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Crop Profile for Highbush Blueberry in Canada, 2014

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Preface

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

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

For detailed information on growing 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.

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

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Crop Profile for Highbush Blueberry in Canada

The highbush blueberry, *Vaccinium corymbosum*, is a perennial, deciduous, woody shrub in the Ericaceae (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 good sources of Vitamins A and C. Highbush blueberries are consumed fresh or processed for whole-pack or crushed frozen product, pie filling, jam, jelly and syrup.

Crop Production

Industry Overview

Table 1. General production information

Canadian production (2014) ¹	68,830 tonnes 9,490 ha ⁴
Farm gate value (2014) ¹	\$ 129 million
Food available (2014) ^{2,5}	1.06 kg/person (fresh) 0.01 kg/ person (canned) 1.91 kg/ person (frozen)
Blueberry imports (2014) ^{3,5}	44,060 tonnes (fresh) 530 tonnes (canned) 14,040 tonnes (frozen)
Blueberry exports (2014) ^{3,5}	35,110 tonnes (fresh) 0 tonnes (canned) 76,670 tonnes (frozen)

¹Source: Statistics Canada. Table 001-0009 - Area, production and farm gate value of fresh and processed fruits by province, annual, CANSIM (database). (Accessed 2016-09-06).

²Source: Statistics Canada. *Table 002-0011 - Food available in Canada, annual (kilograms per person per year unless otherwise noted)*, CANSIM (database). (Accessed 2016-09-06).

³Source: Statistics Canada. Table 002-0010 - Supply and disposition of food in Canada, annual (tonnes unless otherwise noted), CANSIM (database). (Accessed 2016-09-06).

⁴Cultivated area includes bearing and non-bearing area.

⁵Includes highbush and lowbush blueberry

Production Regions

British Columbia produces almost 90 percent of the highbush blueberry crop in Canada. Other provinces that produce this crop include Ontario, Quebec and Nova Scotia. Over 99 percent of commercial blueberry production in British Columbia is located in the lower mainland region, with the remainder on Vancouver Island. In Nova Scotia, the bulk of the production is 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 where several test plantings have been established. 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. Production in Quebec is located in the regions of Monteregie, Quebec City and Chaudiere-Appalaches.

Table 2. Distribution of highbush blueberry production in Canada (2014)

Production regions	Cultivated area (hectares)^{1,2}	Bearing area (hectares)¹	Percent national production (cultivated area)
British Columbia	8,452	8,061	89.1%
Ontario	238	194	2.5%
Quebec	580	421	6.1%
Nova Scotia	202	188	2.1%
Canada	9,490	8,881	99.8%

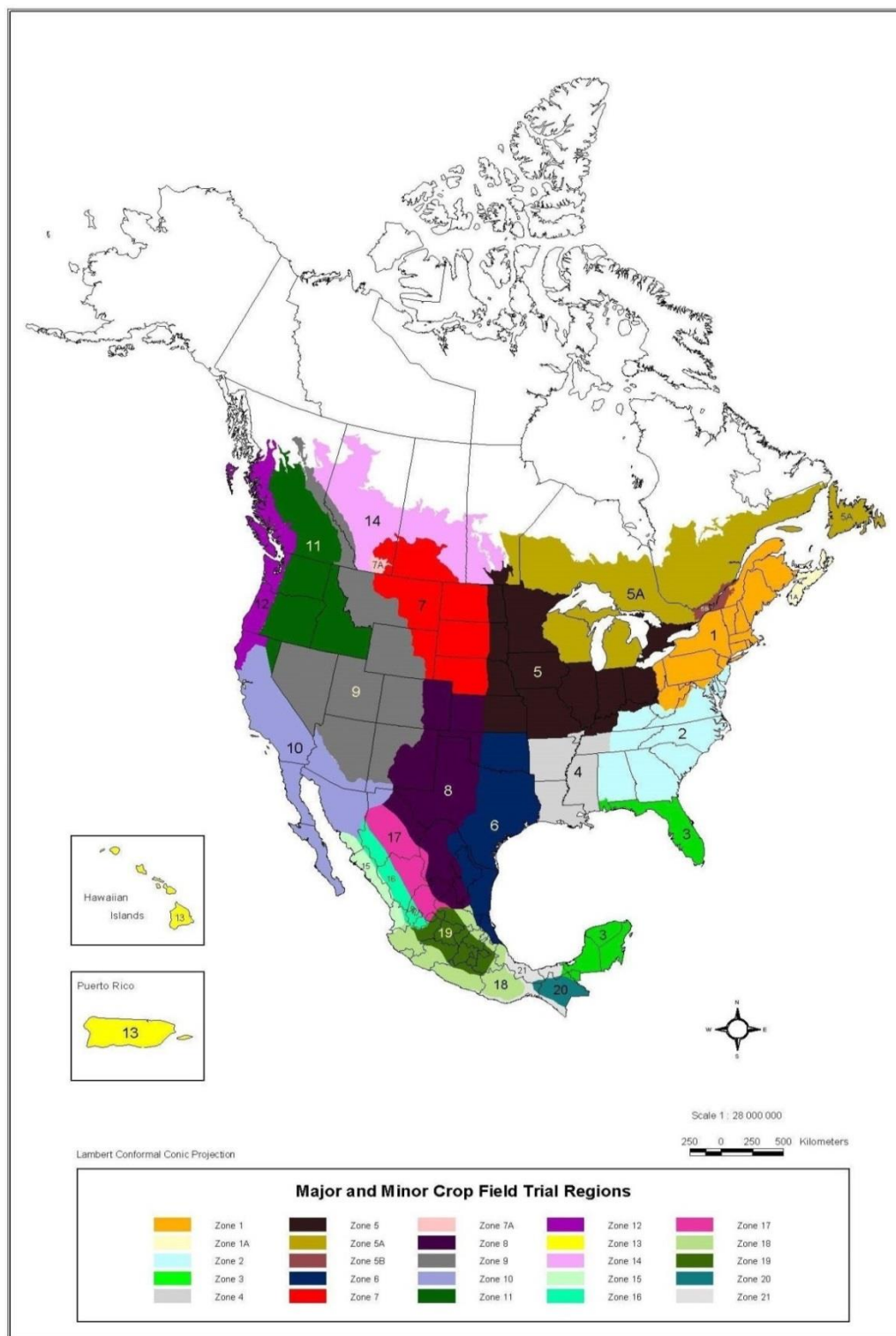
¹Source: Statistics Canada. *Table 001-0009 - Area, production and farm gate value of fresh and processed fruits by province, annual*, CANSIM (database). (Accessed 2016-09-06).

²Cultivated area includes bearing and non-bearing area.

North American Major and Minor Field Trial Regions

Major and minor crop field trial regions (see Figure1) are used by the Pest Management Regulatory Agency (PMRA) in Canada and the United States (US) Environmental Protection Agency (EPA), to identify the regions where residue chemistry crop field trials are required to support the registration of new pesticide uses. The regions are based on a number of parameters, including soil type and climate but they do not correspond to plant hardiness zones. For additional information on field trial regions and requirements, 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



¹Produced 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 muck (organic) to sandy loam, silt loam or clay loam. Highbush blueberries generally produce well in 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.

Perennial cover crops such as fescue are often established between rows in blueberry fields. Sawdust mulches are used to aid in water conservation, maintain soil pH, increase organic matter in the soil, improve soil structure and help control annual weeds. Honeybee hives are placed in the fields while the crop is in bloom in April and May for pollination. Blueberry varieties most commonly grown in British Columbia are 'Bluecrop' which matures mid-season, 'Duke' which matures early and 'Elliott' which is late maturing. In Quebec, more than 60 percent of the plantings are 'Patriot'. Due to significant differences in weather where blueberries are grown in Ontario, there are a large number of blueberry varieties grown, including 'Bluecrop', 'Blueray', 'Duke', 'Patriot', 'Bluejay', 'Northland', 'Elliot', 'Nelson' and 'Northblue'. 'Bluecrop' is presently planted in the greatest acreage. 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'.

