ground or under bark. Cherry fruitworm adults lay eggs on the leaves around blossom time and have one generation per year. The cranberry fruitworms emerge in the summer and lays eggs in late summer. The plum moth spring flight begins in May, lasting for up to four weeks. The plum moth has two generations per year. For all three species, once the eggs hatch, the larvae feed within the berries but remain hidden.

Pest management

Cultural controls: Pheromone traps are used to monitor adult activity and to time insecticide applications. Fruit and leaves can be monitored for eggs beginning in May. Insecticide treatments are timed in order to make contact with the larvae before it enters the fruit. Other practices used to manage green fruit larvae are perimeter spraying and pruning and removal of infested material. Additional management practices for cherry fruitworm are listed in Table 7.

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

Issues for Green Fruit Larvae

1. The impact of these internal feeders on crop yields needs to be determined.
2. Additional research is needed on each pest's life cycle (e.g., peaks in egg, larval and adult abundance).
3. Timing and effectiveness of pest control product applications need to be established.

Plum Curculio (*Conotrachelus nenuphar*)

Pest information

Damage: Preferred hosts of the plum curculio include peaches and plums, although adults will feed and reproduce on other fruits including blueberries, cherries and apple. Adults injure fruit through direct feeding and egg laying. Larvae feed within the fruit causing premature ripening and drop.

Life cycle: Adults overwinter in leaf litter. In the spring as fruit begins to develop, adults feed and lay eggs on fruit. Larvae develop within the fruit and drop to the soil to pupate.

Pest management

Cultural controls: Management of immature stages in the soil is an important factor in reducing curculio populations. Naturally occurring parasites will prey upon eggs and larvae; however, rates of parasitism are usually low.

Resistant Cultivars: None available.

Issues for Plum Curculio

1. There is a need for conventional and non-conventional pest control products that can be integrated into existing pest management systems for plum curculio management.
2. Although plum curculio is currently only present in Quebec and has not yet been detected in British Columbia, it is important that pest control products be available in the event that this pest spreads into B.C. and other new areas.
3. Alternative control methods to chemical insecticides should be established and promoted to highbush blueberry growers.

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 when 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 treatment application timing. Additional management practices for spring feeding caterpillars are listed in Table 7.

Resistant Cultivars: None available.

Issues for Spanworm and Winter Moth

1. There is a need for suitable IPM-friendly insecticides for the management of spring feeding caterpillars.

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 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. When full-grown, larvae pupate and emerge as adults, which 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 fully grown, pupate within rolled leaves. Adults emerge and lay the overwintering eggs.

Pest management

Cultural controls: Pruning plantings helps to reduce numbers of leafrollers by removing overwintering sites.

Resistant Cultivars: None identified.

Issues for Leafrollers

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

Root Weevils: Black Vine Weevil (*Otiorynchus sulcatus*), Obscure Weevil (*Sciopithes obscurus*), Strawberry Root Weevil (*O. ovatus*) 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 in the soil in June and continue until mid-September. Immediately following hatch, the larvae move through the soil and feed 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 into 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 the field 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. Additional management practices for weevils are listed in Table 7.

Resistant Cultivars: None available.

Issues for Weevils

1. There is an urgent need for pest control products that are effective against both the larval and adult stages of root weevils.
2. The presence of weevils is increasing in highbush blueberry growing regions. Visual scouting is time consuming and not always reliable as adults can be difficult to detect in highbush blueberry fields unless numbers are high. 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 insecticide applications.

White Grubs: European Chafer (*Rhizotrogus majalis*), Japanese Beetle (*Popillia japonica*), June Beetle (*Phyllophaga* spp.) and Rose Chafer (*Macrodactylus subspinosus*)

Pest information

Damage: The larval stages of the European chafer, the Japanese beetle, the June beetle and rose chafer are commonly called white grubs, and all feed on the roots of blueberry plants. 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 also feed on foliage and fruit prior to harvest, and can be a fruit contaminant at harvest. Adult rose chafers also feed above ground on flower buds, growing fruits and leaves of many hosts including blueberry. Heavy infestations of adult rose chafer beetles can destroy the foliage and photosynthetic capacity of affected plants.

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, Japanese beetle and rose chafer have one generation per year. June beetles have a three year life cycle.

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. Traps baited with floral scents can be used to trap rose chafer 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.

Resistant Cultivars: None available.

Issues for White Grubs

1. Effective conventional and non-conventional controls for white grubs are required.
2. Japanese and rose beetles continue to expand their geographic range in Quebec. They are advancing east and north. The most common control strategy is insecticide applications targeting adult beetles. Alternative methods including organic insecticides (e.g., pyrethrins and spinosad products), mass trapping and the use of entomophagous nematodes should be evaluated.

Brown Marmorated Stink Bug (*Halyomorpha halys*)

Pest information

Damage: The brown marmorated stink bug (BMSB) is an invasive insect which has caused significant agricultural crop injury in the Mid-Atlantic States. Although BMSB 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 when adults and nymphs inject saliva with digestive enzymes into the plant during feeding. Each feeding puncture results in crop injury. In blueberries, fruit feeding can result in sunken brown lesions, decreasing the fruits' fresh market value.

Life cycle: BMSB spreads through natural means and 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 considered a nuisance pest.

Pest management

Cultural controls: Monitoring for BMSB may be done with aggregation pheromones or through 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, lifecycle and behaviour of the BMSB.
2. There is a need for the development of integrated management approaches for BMSB control, including new effective pest control products.

Weeds

Key Issues

- The development of non-conventional pesticides, including 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. An inventory of various mechanical weeding tools and a cost analysis of non-chemical methods of weed control would be beneficial for producers and advisors.
- International standardization of maximum residue levels for commonly used herbicides in highbush blueberry production would benefit the industry.

