



Agriculture and
Agri-Food Canada

Agriculture et
Agroalimentaire Canada



Crop Profile for Lowbush Blueberry in Canada, 2014

Prepared by:
Pesticide Risk Reduction Program
Pest Management Centre
Agriculture and Agri-Food Canada

First Edition –2008

Crop Profile for Wild Blueberry in Canada

Catalogue No.: A118-10/1-2008E-PDF

ISBN : 978-0-662-46315-3

AAFC No.: 10305E

Second Edition – 2012

Crop Profile for Lowbush Blueberry in Canada, 2011

Catalogue No. A118-10/31-2012E-PDF

ISBN 978-1-100-20656-1

AAFC No. 11751E

Third Edition - 2017

Crop Profile for Lowbush Blueberry in Canada, 2014

Catalogue No.: A118-10/31-2014E-PDF

ISBN: 978-0-660-07144-2

AAFC No.: 12595 E

© Her Majesty the Queen in Right of Canada, as represented by the Minister of Agriculture and Agri-Food 2005, 2011, 2017

Electronic version available at www.agr.gc.ca/pmc-cropprofiles

Paru également en français sous le titre: «Profil de la culture du bleuet nain au Canada, 2014 »

For more information reach us at www.agr.gc.ca or call us toll-free 1-855-773-0241.

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 lowbush blueberry, the reader is referred to provincial crop production guides and provincial ministry websites listed in the Resources Section at the end of the profile.

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

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

For inquiries regarding the contents of the profile, please contact:

Pesticide Risk Reduction Program
Pest Management Centre
Agriculture and Agri-Food Canada
Building 57, 960 Carling Ave
Ottawa, ON, Canada K1A 0C6
pmc.cla.info@agr.gc.ca

Contents

Crop Production.....	1
Industry Overview	1
Production Regions.....	3
North American Major and Minor Field Trial Regions	3
Cultural Practices	5
Abiotic Factors Limiting Production	7
Pollination	7
Temperature extremes	7
Diseases	8
Key issues	8
Anthracnose (ripe rot) (<i>Colletotrichum</i> spp.)	17
Botrytis blight (<i>Botrytis cinerea</i>).....	17
Leaf rust (<i>Naohidemyces vaccinii</i>)	18
Monilinia blight (<i>Monilinia vaccinii-corymbosi</i>)	19
Phomopsis canker (<i>Phomopsis vaccinii</i>)	20
Powdery mildew (<i>Microsphaera penicillata</i> var. <i>vaccinii</i>).....	20
Red leaf (<i>Exobasidium vacinii</i>)	21
Septoria leaf spot (<i>Septoria</i> spp.)	22
Valdensinia leafspot (<i>Valdensinia heterodoxa</i>).....	22
Witches' broom (<i>Pucciniastrum goeppertianum</i>)	23
Insects and Mites	25
Key issues	25
Blueberry case beetle (<i>Neochlamisus cribripennis</i>)	33
Blueberry flea beetle (<i>Altica sylvia</i>).....	33
Blueberry maggot (fruit fly) (<i>Rhagoletis mendax</i>)	34
Blueberry leaftier (<i>Croesia curvalana</i>)	35
Blueberry gall midge (cranberry tipworm) (<i>Dasineura oxycoccana</i>).....	36
Blueberry sawfly (<i>Neopareophora litura</i>).....	36
Blueberry spanworm (<i>Itame argillacearia</i>) and other spanworms	37
Blueberry stem gall wasp (<i>Hemadas nubilipennis</i>)	38
Blueberry thrips (<i>Frankliniella vaccinii</i> and <i>Catinathrips kainos</i>).....	38
Chainspotted geometer (<i>Cingilia catenaria</i>)	39
Whitemarked tussock moth (<i>Orgyia leucostigma</i>)	40
Gypsy moth (<i>Lymantria dispar</i>)	40
Redstriped fireworm (<i>Aroga trialbamaculella</i>).....	41
Spotted wing drosophila (SWD) (<i>Drosophila suzukii</i>).....	42
Weeds	43
Key Issues	43
Vertebrate Pests	52
Birds	52
Bear	52
Coyote	52
Deer	52
Resources	53
IPM/ICM resources for production of lowbush blueberry in Canada	53
Provincial Crop Specialists and Provincial Minor Use Coordinators.	54
National and Provincial lowbush blueberry Grower Organizations	55
Appendix 1	56
References.....	57

List of Tables and Figure

Table 1. General production information	2
Table 2. Distribution of lowbush blueberry production in Canada (2014)	3
Table 3. Lowbush blueberry production and pest management schedule in Canada.....	6
Table 4. Occurrence of diseases in lowbush blueberry production in Canada	9
Table 5. Adoption of disease management practices in lowbush blueberry production in Canada	10
Table 6. Fungicides and bio-fungicides registered for disease management in lowbush blueberry in Canada	12
Table 7. Occurrence of insect pests in Canadian lowbush blueberry production	26
Table 8. Adoption of insect pest management practices in lowbush blueberry production in Canada.....	27
Table 9. Insecticides and bio-insecticides registered for insect management in lowbush blueberry production in Canada.....	29
Table 10. Occurrence of weeds in Canadian lowbush blueberry production.....	44
Table 11. Adoption of weed management practices in lowbush blueberry production in Canada	45
Table 12. Herbicides and bio-herbicides registered for weed management in lowbush blueberry production in Canada.....	47
 Figure 1. Common zone map: North American major and minor field trial regions	4

Crop Profile for Lowbush Blueberry in Canada

The lowbush blueberry is a perennial, native fruit that grows in treeless barrens, fields and burned-over areas of north-eastern North America. It is a member of the Ericaceae or heath family. The crop is unique in that it is not planted, but is harvested from managed, wild stands, unlike the highbush blueberry that is planted and maintained in an orchard. Harvested lowbush blueberry species include *Vaccinium angustifolium* and *V. myrtilloides*.

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

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

Crop Production

Industry Overview

Blueberries rank as the number one fruit crop in Canada with respect to area under production. General production information is presented in Table 1.

Table 1. General production information

Canadian production (2014) ¹	96,527 tonnes 64,214 ha ⁴
Farm gate value (2014) ¹	\$ 136 million
Food available (2014) ²	1.06 kg/person (fresh)
	0.01 kg/ person (canned)
	1.91 kg/ person (frozen)
Blueberry imports (2014) ³	44,060 tonnes (fresh)
	530 tonnes (canned)
	14,040 tonnes (frozen)
Blueberry exports (2014) ³	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 2016-09-30).

²Source: Statistics Canada. *Table 002-0011 - Food available in Canada, annual (kilograms per person per year unless otherwise noted)*, CANSIM (database). (Accessed 2016-09-30).

³Source: Statistics Canada. Table 002-0010 - Supply and disposition of food in Canada, annual (tonnes unless otherwise noted), CANSIM (database). (Accessed 2016-09-30).

⁴Cultivated area includes bearing and non-bearing area.

Production Regions

Lowbush blueberries are produced commercially in eastern Canada, in the provinces of Nova Scotia, New Brunswick, Prince Edward Island, Newfoundland and Labrador and Quebec (refer to Table 2).