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

Time of Year	Activity	Action
January and February: ALL PROV: 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 & 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 & mite and weed management	BC, ON and NS: Spraying, if needed, weed control
June: ALL PROV: Fruit development	Plant care	ALL: Installing bird control devices; fertilizing
	Disease, insect & mite and weed management	ALL: Spraying if needed, weed control
July: ALL PROV: Fruit development and ripening	Plant care	ALL: Harvesting, irrigation if necessary, installing bird control devices
	Disease, insect & mite, and weed management	ALL: Spraying as needed

...continued

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

Time of Year	Activity	Action
July to September: ALL PROV: Harvest	Plant care	ALL: Harvesting, irrigation if necessary, removing bird control devices
		QC: Foliar feeding if necessary.
	Disease, insect & mite and weed management	ALL: Spraying as needed
September: ALL PROV: Post harvest growth	Plant care	ALL: Harvesting, irrigation if necessary, removing bird control devices
		QC: Fertilizing for winter hardening
	Disease, insect & mite and weed management	ALL: Spraying as needed
October ALL PROV: Post harvest growth	Plant care	BC: Pruning
		ON: Apply 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 & December ALL PROV: Plants dormant	Plant care	BC, ON and NS: Sawdust mulch applied if needed
	Disease, insect & 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 stem. 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 of 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.

Table 4. Occurrence of diseases in highbush blueberry production in Canada

Disease	British Columbia	Quebec
Alternaria fruit rot		
Anthrachnose and ripe rot		
Bacterial blight		
Botrytis blight and fruit rot		
Mummy berry		
Godronia canker/ fusicoccum canker		
Phomopsis canker		
Root and crown rot (oomycetes)		
Blueberry scorch		
Blueberry shock		
Tomato ringspot		
Stunt disease		
Witches broom		
Widespread yearly occurrence with high pest pressure.		
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.		
Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high 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.		

¹Source: Highbush blueberry stakeholders in reporting provinces.

²Refer to the colour key (above) and 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

Practice / Pest		Blueberry scorch	Mummy berry	Botrytis blight and fruit rot	Blueberry anthracnose and ripe rot	Bacterial blight	Godronia canker
Avoidance	Resistant varieties						
	Planting/ harvest date adjustment						
	Crop rotation						
	Choice of planting site						
	Optimizing fertilization						
	Reducing mechanical damage or insect damage						
	Thinning/ pruning						
	Use of disease-free seed, transplants						
Prevention	Equipment sanitation						
	Mowing/ mulching/ flaming						
	Modification of plant density (row or plant spacing; seeding rate)						
	Seeding/ planting depth						
	Water/ irrigation management						
	End of season crop residue removal/ management						
	Pruning out/ removal of infected material throughout the growing season						
	Tillage/ cultivation						
Monitoring	Removal of other hosts (weeds/ volunteers/ wild plants)						
	Scouting/ trapping						
	Records to track diseases						
	Soil analysis						
	Weather monitoring for disease forecasting						
	Use of portable electronic devices in the field to access pest identification /management information						
	Use of precision agriculture technology (GPS, GIS) for data collection and field mapping of pests						

...continued

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

Practice / Pest		Blueberry scorch	Mummy berry	Botrytis blight and fruit rot	Blueberry anthracnose and ripe rot	Bacterial blight	Godronia canker
Decision making tools	Economic threshold						
	Weather / weather-based forecast / predictive model						
	Recommendation from crop specialist						
	First appearance of pest or pest life stage						
	Observed crop damage						
	Crop stage						
Suppression	Pesticide rotation for resistance management						
	Soil amendments						
	Biopesticides						
	Controlled atmosphere storage						
	Targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)						
Crop specific practices	Wind machines for frost protection to reduce infection sites						
This practice is used to manage this pest by growers in the province.							
This practice is not used to manage this pest in the province.							
This practice is not applicable for the management of this pest.							
Information regarding the practice for this pest is unknown.							

¹Source: Highbush blueberry stakeholders in British Columbia.

Table 6. Fungicides and bio-fungicides registered for disease management in highbush blueberry in Canada

Active Ingredient ¹	Classification ²	Mode of Action ²	Target Site ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
<i>Agrobacterium radiobacter</i>	biological	unknown	unknown	N/A	R	crown gall
<i>Bacillus subtilis</i> strain QST 713	microbial: <i>Bacillus</i> spp. and the fungicidal lipopeptides they produce	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	44	R	botrytis grey mould, bacterial blight, mummy berry
<i>Streptomyces lydicus</i> strain WYEC 108	biological	unknown	unknown	N/A	R	mummy berry (partial suppression)
azoxystrobin + propiconazole	methoxy-acrylate + triazole	C3: respiration + G1: sterol biosynthesis in membranes	complex III: cytochrome bc1 (ubiquinol oxidase) at Q0site (cyt b gene) + C14: demethylase in sterol biosynthesis (erg11/cyp51)	11 + 3	R + R	monilinia blight, anthracnose, rust, septoria leaf spot (suppression), valdensinia leaf spot (suppression)
boscalid	pyridine-carboxamide	C2: respiration	complex II: succinate-dehydrogenase	7	R	botrytis grey mould
boscalid + pyraclostrobin	pyridine-carboxamide + methoxy-carbamate	C2: respiration + C3: respiration	complex II: succinate-dehydrogenase + complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	7 + 11	R + R	botrytis grey mould, anthracnose, phomopsis

...continued

Table 6. Fungicides and bio-fungicides registered for disease management in highbush blueberry in Canada (continued)

Active Ingredient ¹	Classification ²	Mode of Action ²	Target Site ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
captan	phthalimide	multi-site contact activity	multi-site contact activity	M4	RE	fruit rot, mummy berry
chlorothalonil	chloronitrile (phthalonitrile)	multi-site contact activity	multi-site contact activity	M5	RE	anthracnose fruit rot, alternaria fruit rot, phomopsis canker
copper (present as copper octanoate)	inorganic	multi-site contact activity	multi-site contact activity	M1	R	bacterial blight
copper (present as copper oxychloride)	inorganic	multi-site contact activity	multi-site contact activity	M 1	R	bacterial blight
cyprodinil + difenoconazole	anilino-pyrimidine + triazole	D1: amino acids and protein synthesis + G1:sterol biosynthesis in membranes	methionine biosynthesis (proposed) (cgs gene) + C14-demethylase in sterol biosynthesis (erg11/cyp51)	9 + 3	RE + RE	anthracnose, alternaria leaf spot, botrytis grey mould, monilinia blight and mummy berry, rust (suppression)
cyprodinil + fludioxonil	anilino-pyrimidine + phenylpyrrole	D1: amino acids and protein synthesis + E2: signal transduction	methionine biosynthesis (proposed) (cgs gene) + MAP/histidine-kinase in osmotic signal transduction (os-2, HoG1)	9 + 12	RE + RE	anthracnose, botrytis fruit rot, primary phase of mummy berry / monilinia

...continued

Table 6. Fungicides and bio-fungicides registered for disease management in highbush blueberry in Canada (continued)