Table 8. 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 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 2018, 2019 and 2020 production years.
[2]Refer to Appendix 1 for a detailed explanation of colour coding of occurrence data.

Table 9. Adoption of weed management practices in highbush blueberry production in Canada[1]

Practice / Pest		Annual broadleaf weeds	Annual grasses	Perennial broadleaf weeds	Perennial grasses
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 (e.g., thinning, pruning, row or plant spacing, etc.)				
	Manipulating seeding / planting depth				
	Irrigation management (timing, duration, amount) to maximize crop growth				
	Management of soil moisture (improvements in drainage, use of raised beds, hilling, mounds)				
	Weed management in non-crop lands				
Monitoring	Scouting / field inspection				
	Maintaining records of weed incidence including herbicide resistant weeds				
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of weeds				

…continued

Table 9. Adoption of weed management practices in highbush blueberry production in Canada[1] (continued)

Practice / Pest		Annual broadleaf weeds	Annual grasses	Perennial broadleaf weeds	Perennial grasses
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 non-conventional pesticides)				
	Release of arthropod biological control agents				
	Mechanical weed control (cultivation / tillage)				
	Manual weed control (hand pulling, hoeing, flaming)				
	Use of stale seedbed approach				
	Targeted pesticide applications (e.g., banding, spot treatments, use of variable rate sprayers)				
	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 in the province.

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

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

Information regarding the practice for this pest is unknown.

[1]Source: Highbush blueberry stakeholders in reporting provinces (British Columbia); the data reflect the 2018, 2019 and 2020 production years.

Weeds

Pest information

Damage: Annual and perennial grasses and broadleaf weeds compete with highbush blueberries for nutrients, water and light, and serve as alternate hosts for insects and diseases. They also interfere with irrigation and harvest operations, and 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 hosts to nematode species, which may vector viral diseases.

Life cycle: ***Annual weeds:*** Summer annual weeds germinate in the spring, flower and set seed in the summer or fall, and die before the onset of winter, while winter annual weeds germinate in the fall, overwinter in a vegetative state, flower in the spring, form seeds and die. ***Perennial weeds*****:** Simple perennial weeds regenerate each year from root or crown tissues and reproduce by flowering and setting seed, while creeping perennial weeds can regenerate from roots, shoots and other structures (including broken roots, tubers and rhizomes) and can also reproduce by flowering.

Pest management

Cultural controls: ***Annual weeds:*** 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 in-row weeds. Materials 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 plant roots. Cover crops may be grown between rows to reduce weed growth, as well as to provide leaching and erosion protection. ***Perennial weeds:*** 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 highbush blueberry fields. 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 9.

Issues for Weeds

1. The continued development of non-conventional products (i.e. bioherbicides) and non-chemical approaches to weed management is required.
2. There is a need for crop-safe burn down herbicides that are effective in cool weather.
3. Horsetail is becoming more of a problem in British Columbia and there is a need for pre- and post-emergent control products. The only commercially available pre-emergent herbicide can be hard on young blueberry plants and mature plants of certain varieties, so other options are required. There are no post-emergent products registered for use in highbush blueberries.
4. There is a need for additional cool weather early season burn-down products.

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. *Berries.*
www2.gov.bc.ca/gov/content/industry/agriculture-seafood/animals-and-crops/crop-production/berries

British Columbia Ministry of Agriculture and Lands. Berry Production Guide
Berries - Province of British Columbia (gov.bc.ca)

Canadian Food Inspection Agency. D-02-04: *The Blueberry Certification Program and domestic phytosanitary requirements to prevent the spread of blueberry maggot (Rhagoletis mendax) within Canada* 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

Ontario Ministry of Agriculture, Food and Rural Affairs. 2021. Publication 360B, Crop Protection Guide for Berries. *www.omafra.gov.on.ca/english/crops/pub360/pub360B.pdf*

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

Provincial Contacts

Province	Ministry	Crop Specialist	Minor Use Coordinator
British Columbia	British Columbia Ministry of Agriculture www.gov.bc.ca/agri	Carolyn Teasdale 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 erica.pate@ontario.ca	Joshua Mosindz joshua.mosindz@ontario.ca
Québec	Ministère d'Agriculture, Pêcheries et Alimentation du Québec www.mapaq.gouv.qc.ca	Christina Lacroix christian.lacroix@mapaq.gouv.qc.ca Caroline Turcotte 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/ Perennia www.perennia.ca	Jennifer Haverstock jhaverstock@perennia.ca	Jason Sproule jason.sproule@novascotia.ca

National and Provincial Fruit Grower Organizations

BC Blueberry Council
www.bcblueberry.com

Canadian Horticultural Council
www.hortcouncil.ca/

North American Blueberry Council
www.nabcblues.org

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

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 reporting province is provided in Tables 4, 6 and 8 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="13">Present</td><td rowspan="10">Data available</td><td>Frequency</td><td>Distribution</td><td>Pressure</td><td></td></tr>
<tr><td rowspan="3">**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>Gray</td></tr>
</table>

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British Columbia Ministry of Agriculture and Lands. Berry Production Guide. Berries - Province of British Columbia (gov.bc.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.

Laplante, Nathalie, Christian Lacroix and Gerard Gilbert. *Les phytoplasmes dans le bleuet en corymbe*. Réseau d'avertissements phytosanitaires – Bulletin d'information No. 11 - Petits Fruits 16-30 juin 2016. https://www.agrireseau.net/documents/Document_92828.pdf

Ontario Ministry of Agriculture, Food and Rural Affairs. *Notes on Blueberry Diseases: Blueberry Stunt.* 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

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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