Table 2. Distribution of lowbush blueberry production in Canada (2014)¹

Production regions	Cultivated area (hectares) ^{1,2}	Bearing area (hectares) ¹	Percent national production (cultivated area)
Ontario	F ³	F ³	F ³
Quebec	27,822	13,878	43%
New Brunswick	13,355	5,860	21%
Nova Scotia	17,604	8,105	27%
Prince Edward Island	F ³	F ³	F ³
Newfoundland and Labrador	F ³	F ³	F ³
Canada	64,214	30,202	100%

¹Source: Statistics Canada. *Table 001-0009 - Area, production and farm gate value of fresh and processed fruits by province, annual*, CANSIM (database). (Accessed 2016-09-30).

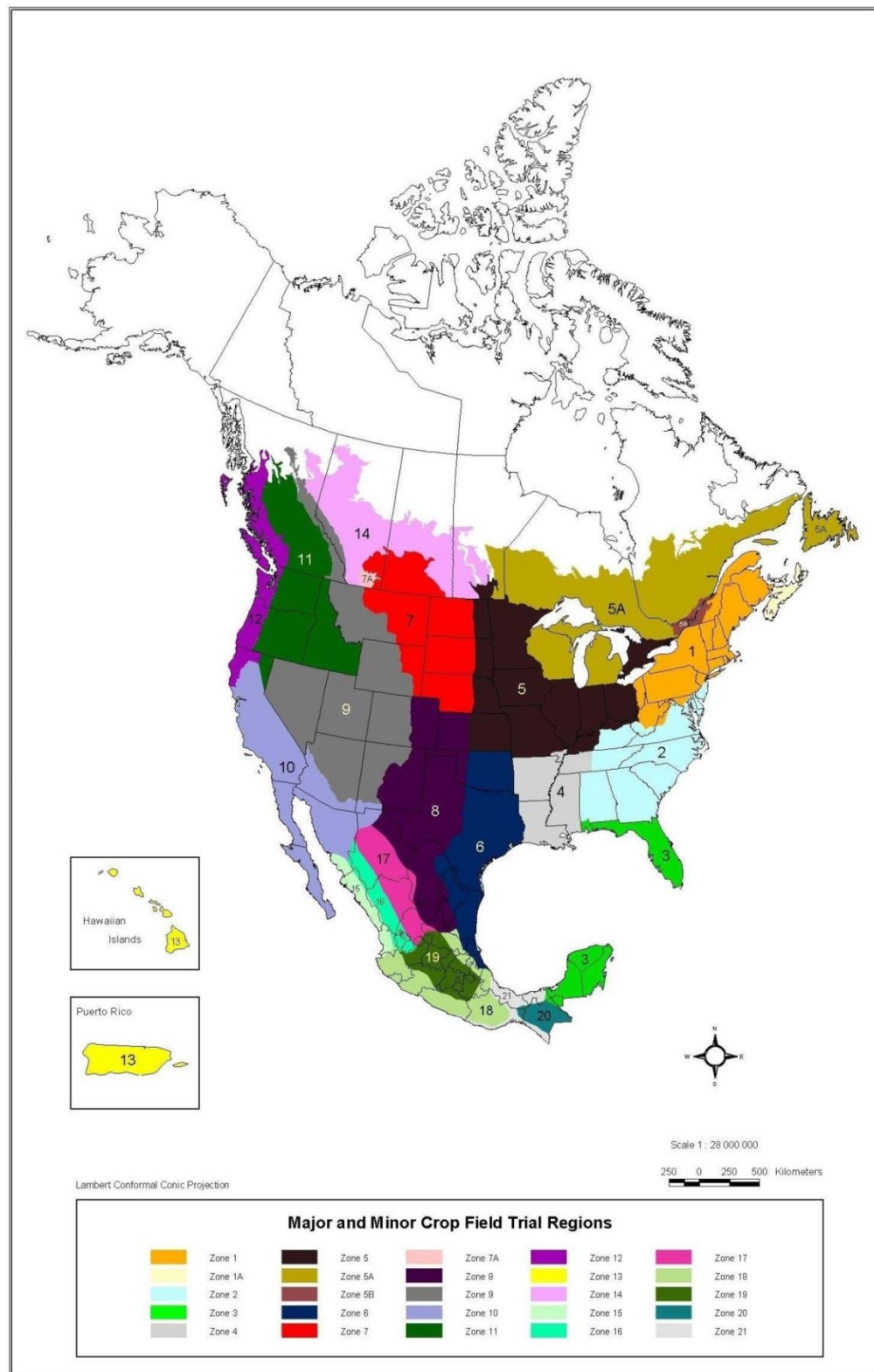
²Cultivated area includes bearing and non-bearing area.

³F - Too unreliable to be published.

North American Major and Minor Field Trial Regions

Major and minor crop field trial regions (Figure 1) are used by the Pest Management Regulatory Agency (PMRA) in Canada and the United States (US) Environmental Protection Agency (EPA) to identify the regions where residue chemistry crop field trials are required to support the registration of new pesticide uses. The regions are based on a number of parameters, including soil type and climate, but they do not correspond to plant hardiness zones. For additional information, please consult the PMRA Regulatory Directive 2010-05 “*Revisions to the Residue Chemistry Crop Field Trial Requirements*” (www.hc-sc.gc.ca/cps-spc/pubs/pest/pol-guide/dir2010-05/index-eng.php).

Figure 1. Common zone map: North American major and minor field trial regions¹



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

Cultural Practices

Lowbush blueberries are a perennial crop. The plants grow wild in areas of sandy, gravelly, well-drained soils with pH levels of 4.2 to 5.5. The blueberry bush spreads through slow-growing, underground stems called rhizomes.

Blueberries grow faster if the ground is undisturbed, so producers manage fields only by pruning, fertilizing, and controlling weeds, insects and diseases. Pruning by mowing or burning encourages the growth of vigorous new stems from underground rhizomes. Generally, blueberry fields are completely pruned every two years. This eliminates much of the above ground vegetation and gives the blueberry plants a competitive advantage during re-growth due to their extensive root system. The crop is usually pruned after harvest, late in the fall or in the early spring and then allowed to re-grow during the “sprout” year. Flower buds are set in the fall of the sprout year. The crop bears fruit the following year or “crop year”. Only half of the acreage is harvested in any one year. In Quebec, a three year cropping system is often used - one sprout or vegetative year and two harvest years. Thus fields are divided into three sections with two thirds of the acreage being harvested in a year.

Most of the crop is mechanically harvested (up to 80 percent in some areas), an innovation that has revolutionized the lowbush blueberry industry. Fields in rough terrain and in forested areas are still harvested by hand-raking.