Active Ingredient ¹	Classification ²	Mode of Action ²	Target Site ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
fenbuconazole	triazole	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	3	R	mummy berry
fenhexamid	hydroxylanilide	G3: sterol biosynthesis in membranes	3-keto reductase, C4-demethylation (erg27)	17	RE	grey mould
ferbam	dithiocarbamate and relatives	multi-site contact activity	multi-site contact activity	M3	RE	botrytis blight, blossom blight, twig blight
fluazinam	2,6-dinitro-aniline	C5: respiration	uncouplers of oxidative phosphorylation	29	RES	suppression of mummy berry, phomopsis fruit rots and fruit anthracnose
fluopyram	pyridinyl-ethyl-benzamide	C2: respiration	complex II: succinate-dehydro-genase	7	R	powdery mildew, botrytis grey mould
fluopyram + pyrimethanil	pyridinyl-ethyl-benzamide + anilino-pyrimidine	C2: respiration + D1: amino acid and protein synthesis	complex II: succinate-dehydrogenase + methionine biosynthesis (proposed) (cgs gene)	7 + 9	R + R	powdery mildew, botrytis grey mould

...continued

Table 6. Fungicides and bio-fungicides registered for disease management in highbush blueberry in Canada (continued)

Active Ingredient ¹	Classification ²	Mode of Action ²	Target Site ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
fluxapyroxad	pyrazole-4-carboxamide	C2: respiration	complex II: succinate-dehydro-genase	7	R	grey mould (suppression)
fosetyl-Al	ethyl phosphonate	unknown mode of action	unknown	33	RE	phytophthora root rot, anthracnose fruit rot, phomopsis canker (suppression)
metalaxyl-m	acylalanine	A1: nucleic acids synthesis	RNA polymerase I	4	R	phytophthora root rot
metconazol	triazole	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	3	R	mummy berry, anthracnose ripe rot, phomopsis twig blight and fruit rot (suppression)
myclobutanil	triazole	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	3	R	powdery mildew
oriental mustard seed meal	diverse	not classified	unknown	NC	R	root knot nematode, verticillium wilt, soil-borne <i>Pythium</i> spp. and <i>Fusarium</i> spp.
phosphites (mono and dibasic sodium, potassium and ammonium phosphite)	not classified	unknown	unknown	N/A	R	septoria leaf spot, phytophthora root rot (suppression),
phosphorous acid (mono and di-potassium salts of phosphorous acid)	phosphonate	unknown	unknown	33	R	phytophthora foliar blight

...continued

Table 6. Fungicides and bio-fungicides registered for disease management in highbush blueberry in Canada (continued)

Active Ingredient ¹	Classification ²	Mode of Action ²	Target Site ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
propiconazole	triazole	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	mummy berry
prothioconazole	triazolinthione	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	monilinia blight (mummy berry), suppression of septoria leaf spot, leaf rust and valdensinia leaf spot
pyraclostrobin	methoxy-carbamate	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	anthracnose, phomopsis
pyrimethanil	anilino-pyrimidine	D1: amino acids and protein synthesis	methionine biosynthesis (proposed) (cgs gene)	9	R	botrytis grey mould
<i>Reynoutria sachalinensis</i> (extract)	complex mixture, ethanol extract	P5: host plant defence induction	P5	P5	R	monilinia blight (mummy berry) (suppression)

¹Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of Sept. 9, 2016. The product label is the final authority on pesticide use and should be consulted for application information. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

²Source: Fungicide Resistance Action Committee. *FRAC Code List 2016: Fungicides sorted by mode of action (including FRAC code numbering)* (www.frac.info/) (accessed Sept. 8, 2016).

³PMRA re-evaluation status: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review, as published in PMRA *Re-evaluation Note REV2016-07, Pest Management Regulatory Agency Re-evaluation and Special Review Workplan 2015-2020*, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

Alternaria fruit rot (*Alternaria alternata* and other species)

Pest information

Damage: Fruit rot and leaf spot caused by *Alternaria* sp. 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 and after harvest. Leaf spots are small (1 to 5 mm wide) and light brown to grey with a brownish red border.

Life cycle: The fungi overwinter on the ground, on twigs and on debris. Spores produced in infected tissues in the spring are dispersed to the fruit and foliage by wind and other means.

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.

Chemical controls: Fungicides registered for the control of alternaria fruit rot are listed in *Table 6. Fungicides and bio-fungicides registered for disease management in highbush blueberry in Canada*. This disease may be kept in check by fungicides sprayed for botrytis.

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 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 disease management practices are listed in *Table 5*.

Adoption of disease management practices in highbush blueberry production in Canada.

Resistant Cultivars: None available.

Chemical controls: Fungicides registered for the control of anthracnose are listed in *Table 6*.

Fungicides and bio-fungicides registered for disease management in highbush blueberry in Canada.

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.

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 the entire branch. Only one-year old shoots are affected.

Life cycle: *Pseudomonas* overwinters on diseased twigs and spreads during cool, wet weather in the spring and fall. Infections occur 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 after the first of July is important to prevent overly vigorous growth which is very susceptible to fall infection. Field history, the weather in the spring, and the severity of disease at winter pruning, can all be used to forecast infection levels. Additional disease management practices are listed in *Table 5*. *Adoption of disease management practices in highbush blueberry production in Canada.*

Resistant Cultivars: None available.

Chemical controls: Chemical controls available for the management of bacterial blight are listed in *Table 6*. *Fungicides and bio-fungicides registered for disease management in highbush blueberry in Canada.*

Issues for bacterial blight

1. There is a need to register alternatives to copper bactericides for the management of bacterial blight. Copper resistant strains of the pathogen have been reported in the Pacific Northwest.

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.

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. Wet weather favours infections. Senescing blossoms are especially susceptible to infection. Spores are spread to ripening fruit later in the season where they cause infections. Berries with minor or undetectable infections can be harvested but may contaminate healthy berries in storage.

Pest management

Cultural controls: Cultural controls involve minimizing periods of wetness in the crop canopy by managing irrigation and increasing air circulation through careful 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. Additional disease management practices are listed in *Table 5. Adoption of disease management practices in highbush blueberry production in Canada.*

Resistant Cultivars: None available.

Chemical controls: Fungicides registered for the control of botrytis blight are listed in *Table 6. Fungicides and bio-fungicides registered for disease management in highbush blueberry in Canada.*

Issues for botrytis blight

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.

Mummy berry (*Monilinia vacinii-corymbosi*)

Pest information

Damage: Early infections of *Monilinia vacinii-corymbosi* cause a wilting and discolouration of young leaves. Eventually entire shoots will wilt. Secondary infections occur on new flowers and shoots and on berries. Infected tissues wilt and turn brown. The disease causes berries to discolour, dry out and drop before harvest.

Life cycle: *M. vacinii-corymbosi* overwinters in mummified fruit called “mummy berries” left on the ground from the previous season. Mummy berries germinate to produce apothecia (spore producing structures) at bud break in the spring. The apothecia release ascospores that infect young, vegetative and floral buds, resulting in primary infections. Infected tissues subsequently give rise to conidia which are the means of secondary spread of the disease. Conidia are spread to young fruit by wind and pollinating insects. The fruit develop into mummy berries, the hardened masses of fungal tissues that overwinter.

Pest management

Cultural controls: Cultural controls are aimed at burying or destroying the mummified fruit and apothecia. Shallow cultivation is done in the fall. In the early spring, apothecia can be destroyed by raking or 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 is also used to bury mummies. Since disease is most severe in low-lying, moist areas or beside windbreaks where air circulation is poor, creating openings in windbreaks may reduce infections, but 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 disease management practices are listed in Table 5. *Adoption of disease management practices in highbush blueberry production in Canada.*

Resistant Cultivars: ‘Rancoccas’, ‘Weymouth’, ‘Earliblue’ and ‘Northland’ are among the most susceptible varieties.

