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Crop Profile for Wild Blueberry in Canada

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

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Canada

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Pest Management Centre
Pesticide Risk Reduction Program
Agriculture and Agri-Food Canada
960 Carling Avenue, Building 57
Ottawa, Ontario
K1A 0C6
CANADA

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Steve Howatt
Atlantic Agritech, Inc.
265 New Glasgow, Hunter River RR#3
Prince Edward Island, Canada
C0A 1N0

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Use of Information

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

This publication is not intended to be used as a production guide. Provincial publications should be consulted by growers for crop production information for their region.

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.

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 objective of the program is to reduce the risks to the environment and to human health from pesticide use in agriculture. To achieve this objective, the PRRP works with grower groups, industry and provinces to identify gaps in pest management and opportunities for pesticide risk reduction. This information is used to develop issue specific pesticide risk reduction strategies. National crop profiles provide baseline information on crop production and pest management practices and document pest management needs and issues faced by growers, information used in the development of risk reduction strategies.

Information contained in the crop profiles is developed through extensive consultation with stakeholders. Pest management information for major crop producing regions is collected by provincial focus groups through the "Canadian Expert Poll on Crop Protection" a software tool developed by the PMRA.

For detailed information on growing wild blueberry, the reader is referred to provincial crop production guides and provincial ministry websites listed in the resources section at the end of the document.

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

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The wild 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. This is unlike the highbush blueberry that is planted and maintained in an orchard. Harvested wild blueberry species include *Vaccinium angustifolium, V. angustifolium f. nigrum* and *V. myrtilloides.*

Wild blueberries were harvested by native peoples long before European settlers arrived in North America. Some native peoples encouraged blueberry growth by periodically burning blueberry fields, which would quickly grow again with new plants. Early settlers in the Atlantic Provinces first 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 1980's, production has increased dramatically because of advancements in management including improved weed control and the increased use of introduced bees for pollination.

Crop Production

Industry Overview

General production information is presented in table 1. Production in Quebec and the Atlantic provinces comprises 45% of world production. Blueberries rank as the number one fruit crop in Canada with respect to area under production.

Wild blueberry fruit is rich in antioxidant compounds that fight free radicals that are associated with cancer, heart disease and premature aging and are high in vitamin C, manganese and fibre. Most of the wild 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. Less than 5% is sold fresh at local markets.

Table 1. General Production Information

Canadian Production (2007)	77,401 metric tonnes 30,274 hectares[1,2]
Farm gate value (2007)	$189 million
Domestic consumption (2007)	1.54 Kg/person[1]
Export (2007)	$ 191.5 million
Imports (2007)	$ 22.7 million

Source(s): Statistics Canada
[1]Includes low & highbush blueberries as fresh & frozen
[2]Fruit bearing area.

Production Regions

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

Table 2: Distribution of blueberry production in Canada (2007)[1]

Production Regions	Cultivated Area [2] 2007 (hectares)	Bearing Area 2007 (hectares)	Percent National Production by Bearing Area
British Columbia[3]	6,475	3,885	12%
Ontario	308	255	1%
Quebec	23,358	12,351	41%
New Brunswick	8,907	4,415	14%
Nova Scotia	15,054	7,345	24%
Prince Edward Island	x	x	
Newfoundland and Labrador	x	x	
Canada	58,756	30,274	100%

Source: Statistics Canada (2007) ; x suppressed to meet the confidentiality requirements of the Statistics Act