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

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

Time of Year	Activity	Action
April	Plant care	Pruning by flail mowing or burning (sprout year (SY))
	Weed management	Pruning by flail mowing or burning (SY)
May	Plant care	Pollination (crop year, (CY)) and fertilization (SY)
	Disease management	Monitoring and spraying if necessary (CY)
	Insect and mite management	Monitoring and spraying if necessary (CY and SY)
	Weed management	Application of pre-emergent herbicides (SY)
June	Plant care	Pollination (CY) and fertilization (SY)
	Disease management	Monitoring and spraying if necessary (CY)
	Insect and mite management	Monitoring and spraying if necessary (CY and SY)
	Weed management	Application of post-emergent herbicides and spot applications (CY and SY)
July	Plant care	Leaf tissue sampling (tip dieback) (SY)
	Soil care	Soil sampling (same time as leaf sampling) (SY)
	Disease management	Monitoring and spraying if necessary (SY)
	Insect and mite management	Monitoring and spraying if necessary (CY)
	Weed management	Spot herbicide applications and physical control options (SY)
August	Plant care	Harvest (prune later in season or in spring) (CY) Leaf tissue sampling (tip dieback – prune year) (SY)
	Soil care	Soil sampling (same time as leaf sampling) (SY)
	Disease management	Limited activity
	Insect and mite management	Limited activity
	Weed management	Limited activity

Abiotic Factors Limiting Production

Pollination

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

Temperature extremes

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

Diseases

Key issues

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

Table 4. Occurrence of diseases in lowbush blueberry production in Canada^{1,2}

Disease	Quebec	New Brunswick	Nova Scotia	Prince Edward Island
Botrytis blight				
Leaf spot complex				
Leaf rust				
Septoria leaf spot				
Valdensinia leaf spot				
Monilinia blight				
Powdery mildew				
Red Leaf				
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 to moderate 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: Lowbush 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 lowbush blueberry production in Canada¹

Practice / Pest		Botrytis blight	Monilinia blight	Septoria leaf spot	Valdensinia leaf spot	Leaf rust
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 sanitization					
	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					
	Removal of other hosts (weeds/ volunteers/ wild plants)					
Monitoring	Scouting/ trapping					
	Records to track diseases					
	Soil analysis					
	Weather monitoring for disease forecasting					
	Use of portable electronic devices in the field to access pest identification /management information					
	Use of precision agriculture technology (GPS, GIS) for data collection and field mapping of pests					

....continued

Table 5. Adoption of disease management practices in lowbush blueberry production in Canada¹ (continued)

Practice / Pest		Botrytis blight	Monilinia blight	Septoria leaf spot	Valdensinia leaf spot	Leaf rust
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	Pruning by mowing or burning					
	Sickle bar mowing pre-burn treatment					
New practices (by province)	Application of foliar nutrients for improving plant health (Nova Scotia)					
This practice is used by growers to manage this pest.						
This practice is not used by growers to manage this pest.						
This practice is not applicable for the management of this pest.						
Information regarding the practice for this pest is unknown.						

¹Source: Lowbush blueberry stakeholders in reporting provinces (Quebec, New Brunswick, Nova Scotia and Prince Edward Island).

Table 6. Fungicides and bio-fungicides registered for disease management in lowbush 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	F3: 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, mummy berry, anthracnose, rust, septoria leaf spot (suppression), valdensinia leaf spot (suppression)
benzovindiflupyr	pyrazole-4-carboxamide	C2: respiration	complex II: succinate dehydrogenase	7	R	blueberry leaf rust, 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, valdensinia leaf spot (suppression), septoria leaf spot (suppression)

...continued

Table 6. Fungicides and bio-fungicides registered for disease management in lowbush 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 (sprout year)	chloronitrile (phthalonitrile)	multi-site contact activity	multi-site contact activity	M5	RE	phomopsis canker, suppression of septoria leaf spot, rust and valdensinia leaf spot
copper (present as copper octanoate)	inorganic	multi-site contact activity	multi-site contact activity	M1	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, grey mould, primary phase of mummy berry / monilinia, sclerotinia berry drop (suppression)

...continued

Table 6. Fungicides and bio-fungicides registered for disease management in lowbush 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
fenhexamid	hydroxyanilide	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, fruit anthracnose and valdensinia leaf spot
fluopyram	pyridinyl-ethyl-benzamide	C2: respiration	complex II: succinate-dehydrogenase	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
fluxapyroxad	pyrazole-4-carboxamide	C2: respiration	complex II: succinate-dehydrogenase	7	R	grey mould (suppression)
isofetamid	phenyl-oxo-ethyl thiophene amide	C2: respiration	complex II: succinate-dehydrogenase	7	R	grey mould
mandestrobin	methoxy-acetamide	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	botrytis grey mould

...continued

Table 6. Fungicides and bio-fungicides registered for disease management in lowbush 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
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.
penthiopyrad	pyrazole-4-carboxamide	C2: respiration	complex II: succinate-dehydrogenase	7	R	mummy berry (suppression)
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
propiconazole	triazole	G1: sterol biosynthesis in membranes	C14- demethylase in sterol biosynthesis (erg11/cyp51)	3	R	monilinia blight (mummy berry)

...continued

Table 6. Fungicides and bio-fungicides registered for disease management in lowbush 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
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
thiophanate-methyl	thiophanate	B1: cytoskeleton and motor proteins	β-tubuline assembly in mitosis	1	RE	blossom and twig blight

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.

Anthracnose (ripe rot) (*Colletotrichum* spp.)

Pest information

Damage: Anthracnose can cause lesions on leaves stems, blossoms and fruit. Lesions on stems develop a target spot appearance with concentric rings. Flowers become blighted and infected fruit becomes shrivelled, often at the blossom end. Symptoms on fruit often do not develop until the fruit ripens. Masses of shiny, salmon-coloured spores develop in infected tissues under moist conditions.

Life cycle: The causal fungus overwinters in infected stems. In the spring, conidia (spores) produced in the overwintering lesions are rain splashed to new tissues where they give rise to new infections. Disease spread continues throughout the growing season during wet weather.

Pest management

Cultural controls: None available

Chemical controls: None available

Issues for anthracnose

None identified.

Botrytis blight (*Botrytis cinerea*)

Pest information

Damage: Botrytis blight can be a serious problem during prolonged wet conditions. Blossoms, fruit and leaves may be affected. Affected leaves turn brown and entire flower clusters may become blighted. Under humid conditions, infected tissues can become covered with grey mould. Frost and herbicide damage increase the susceptibility of the weeds and the blueberry bushes to the disease.

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

Pest management

Cultural controls: Pruning by burning every second or third crop cycle may reduce some overwintering inoculum of *B. cinerea*. The control of weeds in and around blueberry fields will eliminate the overwintering sources of disease. Potential host weeds include bunchberry, sheep sorrel, goldenrod, pearly everlasting, *Potentilla* spp. and some grasses. Monitoring of early flowering clones for infections of *B. cinerea* helps determine if sprays are necessary. Additional management practices for botrytis blight are listed in Table 5. *Adoption of disease management practices in lowbush blueberry production in Canada.*

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

Issues for botrytis blight

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

Leaf rust (*Naohidemyces vaccinii*)

Pest information

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

Life cycle: Leaf rust produces a number of spore types and requires two hosts to complete its life cycle. In the spring, spores produced on hemlock, are wind-blown to blueberry where they infect new foliage. Rust pustules develop in leaf lesions by mid-season and release a second type of spore that can re-infect blueberry leaves. The pathogen overwinters in leaf lesions on blueberry and in the early spring produces spores that re-infect hemlock. Leaf rust may also cycle on blueberry alone since the fungus has been found on blueberry when hemlock has been absent from the area.