Chemical controls: Fungicides registered for the control of mummy berry are listed in Table 6. *Fungicides and bio-fungicides registered for disease management in highbush blueberry in Canada.*

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 is more prevalent in older plantings than new plantings. The fungus only infects new wood. Lesions develop at leaf scars and in the axils of buds and eventually girdle stems, causing wilting and death. The leaves of girdled stems become bright red and these red “flags” are readily visible in late summer.

Life cycle: The fungus overwinters in lesions (cankers) in stems of infected plants. Pycnidia (fungal spore producing bodies) develop in cankers and release spores during rainy periods that cause new infections. Most infections occur from early March to July.

Pest management

Cultural controls: Cultural management practices for 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 over-head irrigation in infected fields or timing of irrigation for early morning, so plants can dry quickly, will minimize infections and disease spread. Additional disease management practices are listed in *Table 5. Adoption of disease management practices in highbush blueberry production in Canada.*

Resistant Cultivars: ‘Jersey’, ‘Pemberton’, ‘Earliblue’ and ‘Bluecrop’ are highly susceptible to godronia canker, while ‘Rubel’ and ‘Rancoccas’ are resistant.

Chemical controls: None available.

Issues for godronia canker

1. There is a need for the registration of fungicides for the control of godronia canker.

Phomopsis canker (*Phomopsis vaccinii*)

Pest information

Damage: Cankers caused by phomopsis 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. They give rise to conidia which 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.

Chemical controls: Fungicides registered for the control of phomopsis canker are listed in Table 6. *Fungicides and bio-fungicides registered for disease management in highbush blueberry in Canada.*

Issues for phomopsis canker

1. Phomopsis canker is a problem, particularly on new plantings of some of the newer cultivars. Continued research is required for improved understanding of the epidemiology of this disease.
2. Registrations of new crop protection materials are required to control phomopsis canker and manage fungicide resistance in the pathogen.

Phytophthora root and crown rot (*Phytophthora cinnamomi* and other species)

Pest information

Damage: Phytophthora destroys the plant roots and eventually causes crown death. Leaves of infected plants become yellow or scorched and stunted. Symptoms can resemble nutrient deficiencies, godronia canker or crown gall. This disease is often seen in patches corresponding to areas where the soil is poorly drained.

Life cycle: *Phytophthora* spp. can persist for many years as chlamydospores (resting spores) or oospores (sexual spores) which, under favourable conditions, 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 into the field. Good 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 drought stress and to prevent other stresses such as fertilizer or herbicide burn will help avoid disease development. Severely affected plants are removed from the field.

Resistant Cultivars: None available.

Chemical controls: Refer to Table 6. *Fungicides and bio-fungicides registered for disease management in highbush blueberry in Canada* for fungicides registered for the control of phytophthora root and crown rot.

Issues for Phytophthora root and crown rot

None identified.

Blueberry scorch virus (BIScV)

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 by 85 percent three years following 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 BIScV.

Pest management

Cultural controls: 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 control since infected plants are symptomless the first year of infection and can be overlooked. 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 spread of the disease. Additional disease management practices 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, the cultivars ‘Duke’ and ‘Bluecrop’ do not develop symptoms when infected with the Northwest strain. The East Coast strain of the virus causes symptoms in all varieties except ‘Jersey’.

Chemical controls: Insecticides registered to control the aphid vector are listed in *Table 9. Pesticides and biopesticides registered for the management of insect pests in highbush blueberry production in Canada.*

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 (BShV)

Pest information

Damage: Blueberry shock virus (BShV) 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 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. Laboratory testing is necessary for correct diagnosis. Plants showing suspicious symptoms should be tested, especially since symptoms strongly resemble blueberry scorch virus.

Life cycle: The virus spreads rapidly via pollen exchange.

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. Management of bees used for pollination to ensure they are not being moved from infected to clean fields is also important.

Resistant Cultivars: None available.

Chemical controls: None available.

Issues for BShV

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 BSHV on yield and plant vigour needs to be determined.

Tomato ringspot virus (ToRSV)

Pest information

Damage: In susceptible varieties, ToRSV results in a gradual decline in productivity of the blueberry bush and eventual death in some varieties. Foliage of infected plants develops symptoms of mosaic.

Life cycle: ToRSV is spread by the soilborne nematode *Xiphinema americanum* (dagger nematode).

Pest management

Cultural controls: It is important that only virus-free planting stock be used. The removal of infected plants and symptomless plants in the immediate vicinity of the infected plants, along with soil treatment (fumigation) for nematodes can help control this disease. The testing of soil for the presence of dagger nematodes in areas selected for new plantings will determine the potential for the development of this viral disease.

Resistant Cultivars: Varieties vary in their susceptibility to ToRSV.

Chemical controls: None available.

Issues for ToRPV

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 (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 the sharp-nosed leafhopper (*Scaphytopius magdalensis*). 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 leafhopper can be monitored throughout the growing season with the use of yellow sticky traps and controls implemented to eliminate disease spread. Infected bushes are typically removed and destroyed.

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

Chemical controls: Refer to Table 9. *Pesticides and biopesticides registered for the management of insect pests in highbush blueberry production in Canada* for insecticides registered for the control of leafhoppers.

Issues for blueberry stunt

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

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 within the blueberry causing the development of numerous lateral buds and shoots, the “brooms” in the spring. Different spore types are produced on the brooms from mid-May to June and are windblown to balsam fir where they cause new infections. The witches' broom is perennial and can produce spores for many years.

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.

Resistant Cultivars: None available.

Chemical controls: None available.

Issues for witches broom

None identified.

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 urgently required for spotted wing drosophila control and to reduce the potential for the development of resistance to available insecticides within the pest population.

Table 7. Occurrence of insect pests in highbush blueberry production in Canada

Insect	British Columbia	Quebec
Aphids (general)		
Blueberry aphid		
Heath spittlebug		
Leafhoppers		
Blueberry gall midge (Cranberry tip worm)		
Blueberry maggot		
Spotted wing drosophila		
Fruitworms		
Bruce spanworm		
Winter moth		
Obliquebanded leafroller		
European leafroller		
Plum curculio		
Black vine weevil		
European chafer		
Japanese beetle		
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 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 importance.		
Pest not present.		
Data not reported.		

¹Source: Highbush blueberry stakeholders in reporting provinces.

²Refer to the colour key (above) and 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

Practice / Pest		Aphids	Blueberry gall midge (cranberry tip worm)	Cranberry fruitworm	Spring feeding caterpillar complex	Spotted wing drosophila	Root weevils
Avoidance	Resistant varieties						
	Planting/ harvest date adjustment						
	Crop rotation						
	Choice of planting site						
	Optimizing fertilization						
	Reducing mechanical damage						
	Thinning/ pruning						
	Trap crops/ perimeter spraying						
	Physical barriers						
Prevention	Equipment sanitation						
	Mowing/ mulching/ flaming						
	Modification of plant density (row or plant spacing; seeding rate)						
	Seeding depth						
	Water/ irrigation management						
	End of season crop residue removal/ management						
	Pruning out/ removal of infested material throughout the growing season						
	Tillage/ cultivation						
	Removal of other hosts (weeds/ volunteers/ wild plants)						

.... continued

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

Practice / Pest		Aphids	Blueberry gall midge (cranberry tip worm)	Cranberry fruitworm	Spring feeding caterpillar complex	Spotted wing drosophila	Root weevils
Monitoring	Scouting/ trapping						
	Records to track pests						
	Soil analysis						
	Weather monitoring for degree day modelling						
	Use of portable electronic devices in the field to access pest identification/ management information						
	Use of precision agriculture technology (GPS, GIS) for data collection and field mapping of pests						
Decision making tools	Economic threshold						
	Weather/ weather-based forecast/ predictive model (eg. degree day modelling)						
	Recommendation from crop specialist						
	First appearance of pest or pest life stage						
	Observed crop damage						
	Crop stage						

...continued

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

Practice / Pest		Aphids	Blueberry gall midge (cranberry tip worm)	Cranberry fruitworm	Spring feeding caterpillar complex	Spotted wing drosophila	Root weevils
Suppression	Pesticide rotation for resistance management						
	Soil amendments						
	Biopesticides						
	Arthropod biological control agents						
	Beneficial organisms and habitat management						
	Ground cover/ physical barriers						
	Pheromones (eg. mating disruption)						
	Sterile mating technique						
	Trapping						
	Targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)						
This practice is used to manage this pest by growers in the province.							
This practice is not used to manage this pest in the province.							
This practice is not applicable for the management of this pest.							
Information regarding the practice for this pest is unknown.							

¹Source: Highbush blueberry stakeholders in British Columbia.

Table 9. Pesticides and biopesticides registered for the management of insect pests in highbush blueberry production in Canada

Active Ingredient ¹	Classification ²	Mode of Action ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
(E,Z)-2,13-octadecadien-1-ol (pheromone)	not classified	N / A	N / A	R	dogwood borer
acetamiprid	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	R	blueberry maggot, blueberry flea beetle, blueberry thrips, cherry fruitworm, cranberry fruitworm, strawberry rootworm (adults), aphids, blueberry spanworm (suppression)
<i>Bacillus thuringiensis</i> subsp. aizawai strain ABTS-351	<i>Bacillus thuringiensis</i> and the insecticidal proteins they produce	microbial disruptor of insect midgut membranes	11A	R	cranberry fruitworm, cherry fruitworm, whitemarked tussock moth, fruittree leafroller, European leafroller, obliquebanded leafroller, three-lined leafroller
<i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> strain EVB113-19	<i>Bacillus thuringiensis</i> and the insecticidal proteins they produce	microbial disruptor of insect midgut membranes	11A	R	cranberry fruitworm, cherry fruitworm, whitemarked tussock moth, fruittree leafroller, European leafroller, obliquebanded leafroller, three-lined leafroller
bifenthrin	pyrethroid, pyrethrin	sodium channel modulator	3A	RE (Emergency use registration June 15, 2016 to Aug. 31, 2016 in BC)	spotted wing drosophila

...continued

Table 9. Pesticides and biopesticides registered for the management of insect pests in highbush blueberry production in Canada (continued)

Active Ingredient ¹	Classification ²	Mode of Action ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
carbaryl	carbamate	acetylcholinesterase (AChE) inhibitor	1A	RES*	blueberry maggot, cherry fruitworm, cranberry fruitworm, lecanium scale, leafrollers, Bruce spanworm
chlorantraniliprole	diamide	ryanodine receptor modulator	28	R	cranberry fruitworm, cherry fruitworm, obliquebanded leafroller, three-lined leafroller, lesser appleworm, redstriped fireworm, blueberry spanworm, Japanese beetle (suppression)
cyantraniliprole	diamide	ryanodine receptor modulator	28	R	blueberry gall midge, blueberry maggot, (suppression), plum curculio, Japanese beetle, spotted wing drosophila, flea beetles, cranberry fruitworm, obliquebanded leafroller, threelined leafroller, fruittree leafroller, European leafroller, eyespotted bud moth, blueberry aphid, black vine weevil (adults), clay coloured weevil (adults)
deltamethrin	pyrethroid, pyrethrin	sodium channel modulator	3A	RE	leaf tier, Bruce spanworm, blueberry aphid,
dichlorvos (toxicant in commercial insect traps)	not classified	unknown	N/A	RES*	gypsy moth, forest tent caterpillar, other lepidopterous pests
dimethoate	organophosphate	acetylcholinesterase (AChE) inhibitor	1B	R	blueberry maggot

...continued

Table 9. Pesticides and biopesticides registered for the management of insect pests in highbush blueberry production in Canada (continued)

Active Ingredient ¹	Classification ²	Mode of Action ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
ferric phosphate	not classified	unknown	N/A	R	slugs, snails
flupyradifurone	butenolide	nicotinic acetylcholine receptor (nAChR) competitive modulator	4D	R	aphids, blueberry maggot
imidacloprid	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	RES*	European chafer and Japanese beetle (reduction in numbers or larvae), Japanese beetle (adults), aphids, leafhoppers (suppression), blueberry maggot
iron (present as ferric phosphate)	not classified	N / A	N / A	R	slugs, snails
lime sulphur or calcium polysulphide	not classified	unknown	N/A	R	scale insects, general clean-up
malathion	organophosphate	acetylcholinesterase (AChE) inhibitor	1B	R	aphids, cranberry fruitworm, cherry fruitworm, leafhoppers, leafrollers, rose chafers, spider mites, strawberry root weevil (adults, BC only), thrips, blueberry maggot (adults), cherry fruitworm, brown marmorated stinkbug (suppression)
malathion	organophosphate	acetylcholinesterase (AChE) inhibitor	1B	Emergency use registration June 1, 2016 to Nov. 30, 2016	spotted wing drosophila

...continued

Table 9. Pesticides and biopesticides registered for the management of insect pests in highbush blueberry production in Canada (continued)

Active Ingredient ¹	Classification ²	Mode of Action ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
methoxyfenozide	diacylhydrazine	ecdysone receptor agonist	18	R	spanworms, obliquebanded leafroller, cranberry fruitworm,
mineral oil	not classified	unknown	N/A	R	lecanium scale, general clean-up
novaluron	benzoylurea	inhibitor of chitin biosynthesis, type 0	15	R	cherry fruitworm, cranberry fruitworm
phosmet	organophosphate	acetylcholinesterase (AChE) inhibitor	1B	RE	blueberry maggot, blueberry spanworm, Japanese beetle (adults), spotted wing drosophila
potassium salts of fatty acids	not classified	unknown	N/A	R	aphids, mealybugs, spider mites, whitefly, soft brown scale, psyllids, rose or pear slugs, earwigs, elm leaf miner
triethanolamine salts of fatty acids	not classified	unknown	N / A	R	aphids, mealybugs, spider mites, whiteflies, soft brown scale, psyllids, rose and pear slugs, earwigs
triethanolamine salts of fatty acids	not classified	unknown	N / A	R	aphids, mealybugs, spider mites, whiteflies, soft brown scale, psyllids, rose and pear slugs, earwigs
pymetrozine	pyridine azomethine derivative	chlordotonal organ TRPV channel modulators	9B	RES	blueberry aphid and other known vectors of blueberry scorch virus
pyrethrin	pyrethroid, pyrethrin	sodium channel modulator	3A	RE	aphids, leafhoppers
spinetoram	spinosyn	nicotinic acetylcholine receptor (nAChR) allosteric modulator	5	R	blueberry flea beetle, obliquebanded leafroller, winter moth, blueberry spanworm (suppression), spotted wing drosophila

...continued

Table 9. Pesticides and biopesticides registered for the management of insect pests in highbush blueberry production in Canada (continued)

Active Ingredient ¹	Classification ²	Mode of Action ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
spinosad	spinosyn	nicotinic acetylcholine receptor (nAChR) allosteric modulator	5	R	obliquebanded leafroller, spanworm, winter moth, spotted wing drosophila, blueberry maggot
spirodiclofen	tetronic and tetramic acid derivative	inhibitor of acetyl CoA carboxylase	23	R	blueberry bud mite
spirotetramat	tetronic and tetramic acid derivative	inhibitor of acetyl CoA carboxylase	23	R	aphids, blueberry maggot, blueberry gall midge / cranberry tipworm, lecanium scale (suppression)
tebufenozide	diacylhydrazine	ecdysone receptor agonist	18	RE	cherry fruitworm, cranberry fruitworm, obliquebanded leafroller, redbanded leafroller, variegated leafroller, spanworm, army cutworm
thiamethoxam	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	RES	black vine weevil, obscure root weevil, brown marmorated stinkbug (suppression)

¹Source: 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 Sept 12, 2016. The product label is the final authority on pesticide use and should be consulted for application information. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

²Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (Version 8.1; April 2016)* (www.irac-online.org) (accessed Sept. 8, 2016).