Pest management

Cultural controls: Management practices for leaf rust are listed in *Table 5. Adoption of disease management practices in lowbush blueberry production in Canada.*

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

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

Issues for leaf rust

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

Monilinia blight (*Monilinia vaccinii-corymbosi*)

Pest information

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

Life cycle: The fungus overwinters as mummy berries. During bud break, mummy berries give rise to apothecia, structures that release spores (ascospores). Under cool and wet conditions, these spores infect the vegetative and floral buds, with disease symptoms appearing in 10 to 20 days. Exposure to frost increases the susceptibility of buds to infection. Conidia (a second type of spore) are produced in the diseased tissues and are carried by wind or pollinating insects to new plants where they cause new infections. Fruits developing from infected blossoms remain symptom-less until they are almost mature, at which time they drop to the ground and the fungus completes its life cycle.

Pest management

Cultural controls: Pruning by burning helps destroy mummy berries. Measures to improve drainage and air circulation in a field can help reduce the susceptibility of blueberries to monilinia blight. Additional management practices for monilinia blight are listed in *Table 5.*

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

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

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

Issues for monilinia blight

1. A forecasting model for monilinia blight has been developed. To be implemented, the model needs to incorporate a system for the collection of field specific weather data and be made available to growers.
2. New fungicides other than the demethylation inhibitors (DMI's) are required for the management of monilinia blight as resistance management tools. The registration of fungicides with protectant properties is required for the management of this disease.
3. It is critical that all new product registrations have pre-harvest intervals that enable the crop to meet maximum residue levels (MRLs) for export as well as domestic markets.

Phomopsis canker (*Phomopsis vaccinii*)

Pest information

Damage: *Phomopsis vaccinii* causes elongated, flattened cankers on stem bases. The cankers kill stems, causing leaf reddening and drop. Phomopsis canker can be devastating to bushes in low areas where winter injury and spring frosts are a problem. The disease is not as common in fruiting fields as it is in sprout fields.

Life cycle: Conidia produced in stem lesions from mid-summer until fall and are spread by splashing rain to new infection sites. Injuries from mechanical damage, winter stresses or spring frost are necessary for phomopsis infection. Wounds from mechanical harvesting or pruning may also facilitate infections.

Pest management

Cultural controls: Monitoring of fields for phomopsis canker is done in early September of the sprout year. Pruning by burning reduces disease incidence. Avoiding mechanical injury to the plants will minimize infection sites.

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

Issues for phomopsis canker

None identified.

Powdery mildew (*Microsphaera penicillata* var. *vaccinii*)

Pest information

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

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

Pest management

Cultural controls: Pruning by burning may reduce inoculum.

Chemical controls: Powdery mildew is suppressed by fungicide applications for leaf rust and septoria leafspot. Fungicides registered for the control of powdery mildew are listed in *Table 6. Fungicides and bio-fungicides registered for disease management in lowbush blueberry in Canada.*

Issues for powdery mildew

None identified.

Red leaf (*Exobasidium vacinii*)

Pest information

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

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

Pest management

Cultural controls: The practice of burn pruning does not control rhizome infections but may destroy new infections in the shoots that have not yet progressed into the rhizome.

Chemical controls: In fields where red leaf is a problem, diseased plants may be eradicated by spot spraying with a recommended herbicide in the sprout year.

Issues for red leaf

1. The industry-wide impact of this disease is minor, but yield reduction does occur in some production regions. Further studies on the biology, yield impact and effective management, including potential benefits of improved soil nutrition, are required.

Septoria leaf spot (*Septoria* spp.)

Pest information

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

Life cycle: The fungus overwinters on infected leaves and twigs. Spores are released from late spring to early summer. Septoria leaf spot severity is dependent upon the number of wet periods that occur during this time.

Pest management

Cultural controls: Pruning by burning reduces inoculum. Additional management practices for septoria leaf spot are listed in *Table 5. Adoption of disease management practices in lowbush blueberry production in Canada.*

Chemical controls: Fungicides registered for the control of septoria leaf spot are listed in *Table 6. Fungicides and bio-fungicides registered for disease management in lowbush blueberry in Canada.*

Issues for septoria leaf spot

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

Valdensinia leafspot (*Valdensinia heterodoxa*)

Pest information

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

Life cycle: The fungus overwinters as sclerotia (resting bodies) in infected leaves. In the spring, tiny apothecial cups (sexual spore producing structures) form on infected leaves and release ascospores during wet conditions. Conidia, produced in lesions on fallen leaves, spread to the foliage canopy and cause new infections. The fungus is readily spread from field to field on equipment, footwear, etc. Other hosts of valdensinia which may be near blueberry fields include wild raspberry, birch saplings, bunchberry, maple saplings and wild strawberry.

Pest management

Cultural controls: Pruning by burning will reduce inoculum. Cleaning equipment and boots between fields will help reduce spread. Cleaning and sanitizing boxes and bins used during harvest before re-use will help to limit the spread of the pathogen. Additional management practices for valdensinia leaf spot are listed in *Table 5. Adoption of disease management practices in lowbush blueberry production in Canada.*

Chemical controls: Fungicides registered for the control of valdensinia leaf spot are listed in *Table 6. Fungicides and bio-fungicides registered for disease management in lowbush blueberry in Canada.*

Issues for valdensinia leaf spot

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

Witches' broom (*Pucciniastrum goeppertianum*)

Pest information

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

Life cycle: *Pucciniastrum* has a complex life cycle. From mid-May to late June, rust spores (teliospores) develop on infected shoots and germinate to produce another type of spore (basidiospore). Basidiospores are carried by wind to balsam fir trees that serve as alternate hosts and where aeciospores are produced. Aeciospores are carried by wind back to blueberry plants where they cause new infections, stimulating the production of lateral buds that develop into the characteristic, broom-like swollen shoots. Finally, teliospores are formed on the swollen, broom-like shoots of blueberry plants and overwinter there. The brooms are perennial and produce new growth each spring, serving as sources of the fungus for many years.

Pest management

Cultural controls: Infected blueberry plants are removed as they cannot be 'cured'. Due to the systemic nature of the disease in crowns and rhizomes, burning or flail mowing does not eliminate the disease. Removal of the alternate host (balsam fir) within 400 to-500 metres of blueberry fields may be effective, but may not be practical.

Chemical controls: Infected blueberry plants are killed by spot treatment with a systemic herbicide to prevent the spread of the disease.

Issues for witches' broom

None identified.