³PMRA re-evaluation status: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review, as published in PMRA *Re-evaluation Note REV2016-07, Pest Management Regulatory Agency Re-evaluation and Special Review Workplan 2015-2020*, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

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 on the plants. The eggs hatch about May and 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 high nitrogen applications will help prevent excessive vegetative growth favourable for aphids. 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*). Cultural practices for the management of aphids are listed in Table 8. *Adoption of insect pest management practices in highbush blueberry production in Canada.*

Resistant Cultivars: None identified.

Chemical controls: Insecticides registered for the control of aphids in blueberries are listed in Table 9. *Pesticides and biopesticides registered for the management of insect pests in highbush blueberry production in Canada.*

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.
2. There is a need for the registration of new insecticide chemistries for aphids for resistance management.

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.

Life cycle: The spittlebug 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 immature stages after which the adult emerges. There is one generation per year.

Pest management

Cultural controls: None available. Economic thresholds for blueberry spittle bugs have not been determined.

Resistant Cultivars: None available.

Chemical controls: Insecticides registered for the control of spittlebugs are listed in *Table 9*.

Pesticides and biopesticides registered for the management of insect pests in highbush blueberry production in Canada.

Issues for blueberry spittlebug

None identified.

Leafhoppers (various species)

Pest information

Damage: Leafhoppers feed by sucking plant sap. During feeding leafhoppers may pick up the blueberry stunt phytoplasma from diseased plants and transmit it to uninfected plants. The sharp-nosed leafhopper (*Scaphytopius magdalensis*) is a key vector of blueberry stunt but other species including the potato leafhopper (*Empoasca fabae*), *Limotettix corniculus* and the aster leafhopper (*Macrostelus quadrilineatus*) will also transmit the pathogen.

Life cycle: There are one to two generations per year. Leafhoppers develop from egg through a number of nymphal stages to adult.

Pest management

Cultural controls: Leafhoppers may be monitored through the use of yellow sticky traps.

Economic thresholds have not been established for leafhoppers.

Resistant Cultivars: None available.

Chemical controls: Insecticides registered for leafhopper control are listed in *Table 9*. *Pesticides and biopesticides registered for the management of insect pests in highbush blueberry production in Canada.*

Issues for leafhoppers

None identified.

Blueberry gall midge (cranberry tip worm) (*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 small fly that lays its eggs on the growing tips of plants. The maggot-like larvae feed within the buds and when fully grown, drop to the soil to pupate. There can be several generations per year.

Pest management

Cultural controls: Practices used for the management of gall midge are listed in Table 8.

Adoption of insect pest management practices in highbush blueberry production in Canada.

Resistant Cultivars: None available.

Chemical controls: None available.

Issues for blueberry gall midge

None identified.

Blueberry maggot (blueberry fruit fly) (*Rhagoletis mendax*)

Pest information

Damage: Blueberry maggot larvae develop within the fruit making it unmarketable. If left uncontrolled, almost 100 percent 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: The movement of blueberry plants, fresh fruit and soil from areas known to be infested is prohibited under the federal Plant Protection Act. Cultural controls include completely harvesting the crop, eliminating all crop debris, and controlling weeds that provide shelter for adult flies. Yellow sticky boards (ammonium carbonate bait) and pheromone traps may be used to monitor for the presence of blueberry maggot adults and predict the timing of sprays.

Resistant Cultivars: None available.

Chemical controls: Insecticides registered for the control of blueberry maggot are listed in Table 9. *Pesticides and biopesticides registered for the management of insect pests in highbush blueberry production in Canada.*

Issues for blueberry maggot

1. The blueberry maggot has not been detected in British Columbia and there are areas of Quebec where this pest is not present. Continued vigilance is required to prevent the introduction of this pest into non-infested areas.

Spotted wing Drosophila (SWD) (*Drosophila suzukii*)

Pest information

Damage: Spotted wing drosophila (SWD) can attack many types of berries and stone fruit.

Unlike other fruit flies, female SWD have a serrated ovipositor that enables them to lay eggs in unblemished, ripening fruit in addition to laying eggs in overripe, fallen or decaying fruit. Feeding by larvae within the fruit turns the flesh of the fruit brown and soft. Damage can provide entry sites for infection by secondary fungi and bacteria causing further deterioration of the fruit. This injury results in unmarketable fruit and economic loss to growers.

Life cycle: SWD overwinter as adult flies. The flies become active in the spring when they mate and lay eggs in susceptible fruit. After hatching, larvae feed internally within fruit. Pupation takes place within or outside the fruit. There can be multiple, overlapping generations in a year. The insect can be dispersed by wind or moved into new areas through the movement of infested fruit.

Pest management

Cultural controls: Sanitation practices such as the removal of over-ripe and fallen fruit, the elimination of old fruit in processing areas and in equipment, and the removal of nearby, wild, alternate hosts, will help to reduce the SDW population. 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 are listed in *Table 8. Adoption of insect pest management practices in highbush blueberry production in Canada.*

Resistant Cultivars: None available.

Chemical controls: Pesticides registered for the control of SWD in highbush blueberry are listed in *Table 9. Pesticides and biopesticides registered for the management of insect pests in highbush blueberry production in Canada.*

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.

Fruitworms: Cranberry fruitworm (*Acrobasis vaccinii*) and cherry fruitworm (*Grapholitha packardii*)

Pest information

Damage: Both the cranberry fruitworm and the cherry fruitworm feed on blueberry fruit. The cranberry fruitworm feeds by webbing fruit together, damaging several berries. The cherry fruitworm feeds within the fruit with one larva damaging one to two berries.

Life cycle: The cranberry fruitworm overwinters as mature larvae in a cocoon in weeds and soil debris. Mature larvae of the cherry fruitworm overwinter under bark. The adults of both insects emerge in late spring following pupation and lay eggs directly on the fruit. The cherry fruitworm adult also lays eggs on the leaves around blossom time. Once the eggs hatch, the larvae feed within the berries but remain hidden. Both species of moths have 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. There are no economic thresholds available. Treatments are timed for the first entry of larvae into the fruit. Other practices used to manage fruitworms are listed in *Table 8. Adoption of insect pest management practices in highbush blueberry production in Canada.*

Resistant Cultivars: None identified.

Chemical controls: Insecticides registered for fruitworm control on highbush blueberries are listed in *Table 9. Pesticides and biopesticides registered for the management of insect pests in highbush blueberry production in Canada.*

Issues for cranberry fruitworm and cherry fruitworm

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

Plum curculio (*Conotrachelus nenuphar*)

Pest information

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

Life cycle: Adult plum curculios 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 at maturity 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. Some naturally occurring parasites will prey upon eggs and larvae, but rates of parasitism are usually low.

Resistant Cultivars: None available.

Chemical controls: Refer to *Table 9. Pesticides and biopesticides registered for the management of insect pests in highbush blueberry production in Canada* for pesticides registered for the control of plum curculio.

Issues for plum curculio

1. The registration of insecticides which can be used in integrated pest management systems for plum curculio is required.
2. Plum curculio has not been detected in British Columbia; however it is important that control products be available in the event that this pest spreads into B.C. and other new areas.

Spring feeding caterpillars: Bruce spanworm (*Operophtera 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: Management practices for these insects are listed in *Table 8. Adoption of insect pest management practices in highbush blueberry production in Canada*.

Resistant Cultivars: None available.

Chemical controls: Insecticides registered for the control of spanworm and winter moth are listed in *Table 9. Pesticides and biopesticides registered for the management of insect pests in highbush blueberry production in Canada*.

Issues for winter moth and spanworm

None identified.

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 on the blueberry plant and complete their feeding 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 by removing over-wintering sites.

Additional practices for the management of these insects are listed in *Table 8. Adoption of insect pest management practices in highbush blueberry production in Canada*

Resistant Cultivars: None identified.

Chemical controls: Insecticides registered for these pests are listed in *Table 9. Pesticides and biopesticides registered for the management of insect pests in highbush blueberry production in Canada.*

Issues for leafrollers

None identified

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 plants. Adults feed at night and cause notching on the leaf edges. Affected bushes may become stunted, yield poorly and die.

Life cycle: 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 or on the soil in June and continue until mid-September. Immediately following hatch, the larvae work through the soil and begin feeding on roots.

Pest management

Cultural controls: Use 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. 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 listed in *Table 8. Adoption of insect pest management practices in highbush blueberry production in Canada.*

Resistant Cultivars: None available.

Chemical controls: Insecticides registered for the control of weevils are listed in *Table 9.*

Pesticides and biopesticides registered for the management of insect pests in highbush blueberry production in Canada.

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 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*), Japanese beetle (*Popillia japonica*) and June beetle (*Phyllophaga* sp.)

Pest information

Damage: The larval stage of European chafers, Japanese beetles and June beetles, 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.

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 back in the soil.

European chafer and Japanese beetles complete one generation per year, but June beetles take three years to complete their life cycle.

Pest management

Cultural controls: It is important to check sites for the presence of white grubs prior to planting.

Resistant Cultivars: None available.

Chemical controls: Insecticides registered for the control of white grubs are listed in *Table 9*.

Pesticides and biopesticides registered for the management of insect pests in highbush blueberry production in Canada.

Issues for white grubs

1. Effective controls for white grubs are required.

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.

Table 10. Occurrence of weeds in highbush blueberry production in Canada

Weed	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 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.		

¹Source: Highbush blueberry stakeholders in reporting provinces.

²Refer to the colour key (above) and 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

Practice / Pest		Annual broadleaf weeds	Annual grass weeds	Perennial broadleaf weeds	Perennial grass weeds
Avoidance	Planting/ harvest date adjustment				
	Crop rotation				
	Choice of planting site				
	Optimizing fertilization				
	Use of weed-free seed				
Prevention	Equipment sanitation				
	Mowing/ mulching/ flaming				
	Modification of plant density (row or plant spacing; seeding)				
	Seeding/ planting depth				
	Water/ irrigation management				
	Weed management in non-crop lands				
	Weed management in non-crop years				
	Tillage/ cultivation				
Monitoring	Scouting/ field inspection				
	Field mapping of weeds/ record of resistant weeds				
	Soil analysis				
	Use of portable electronic devices in the field to access pest identification/management information				
	Use of precision agriculture technology (GPS, GIS) for data collection and field mapping of pests				
Decision making tools	Economic threshold				
	Weather/ weather-based forecast/ predictive model				
	Recommendation from crop specialist				
	First appearance of weed or weed growth stage				
	Observed crop damage				
	Crop stage				
Suppression	Pesticide rotation for resistance management				
	Soil amendments				
	Biopesticides				
	Arthropod biological control agents				
	Habitat/ environment management				
	Ground cover/ physical barriers				
	Mechanical weed control				
	Targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)				
This practice is used to manage this pest by growers in the province.					
This practice is not used to manage this pest in the province.					
This practice is not applicable for the management of this pest.					
Information regarding the practice for this pest is unknown.					

¹Source: Highbush blueberry stakeholders in British Columbia.

Table 12. Herbicides and bioherbicides registered for the management of weeds in highbush blueberry production in Canada

Active Ingredient ¹	Classification ²	Mode of Action ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
2,4-D	phenoxy-carboxylic-acid	synthetic auxin	4	RES	annual and perennial broadleaf weeds
ammonium soap of fatty acids	not classified	unknown	N/A	R	moss, annual broadleaf weeds and grasses, burn down of perennial weeds
bentazon (bendioxide)	benzothiadiazinone	inhibition of photosynthesis at photosystem II (site B)	6	R	broadleaf weeds, yellow nutsedge
bentazon (bendioxide)	benzothiadiazinone	inhibition of photosynthesis at photosystem II (site B)	6	R	broadleaf weeds, yellow nutsedge
carfentrazone-ethyl (hooded sprayer application)	triazolinone	inhibition of protoporphyrinogen oxidase (Protox, PPO)	14	R	broadleaf weeds
clethodim	cyclohexanedione 'DIMs'	inhibition of acetyl CoA carboxylase (ACCase)	1	RE	annual grass weeds, quackgrass
clopyralid	pyridine carboxylic acid	synthetic auxin	4	R	vetch, red clover, white clover

...continued

Table 12. Herbicides and bioherbicides registered for the management of weeds in highbush blueberry production in Canada (continued)

Active Ingredient ¹	Classification ²	Mode of Action ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
fluazifop-p-butyl	aryloxyphenoxy-propionate 'FOP'	inhibition of acetyl CoA carboxylase (ACCase)	1	RES	annual grass weeds , quackgrass
flumioxazin	N-phenylphthalimide	inhibition of protoporphyrinogen oxidase (Protox, PPO)	14	R	redroot pigweed, green pigweed, common ragweed, common lamb's-quarters, green foxtail, hairy nightshade, dandelion, eastern black nightshade, kochia, Canada fleabane
glyphosate (spot treatment; site preparation)	glycine	inhibition of 5-enolpyruvyl-shikimate-3-phosphate synthase (EPSPS)	9	RE	annual and perennial weeds, woody brush and trees
halosulfuron	sulfonylurea	inhibition of acetolactate synthase (ALS) or acetohydroxyacid synthase (AHAS)	2	R	nutsedge, certain broadleaf weeds
mesotrione	triketone	inhibition of 4-hydroxyphenyl-pyruvate-dioxygenase (4-HPPD)	27	R	lamb's-quarters, redroot pigweed, velvetleaf, wild mustard, eastern black nightshade, common ragweed (suppression)
Newly planted highbush blueberry					
metribuzin	triazinone	inhibition of photosynthesis at photosystem II site A	5	R	annual broadleaf and grass weeds
oxyfluorfen	diphenylether	inhibition of protoporphyrinogen oxidase (Protox, PPO)	14	R	certain broadleaf weeds, field pansy, wood sorrel
s-metolachlor and R- enantiomer	chloroacetamide	mitosis inhibitor	15	RE	American nightshade, eastern black nightshade, crabgrass (smooth, hairy), barnyard grass, fall panicum, foxtail (green, yellow, giant), old witchgrass, redroot pigweed (suppression)

...continued

Table 12. Herbicides and bioherbicides registered for the management of weeds in highbush blueberry production in Canada (continued)