Key issues

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

Table 7. Occurrence of insect pests in Canadian lowbush blueberry production^{1,2}

Pest	Quebec	New Brunswick	Nova Scotia	Prince Edward Island
Blueberry case beetle				
Blueberry flea beetle				
Blueberry gall midge				
Blueberry maggot				
Spotted wing drosophila				
Blueberry sawfly				
Spanworms				
Blueberry spanworm				
Blueberry stem gall wasp				
Blueberry thrips (general)				
Plant bugs				
Redstriped fireworm				
Widespread yearly occurrence with high pest pressure.				
Widespread yearly occurrence with moderate pest pressure, OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.				
Widespread yearly occurrence with low to moderate 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: Lowbush 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 lowbush blueberry production in Canada¹

Practice / Pest		Blueberry flea beetle	Blueberry leaf tier	Blueberry maggot	Blueberry spanworm	Spotted wing drosophila
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 sanitization					
	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)					
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					

...continued

Table 8. Adoption of insect pest management practices in lowbush blueberry production in Canada¹ (continued)

Practice / Pest		Blueberry flea beetle	Blueberry leaf-tier	Blueberry maggot	Blueberry spanworm	Spotted wing drosophila
Decision-making tools	Economic threshold					
	Weather/ weather-based forecast/ predictive model (eg. degree day modelling)					
	Recommendation from crop specialist					
	First appearance of pest or pest life stage					
	Observed crop damage					
	Crop stage					
Suppression	Pesticide rotation for resistance management					
	Soil amendments					
	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.)					
Crop specific Practices	Pruning by mowing or burning					
	Use of light traps for detection / control of adult insects					
	Monitoring in sprout / vegetative year					

Table 9. Insecticides and bio-insecticides registered for insect management in lowbush blueberry production in Canada

Active Ingredient ¹	Classification ²	Mode of Action ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
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. <i>aizawai</i> strain ABTS-351	<i>Bacillus thuringiensis</i> and the insecticidal proteins they produce	microbial disruptor of insect midgut membranes	11A	R	blueberry spanworm, chainspotted geometer, Rannoch looper, 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	blueberry spanworm, chainspotted geometer, Rannoch looper, whitemarked tussock moth, fruittree leafroller, European leafroller, obliquebanded leafroller, three-lined leafroller
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	obliquebanded leafroller, three lined leafroller, climbing cutworm, Japanese beetle (suppression), cranberry fruitworm, cherry fruitworm, lesser appleworm, redstriped fireworm, blueberry spanworm
cyantraniliprole	diamide	ryanodine receptor modulator	28	R	blueberry gall midge, blueberry maggot, (suppression), plum curculio, Japanese beetle, spotted wing drosophila, flea beetle, cranberry fruitworm, obliquebanded leafroller, threelined leafroller, fruittree leafroller, European leafroller, eyespotted bud moth, blueberry aphid, cranberry fruitworm, black headed fire worm, Sparganothis fruitworm, black vine weevil (adults), clay coloured weevil (adults)
deltamethrin	pyrethroid, pyrethrin	sodium channel modulator	3A	RE	leaf tier, Bruce spanworm, blueberry aphid

...continued

Table 9. Insecticides and bio-insecticides registered for insect management in lowbush blueberry production in Canada

Active Ingredient ¹	Classification ²	Mode of Action ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
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
ferric phosphate	not classified	unknown	N/A	R	slugs, snails
flonicamid	flonicamid	chlordotonal organ modulator - undefined target site	29	R	aphids, lygus bugs including tarnished plant bug (suppression)
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
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)

...continued

Table 9. Insecticides and bio-insecticides registered for insect management in lowbush blueberry production in Canada

Active Ingredient ¹	Classification ²	Mode of Action ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
malathion	organophosphate	acetylcholinesterase (AChE) inhibitor	1B	Emergency use registration June 1, 2016 to Nov. 30, 2016	spotted wing drosophila
methoxyfenozide	diacylhydrazine	ecdysone receptor agonist	18	R	spanworms, obliquebanded leafroller, cranberry fruitworm,
novaluron	benzoylurea	inhibitor of chitin biosynthesis, type 0	15	R	cherry fruitworm, cranberry fruitworm
permethrin (vegetative year only)	pyrethroid, pyrethrin	sodium channel modulator	3A	RE	thrips
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
pyrethrin	pyrethroid, pyrethrin	sodium channel modulator	3A	RE	aphids, leafhoppers
spinetoram	spinosyn	nicotinic acetylcholine receptor (nAChR) allosteric modulator	5	R	blueberry flea beetle, blueberry spanworm (suppression), spotted wing drosophila
spinosad	spinosyn	nicotinic acetylcholine receptor (nAChR) allosteric modulator	5	R	flea beetle (suppression), oblique banded leafroller, spanworm, cabbage looper, winter moth, spotted wing drosophila, blueberry maggot

...continued

Table 9. Insecticides and bio-insecticides registered for insect management in lowbush blueberry production in Canada
(continued)

Active Ingredient ¹	Classification ²	Mode of Action ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
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, strawberry root weevil (suppression), brown marmorated stinkbug (suppression), cranberry weevil

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.

Blueberry case beetle (*Neochlamisus cribripennis*)

Pest information

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

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

Pest management

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

Chemical controls: None available.

Issues for blueberry case beetle

None identified.

Blueberry flea beetle (*Altica sylvia*)

Pest information

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

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

Pest management

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

Chemical controls: Refer to Table 9. *Insecticides and bio-insecticides registered for insect management in lowbush blueberry production in Canada* for insecticides registered for blueberry flea beetle control.

Issues for blueberry flea beetle

1. Further studies are required on integrated management approaches for blueberry flea beetle including controls for implementation in the sprout year
2. The registration of reduced risk, pollinator friendly, insecticides is required for the control of blueberry flea beetle.
3. A model to predict the emergence of blueberry flea beetle has been developed; however this requires additional verification.

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

Pest information

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

Life cycle: Adult flies emerge from soil from late June to early August, and live for approximately 30 days. Females lay eggs in fruit as it begins to ripen. Each female can lay up to 100 eggs, usually depositing one egg per berry. Larvae develop inside the berries and when full grown, drop to the soil where they pupate. A small portion of the infested berries remain on the plant and are harvested. The adults typically emerge the following year, with some emerging two to four years later.

Pest management

Cultural controls: Since the majority of flies emerge during the non-crop year in a two-year cropping system, it is important that crop and non-crop fields remain isolated from one another to reduce new infestations. Sanitation practices such as destroying or burying debris from winnowing piles and the picking and removal of infested berries will help to reduce re-infestation. Adult flies may be monitored using yellow sticky traps placed in the outer margin of the field. It is important to check traps frequently and to keep records throughout the season. The action threshold has been set at one captured fly due to the intolerance for this pest in export markets. Monitoring after the threshold has been reached is important to allow

for the evaluation of the effectiveness of treatments and to determine the need for follow up treatments. Additional management practices for blueberry maggot beetle are listed in *Table 8. Adoption of insect pest management practices in lowbush blueberry production in Canada*. *Chemical controls:* Refer to Table 9. *Insecticides and bio-insecticides registered for insect management in lowbush blueberry production in Canada* for insecticides registered for the control of blueberry maggot.

Issues for blueberry maggot

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

Blueberry leaftier (*Croesia curvalana*)

Pest information

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

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

Pest management

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

Chemical controls: Refer to Table 9. *Insecticides and bio-insecticides registered for insect management in lowbush blueberry production in Canada* for insecticides registered for leaftier.

Issues for blueberry leaf-tier

1. Information on scouting and monitoring is required by growers to help establish the degree of damage caused by the blueberry leaf-tier.

Blueberry gall midge (cranberry tipworm) (*Dasineura oxycoccana*)

Pest information

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

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

Pest Management

Cultural Controls: It is important to apply balanced fertilizers that do not stimulate the excessive growth that is attractive to this insect. The presence of gall midge can be detected by visual examination of blackened shoot tips when leaf buds unfold in the spring.

Chemical Controls: None available.

Issues for blueberry gall midge

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

Blueberry sawfly (*Neopareophora litura*)

Pest information

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

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

Pest management

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

Chemical controls: The blueberry sawfly is usually kept in check by treatments for other insects such as the blueberry flea beetle or spanworm. Refer to *Table 9. Insecticides and bio-insecticides registered for insect management in lowbush blueberry production in Canada* for insecticides registered for sawfly.

Issues for blueberry sawfly

None identified.

Blueberry spanworm (*Itame argillacearia*) and other spanworms

Pest information

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

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

Pest management

Cultural controls: Burning can reduce the number of spanworms in the field by killing overwintering eggs. Several species of parasitic wasp attack the blueberry spanworm and help to control the population. The pest can be monitored using a sweep net, and action thresholds applied in treatment decisions. Additional management practices for spanworms are listed in *Table 8. Adoption of insect pest management practices in lowbush blueberry production in Canada*.

Chemical controls: Insecticides registered for the control of spanworms are listed in *Table 9. Insecticides and bio-insecticides registered for insect management in lowbush blueberry production in Canada*.

Issues for blueberry spanworm

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

Blueberry stem gall wasp (*Hemadas nubilipennis*)

Pest information

Damage: The blueberry stem gall wasp causes the formation of galls (irregular growths) on the stems of the plant in response to egg laying and larval feeding on blueberry. Tissue at the tip of the stem is destroyed, stopping the formation of fruit buds on affected stems. If this damage occurs during the vegetative year, yield can be reduced the following year. The mechanism of the effect of galls on yield is not well understood. Galls can also break off the stem during harvesting, pass through the processing line and end up as foreign objects in the finished product. Field infestations can be high in production areas that are near processing plants or in fields which have been exclusively mechanically pruned for an extended number of years.

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

Pest management

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

Chemical controls: None available.

Issues for blueberry stem gall

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

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

Pest information

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

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

Pest management

Cultural controls: Fields can be inspected for the presence of thrips and damage beginning in early June. Infested areas can be treated the following spring, when the plants are small and the overwintered adults first appear.

Chemical controls: Pesticides registered for the control of thrips are listed in *Table 9*.

Insecticides and bio-insecticides registered for insect management in lowbush blueberry production in Canada.

Issues for thrips

1. The window for insecticide treatments for thrips is very narrow resulting in difficulties in the effective application of these products. Studies are required to determine whether this interval can be extended with the newer chemistries now available to blueberry producers.

Chainspotted geometer (*Cingilia catenaria*)

Pest information

Damage: The chainspotted geometer feeds on a wide variety of plants including blueberry and cranberry. Most of the damage is done by the later instar larvae which consume both leaves and fruit. When larvae are numerous, large areas may be completely defoliated. Outbreak levels are rare and tend to be quite patchy in distribution throughout the field.

Life cycle: The adult moths emerge in early September and lay eggs on the underside of leaves of the host plant until late October. In blueberry fields, sweet fern (*Comptonia peregrina*) is the preferred host plant, but other plants, including blueberry are used if sweet fern is not present. Larvae begin hatching from eggs in early June. There are five larval instars. Pupation takes place in the leaf litter from August to early September.

Pest management

Cultural controls: Weed control in the field and field margins, especially of sweet fern, may help reduce the attractiveness of the site for egg laying. Several natural parasites have been recorded for the chainspotted geometer. These include flies of the family Tachinidae, and wasps in the families, Braconidae, Chalcididae and Ichneumonidae. The fungal disease *Entomophthora aulicae* and a multi-capsid nuclear-polyhedrosis virus (MVPV) have also been noted as natural controls.

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

Insecticides and bio-insecticides registered for insect management in lowbush blueberry production in Canada.

Issues for chainspotted geometer

None identified.

Whitemarked tussock moth (*Orgyia leucostigma*)

Pest information

Damage: The whitemarked tussock moth is a general feeder and will attack many plants including blueberry. Larvae feed on the foliage of lowbush blueberry and can completely defoliate large portions of a field. The damage can take place at a critical time of development in the growth of both crop and sprout fields. Outbreaks are sporadic, with a history of outbreaks every 20 years that last from two to three years at a time.

Life cycle: The pest overwinters in egg masses and hatches from late June to mid-July. First instar caterpillars feed on the upper surface of leaves and can easily be dispersed by wind. After six weeks of feeding, the caterpillar pupates in a loosely spun cocoon on the host plant. The pupal stage lasts for about two weeks and adults emerge from mid-August to September. Females lay eggs on or near the cocoon from which the female emerged in masses of 50 to 100 encased within a protective coating of white foam. Since the females are wingless, the dispersal of the infestation by adults is limited.

Pest management

Cultural controls: The population of the moth is normally kept in check by several parasites and a viral disease. However, given the cyclical and sporadic nature of white marked tussock moth, annual monitoring is required to ensure potentially damaging populations are not overlooked. Monitoring for caterpillars must be conducted in both crop and sprout fields in early July to time spray applications. The potential for caterpillar populations in the following year can be estimated by scouting in late September and October for egg masses in field and in wooded field margins. There are no formal thresholds established for the whitemarked tussock moth. Workers in fields heavily infested with the caterpillars need to be cautious and wear protective clothing and dust filters to avoid contact with hairs that are easily dislodged from the body of the insect and can cause severe irritation.

Chemical controls: Registered insecticides are listed in *Table 9. Insecticides and bio-insecticides registered for insect management in lowbush blueberry production in Canada.*

Issues for whitemarked tussock moth

1. None identified.

Gypsy moth (*Lymantria dispar*)

Pest Information

Damage: Gypsy moths feed on a wide variety of plants including oak, apple, hawthorn, birch and willow. Gypsy moth larvae feed on foliage and buds of lowbush blueberry in the spring, resulting in fruit losses.

Life cycle: Gypsy moths overwinter as eggs which hatch in the early spring. Young larvae may also blow into blueberry fields on silken threads from neighbouring forested areas. Larvae feed on stems, leaves and blossoms until early July. At maturity, the larvae pupate in protected sites in the blueberry field. Adults emerge in one to two weeks and following mating, the female moth lays eggs back on the blueberry plants. Female moths are flightless so eggs are laid in the vicinity of the pupation site. There is one generation per year.

Pest management

Cultural controls: None identified.

Chemical controls: None available.

Issues for gypsy moth

None identified.

Redstriped fireworm (*Aroga triangularbamaculella*)

Pest information

Damage: The redstriped fireworm is more prevalent in sprout fields but can also be found in crop fields. The larvae web stems and leaves together and feed within the webbed leaves. They may also web together fruit, which may affect fruit size and interfere with harvest. The caterpillars can be harvest contaminants.

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

Pest management

Cultural controls: It is important to monitor for this insect as it can cause problems as a harvest contaminant.

Chemical controls: Insecticides registered for the control of redstriped fireworm are listed in Table 9. *Insecticides and bio-insecticides registered for insect management in lowbush blueberry production in Canada.*

Issues for fireworm

1. Studies are required on the impact of redstriped fireworm feeding in the sprout year on yields the following year.

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

Pest information

Damage: SWD attacks many wild and cultivated berry and stone fruit crops. Female SWD have a serrated ovipositor that enables them to lay eggs in 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 and move into commercial crops once fruit begins to ripen. Female flies lay eggs in susceptible fruit. Following egg hatch, larvae feed internally within fruit. Pupation takes place within or outside the fruit. With warm summer temperatures, the time required for one generation can be as short as ten days. 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. Fields and earlier fruiting hosts in the vicinity of the blueberry field are closely monitored through the use of apple cider vinegar baited traps for the presence of SWD. Treatments are initiated when the first male fly is detected. Additional practices used for the management of SWD are listed in *Table 8*.