Active Ingredient ¹	Classification ²	Mode of Action ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
Established plantings					
dichlobenil	nitrile	inhibition of cell wall synthesis site A	20	RES	annual broadleaf weeds, blue aster, bracken fern, loosetrife, horsetail, knotweed, plantain, smartweed, grasses (certain sedges and Juncus species)
glufosinate ammonium	phosphinic acid	inhibition of glutamine synthetase	10	R	annual grass and broadleaf weeds
napropamide	acetamide	mitosis inhibitor	15	R	annual grasses and some broadleaf weeds
paraquat	bipyridylum	photosystem-I-electron diversion	22	RES	grasses, broadleaf weeds
rimsulfuron	sulfonylurea	inhibition of acetolactate synthase (ALS) or acetohydroxyacid synthase (AHAS)	2	R	barnyard grass, fall panicum, green foxtail, yellow foxtail, redroot pigweed, quackgrass, witchgrass, lamb's-quarters (suppression)
simazine and related triazines	triazine	inhibition of photosynthesis at photosystem II site A	5	RES	lady's-thumb, lamb's-quarters, purslane, ragweed, wild buckwheat, smartweed, volunteer clovers, baryard grass, crabgrass, wild oats, yellow foxtail, perennial species starting from seed

...continued

Table 12. Herbicides and bioherbicides registered for the management of weeds in highbush blueberry production in Canada (continued)

Active Ingredient ¹	Classification ²	Mode of Action ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
terbacil	uracil	inhibition of photosynthesis at photosystem II site A	5	R	grasses and certain weeds including sheep sorrel, buttercup, sedges, plantain, lady's thumb, fireweed, ragweed, wild radish, fall dandelion

¹Source: 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 Sept. 8, 2016. The product label is the final authority on pesticide use and should be consulted for application information. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

²Source: Weed Science Society of America (WSSA). Herbicide Mechanism of Action (MOA) Classification list (last modified 09/11/2016) <http://wssa.net> (accessed Sept. 13, 2016)

³PMRA re-evaluation status: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review, as published in PMRA *Re-evaluation Note REV2016-07, Pest Management Regulatory Agency Re-evaluation and Special Review Workplan 2015-2020*, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA

Annual grass and broadleaf weeds

Pest information

Damage: 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.

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.

Pest management

Cultural controls: By managing 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 pruning the blueberry roots. Cover crops may be grown between rows to reduce weed growth, as well as to provide leaching and erosion protection. Common cover crops including “companion grass” (a blend of perennial dwarf ryegrass and fescue), buckwheat, pearl millet or Sudan grass are seeded the year before blueberry planting. Practices used in the management of annual weeds are listed in *Table 11*.

Adoption of weed management practices in highbush blueberry production in Canada.

Chemical controls: Pre-plant soil fumigants for nematodes also help suppress annual weeds.

Herbicides registered for the control of annual weeds are listed in *Table 12*. *Herbicides and bioherbicides registered for the management of weeds in highbush blueberry production in Canada.*

Issues for annual weeds

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

Perennial broadleaf and grass weeds

Pest information

Damage: 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.

Life cycle: Perennial weeds live for many years and re-grow each spring from rhizomes, crowns, rootstocks or tubers. They also flower and produce seed.

Pest management

Cultural controls: Control of perennial weeds before planting will help to reduce the pressure from these weeds over time. Herbicides and cultural practices used in rotational crops will help manage perennial weeds in blueberries. Serious perennial infestations require persistent control for many years. By managing weeds in headlands and other non-crop areas and by preventing them from setting seed on crop land, growers can gradually decrease the reservoir of weed seeds in their fields. Following strict sanitation procedures will reduce the spread of perennial roots, tubers or rhizomes in soil and water and on field equipment. Practices used in the management of perennial weeds are listed in *Table 11. Adoption of weed management practices in highbush blueberry production in Canada.*

Table 11. Adoption of weed management practices in highbush blueberry production in

Canada
Chemical controls: Herbicides registered for the control of perennial weeds are listed in *Table 12. Herbicides and bioherbicides registered for the management of weeds in highbush blueberry production in Canada.*

Issues for perennial broadleaf and grass weeds

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

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 before they climb into the plants. Baits may be used to eliminate slugs and snails.

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 physical 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 only effective when used 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.

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.

Resources

IPM/ICM resources for production of highbush blueberry in Canada

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

British Columbia Ministry of Agriculture and Lands, berry information
(www.agf.gov.bc.ca/berries)

British Columbia Ministry of Agriculture and Lands. 2012-2013 Berry Production Guide, *Beneficial Management Practices for BC Berry Growers*. (www.productionguide.agrifoodbc.ca)

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

Ontario Ministry of Agriculture, Food and Rural Affairs. Publication 360, Guide to Fruit Production, 2016-17. (www.omafr.gov.on.ca/english/crops/pub360/p360toc.htm)

Ontario Ministry of Agriculture, Food and Rural Affairs, berry information
(<http://www.omafr.gov.on.ca/english/crops/hort/berry.html>)

Provincial Crop Specialists and Provincial Minor Use Coordinators

Province	Ministry	Crop Specialist	Minor Use Coordinator
British Columbia	British Columbia Ministry of Agriculture www.gov.bc.ca/agri	Carolyn Teasdale carolyn.teasdale@gov.bc.ca	Caroline Bédard caroline.bedard@gov.bc.ca
Québec	Ministère d'Agriculture, Pêcheries et Alimentation du Québec www.mapaq.gouv.qc.ca	Christian Lacroix Christian.lacroix@mapaq.gouv.qc.ca	Luc Urbain luc.urbain@mapaq.gouv.qc.ca

National and Provincial Fruit Grower Organizations

BC Blueberry Council (www.bcblueberry.com)

North American Blueberry Council (www.nabcblues.org)

Ontario Berry Growers Association (<http://ontarioberries.com/>)

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 11 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.

Presence	Occurrence information				Colour Code
Present	Data available	Frequency	Distribution	Pressure	
		Yearly - Pest is present 2 or more years out of 3 in a given region of the province.	Widespread - The pest population is generally distributed throughout crop growing regions of the province. In a given year, outbreaks may occur in any region.	High - If present, potential for spread and crop loss is high and controls must be implemented even for small populations.	Red
				Moderate - If present, potential for spread and crop loss is moderate: pest situation must be monitored and controls may be implemented.	Orange
				Low - If present, the pest causes low or negligible crop damage and controls need not be implemented.	Yellow
			Localized - The pest is established as localized populations and is found only in scattered or limited areas of the province.	High - see above	Orange
				Moderate - see above	White
				Low - see above	White
		Sporadic - Pest is present 1 year out of 3 in a given region of the province.	Widespread - as above	High - see above	Orange
				Moderate - see above	Yellow
				Low - see above	White
			Localized - as above	High - see above	Yellow
				Moderate -see above	White
Low - see above	White				

...continued

Appendix 1 (continued)

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

<u>Presence</u>	Occurrence information		Colour Code
Present	Data not available	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.	White
		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.	Blue
Not present	The pest is not present in commercial crop growing areas of the province, to the best of your knowledge.		Black
Data not reported	Information on the pest in this province is unknown. No data is being reported for this pest.		Grey

References

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- 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>. (accessed 2016-04-20).
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- 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>. (accessed June 2, 2016)
- Laplante, Nathalie, Christian Lacroix and Gerard Gilbert. *Les phytoplasmes dans le bleuets en corymbe*. Réseau d'avertissements phytosanitaires – Bulletin d'information No. 11 - Petits Fruits 19 juin 2014. <https://www.agrireseau.net/Rap/documents/b11pf14.pdf> (accessed June 2, 2016)
- Wild Blueberry Production Guide 36. *Blueberry spittlebug* <http://perlebleue.ca/images/documents/amenagement/guideanglais/e036.pdf> (accessed June 2, 2016).