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

Chemical controls: Pesticides registered for the control of SWD in lowbush blueberry are listed in *Table 9*. *Insecticides and bio-insecticides registered for insect management in lowbush blueberry production in Canada.*

Issues for spotted wing drosophila

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

Key Issues

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

Table 10. Occurrence of weeds in Canadian lowbush blueberry production^{1,2}

Weeds	Quebec	New Brunswick	Nova Scotia	Prince Edward Island
Annual broadleaf weeds				
Annual grass weeds				
Perennial broadleaf weeds				
Perennial grass weeds				
Woody plants				
Widespread yearly occurrence with high pest pressure.				
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.				
Widespread yearly occurrence with low to moderate 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: Lowbush 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 lowbush blueberry production in Canada¹

Practice / Pest		Annual broadleaf weeds	Annual grass weeds	Perennial broadleaf weeds	Perennial grass weeds	Woody plants
Avoidance	Planting/ harvest date adjustment					
	Crop rotation					
	Choice of planting site					
	Optimizing fertilization					
	Use of weed-free seed					
Prevention	Equipment sanitization					
	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					

...continued

Table 11. Adoption of weed management practices in lowbush blueberry production in Canada¹ (continued)

Practice / Pest		Annual broadleaf weeds	Annual grass weeds	Perennial broadleaf weeds	Perennial grass weeds	Woody plants
Decision-making tools	Economic threshold					
	Weather/ weather-based forecast/ predictive model					
	Recommendation from crop specialist					
	First appearance of weed or weed growth stage					
	Observed crop damage					
	Crop stage					
Suppression	Pesticide rotation for resistance management					
	Soil amendments					
	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.)					
Crop specific practices	Pruning by mowing or burning					
This practice is used by growers to manage this pest.						
This practice is not used by growers to manage this pest.						
This practice is not applicable for the management of this pest.						
Information regarding the practice for this pest is unknown.						

¹Source: Lowbush blueberry stakeholders in reporting provinces (Quebec, New Brunswick, Nova Scotia and Prince Edward Island).

Table 12. Herbicides and bio-herbicides registered for weed management in lowbush blueberry production in Canada

Active Ingredient ¹	Classification ²	Mode of Action ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
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
carfentrazone-ethyl (hooded sprayer application)	triazolinone	inhibition of protoporphyrinogen oxidase (Protox, PPO)	14	R	broadleaf weeds
clopyralid (eastern Canada only)	pyridine carboxylic acid	synthetic auxin	4	R	tufted vetch
dicamba	benzoic acid	synthetic auxin	4	R	sweet-fern, lambkill (sheep laurel), additional broadleaf weeds
dichlobenil	nitrile	inhibition of cell wall (cellulose) synthesis site A	20	RES	many annual grasses, broadleaf weeds, certain perennial weeds
fluazifop-p-butyl	aryloxyphenoxy-propionate 'FOP'	inhibition of acetyl CoA carboxylase (ACCase)	1	RES	annual grasses, witchgrass, fall panicum; suppression of ticklegrass and perennial native grasses including Canada bluegrass, poverty oatgrass and quackgrass

...continued

Table 12. Herbicides and bio-herbicides registered for weed management in lowbush blueberry production in Canada

Active Ingredient ¹	Classification ²	Mode of Action ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
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, moss (suppression)
hexazinone	triazinone	inhibition of photosynthesis at photosystem II site A	5	RES	grasses, many perennial broadleaf weeds, woody weeds including trailing blackberry, lamb-kill and hard hack
mesotrione	triketone	inhibition of 4-hydroxyphenyl-pyruvate-dioxygenase (4-HPPD)	27	R	lamb's-quarters, redroot pigweed, velvetleaf, wild mustard, eastern black nightshade, velvetleaf, redroot pigweed, common ragweed (suppression)
napropamide (established plantings)	acetamide	mitosis inhibitor	15	R	germinating annual grasses and broadleaf weeds
propyzamide (pronamide)	benzamide	microtubule assembly inhibition	3	R	perennial grasses, quackgrass, annual grasses
sethoxydim	cyclohexanedione 'DIM'	inhibition of acetyl CoA carboxylase (ACCase)	1	R	annual grasses, wild oats, volunteer cereals, quackgrass
simazine and related triazines (planting established for one year or more)	triazine	inhibition of photosynthesis at photosystem II site A	5	RES	lady's-thumb, lamb's-quarters, purslane, ragweed, wild buckwheat, smartweed, volunteer clovers, barnyard grass, crabgrass, wild oats, yellow foxtail, perennial species starting from seed
tribenuron-methyl (eastern Canada only)	sulfonylurea	inhibition of acetolactate synthase (ALS) or acetohydroxyacid synthase (AHAS)	2	R	bunchberry, yellow loosestrife, speckled alder, wild rose, bracken fern
triclopyr (site preparation)	pyridine carboxylic acid	synthetic auxin	4	R	alder, ash, birch, chokecherry, maples (red maple) poplar

...continued

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

Active Ingredient ¹	Classification ²	Mode of Action ²	Resistance Group ²	Re-evaluation Status ³	Targeted Pests ¹
Applications in non-bearing year					
foramsulfuron (eastern Canada only; dormant lowbush blueberries)	sulfonylurea	inhibition of acetolactate synthase (ALS) or acetohydroxyacid synthase (AHAS)	2	R	annual grasses, broadleaf weeds, quackgrass, fescues
glufosinate ammonium (eastern Canada and BC; dormant lowbush blueberries)	phosphinic acid	inhibition of glutamine synthetase	10	R	annual grass and broadleaf weeds, perennial weeds (suppression)
glyphosate	glycine	inhibition of 5-enolpyruvyl-shikimate-3-phosphate synthase (EPSPS)	9	RE	annual and perennial weeds, woody brush and trees
nicosulfuron + rimsulfuron (eastern Canada only)	sulfonylurea	inhibition of acetolactate synthase (ALS) or acetohydroxyacid synthase (AHAS)	2	R	quackgrass, annual grasses, redroot pigweed, black bulrush, suppression of poverty oatgrass and ticklegrass
terbacil (eastern Canada only; planting established for one year or more)	uracil	inhibition of photosynthesis at photosystem II site A	5	R	grasses, germinating annual broadleaf weeds and grasses

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

All Weeds

Pest information

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

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

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

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

Pest management

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

Chemical controls: Herbicides registered for weed control in lowbush blueberry are listed in *Table 12. Herbicides and bio-herbicides registered for weed management in lowbush blueberry production in Canada.*

Issues for annual weeds

1. There is a need for improved understanding of the impact of fertilization and soil nutrient levels on the growth and vigour of annual broadleaf weeds. There is a need for the registration of post-emergent grass weed herbicides in groups other than group 1, for resistance management.

<i>Issues for perennial weeds</i>
--

1. There is a need for a clearer understanding of the spectrum of weeds controlled by currently available herbicides for improved treatment decisions
2. Additional information is required on the best timing of herbicide applications and the combining of herbicides for perennial broadleaf weed control.
3. There is a need for the registration of reduced risk products which control a more targeted range of weeds, to allow for more precise herbicide applications and reduce the need for broad spectrum pre-emergent herbicides.
4. St. John's wort (*Hypericum perforatum*), spreading dogbane (*Apocynum androsaemifolium*), barrenberry (*Photinia* spp.) and spreading blackberry (*Rubus* spp.) are weed species that are particularly challenging to control. Witchgrass (*Panicum capillare*) is an emerging problem in lowbush blueberry fields.
5. The development of a protocol for equipment sanitation is required to help growers reduce the spread of weeds between fields in lowbush blueberry.
6. There is a need for further research on the effect of soil nutrition and pH on the growth of perennial weeds.
7. Perennial grasses, including poverty oat grass (*Danthonia spicata*) and fescues (*Festuca* spp.) are an increasing problem in lowbush blueberry. The registration of additional reduced risk products is needed to enable product rotation and reduce the likelihood of resistance development.
8. It is critical that all new product registrations have pre-harvest intervals that enable the crop to meet MRLs for domestic and export markets to ensure the marketability of the crop.

Vertebrate Pests

Birds

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

Bear

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

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

Coyote

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

Deer

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

As an attempt to deter deer, some products are sprayed around the perimeters of fields. However, success is spotty at best. In a very few cases fences have been erected, but this is expensive and in most fields not practical. Often, growers live with the damage and crop loss.

Resources

IPM/ICM resources for production of lowbush blueberry in Canada

Agriculture and Agri-Food Canada. *Diseases of lowbush blueberry and their identification*. 2016. AAFC No. 12476E. ISBN 978-0-660-04178-0. Catalogue Number. A59-37/2016E-PDF. Available from www.publications.gc.ca/site/eng/home.html

Agrinova, Club Conseil Blueete, MAPAQ Saguenay-Lac-Saint-Jean, Centre de référence en agriculture et agroalimentaire du Québec (CRAAQ). *Wild Blueberry Production Guide*. http://nbwildblue.ca/wp-content/uploads/2014/03/OP6249_Final_Report_guide_2013.pdf

Centre de référence en agriculture et agroalimentaire du Québec (CRAAQ). *Guide de production du bleuets sauvag*. www.craaq.qc.ca/Recherche/r?q=bleuet

New Brunswick Department of Agriculture, Aquaculture and Fisheries. *Wild Blueberry IPM Weed Management Guide*. 2016. 31 pp. Wild Blueberry Fact Sheet C.4.2.0 www2.gnb.ca/content/dam/gnb/Departments/10/pdf/Agriculture/WildBlueberries-BleuetsSauvages/C420-E.pdf

Perennia. *Guide to Weed, Insect and Disease Management in Wild Blueberry. Nova Scotia Guide to Pest Management in Wild Blueberry 2016* [WBLUE1-16]. (Updated April 7, 2016 by Peter Burgess). www.perennia.ca

Perennia. Wild Blueberry Fungicide Chart 2016 www.perennia.ca

Perennia. Wild Blueberry Herbicide Chart 2016 www.perennia.ca

Perennia. Wild Blueberry Insecticide Chart 2016. www.perennia.ca

Perennia. Wild Blueberries Publications and Factsheets. www.perennia.ca

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

Provincial Crop Specialists and Provincial Minor Use Coordinators.

Province	Ministry	Crop Specialist	Minor Use Coordinator
Ontario	Ontario Ministry of Agriculture and Food www.omafra.gov.on.ca/english	Pam Fisher pam.fisher@ontario.ca	Jim Chaput jim.chaput@ontario.ca
Quebec	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec www.mapaq.gouv.qc.ca	André Gagnon andre.gagnon@mapaq.gouv.qc.ca Andrée Tremblay andree.tremblay@mapaq.gouv.qc.ca	Luc Urbain luc.urbain@mapaq.gouv.qc.ca
New Brunswick	New Brunswick Department of Agriculture, Aquaculture and Fisheries www.gnb.ca/0027/index-e.asp	Michel Melanson michel.melanson@gnb.ca	Gavin Graham gavin.graham@gnb.ca
Nova Scotia	Nova Scotia Department of Agriculture www.gov.ns.ca/agri/	N/A	Jason Sproule sprouljm@gov.ns.ca
	Perennia www.agrapoint.ca	Peter Burgess pburgess@perennia.ca	—
Prince Edward Island	Prince Edward Island Department of Agriculture and Forestry www.gov.pe.ca/af/	Chris Jordan chriswjordan@gov.pe.ca	Shauna Mellish mmellish@gov.pe.ca

National and Provincial Lowbush Blueberry Grower Organizations

Wild Blueberry Association of North America
www.wildblueberries.com/

Wild Blueberry Producers Association of Nova Scotia (www.nswildblueberries.com)

Wild Blueberry Producers of New Brunswick (www.nbwildblue.ca)

PEI Wild Blueberry Growers Association (<http://peiwildblueberries.com/>)

Syndicat des producteurs de bleuets du Québec (<http://perlebleue.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 importance 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	
	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.					
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

Heidenreich, Cathy, Dena Fiacchino and Wolfram Koeller. Blueberry Disease Fast Facts: Anthracnose Ripe Rot. Cornell Cooperative Extension of Oswego County, Mexico NY and Department of Plant Pathology, Cornell University New York State Agricultural Experiment Station, Geneva NY

<http://www.fruit.cornell.edu/berry/ipm/ipmpdfs/BB%20anthracnose%20fast%20fact.pdf>

(Accessed Aug. 4, 2016)

Reekie, M., McKenzie, K and B. Lees. *The biology and pest potential of cranberry tipworm (Diptera Cecidomyiidae) in lowbush blueberry*. 2009. Proceedings of the IX International Vaccinium Symposium, ISHS Acta Horticulture 810: 401-410

Wood, George W. 2004. *The Wild Blueberry Industry – Past.*

www.haworthpress.com/store/ArticleAbstract.asp?ID=46088

Wild Blueberries – Nature’s #1 Superfruit

www.wildblueberries.com/health_benefits/ (Accessed Sept. 6, 2016)

Wild Blueberry Producers Association of Nova Scotia. *Botrytis blight of lowbush blueberry in Nova Scotia.* www.nswildblueberries.com/

Wild Blueberry Network Information Centre <http://nsac.ca/wildblue/>

Wild Blueberry Producers Association of Nova Scotia. 2011. *Blueberry gall Midge (also known as cranberry tipworm, tip midge).*

<http://www.perennia.ca/Fact%20Sheets/Horticulture/Fruit/Blueberry/Blueberry%20Gall%20Midge.pdf> (Accessed June 3, 2016).

New Brunswick Department of Agriculture, Aquaculture and Fisheries. *Wild Blueberry IPM Weed Management Guide*. 2016. 31 pp.

<http://www2.gnb.ca/content/dam/gnb/Departments/10/pdf/Agriculture/WildBlueberries-BleuetsSauvages/C420-E.pdf>. (Accessed Sept. 2, 2016)