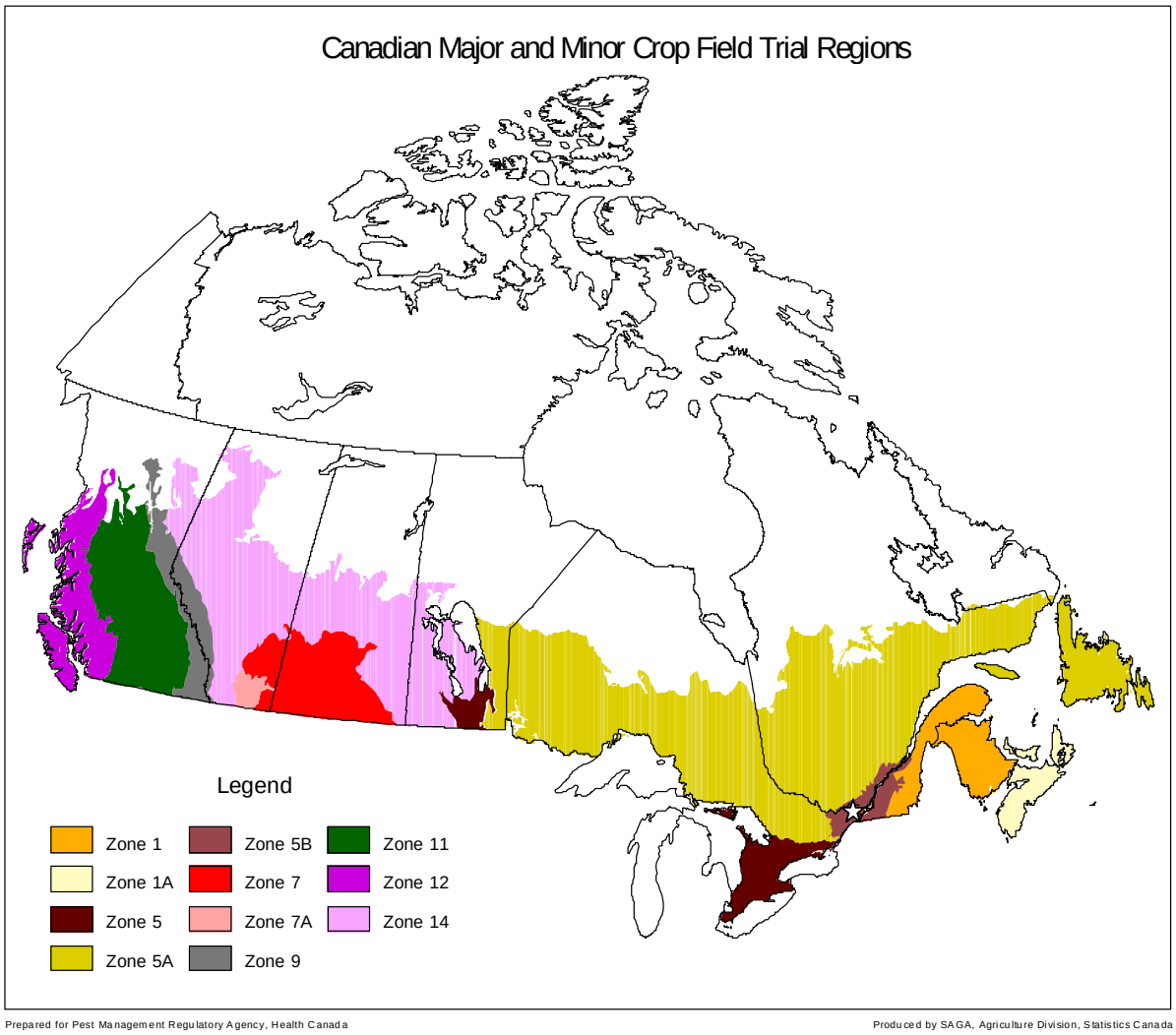
[1] Includes wild and highbush blueberries.

[2] Cultivated area includes bearing and non-bearing area.

[3] In Canada, wild blueberry production occurs almost exclusively in the Atlantic Provinces and Quebec. Primarily highbush blueberry is grown in BC which comprises 97% of the highbush blueberry production in Canada.

Figure 1. Common Zone Map: Canadian Major and Minor Crop Field Trial Regions

The major and minor crop field trial regions were developed following extensive stakeholder consultation and have been harmonized between the Pest Management Regulatory Agency (PMRA) and the Environmental Protection Agency of the USA. The identified regions are used for experimental studies in support of residue chemistry data requirements for the registration of new pesticide uses. The regions are based on soil type and climate and do not correspond to plant hardiness zones. For additional information, please consult the PMRA Directive 98-02 Residue Chemistry Guidelines www.hc-sc.gc.ca/cps-spc/pubs/pest/_pol-guide/dir98-02/index-eng.php).



Cultural Requirements

Wild blueberries are a perennial succession crop. The plants grow wild in areas of sandy, gravelly, well drained soils with acidity levels of 4.2-5.5 that are generally unsuitable for other types of agriculture. 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, reducing weeds and controlling pests 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 all 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. This enables the crop to regenerate in the absence of competition. Flower buds are set in the fall of the sprout year. The crop bears fruit the following year or "crop year". Thus, 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 3 sections with 2/3rds of the acreage being harvested in a year.

Until the mid-1980's, the entire crop was harvested by hand or by raking. Today, fields in rough terrain and in forested areas are still hand raked, but most of the crop is mechanically harvested (up to 80% in some areas), an innovation that has revolutionized the wild blueberry industry. In established fields, modern practices yield between 0.5 and 10 tonnes per hectare.

The following table (table 3) describes production practices and worker activities for wild blueberry throughout the season.

Table 3. Canadian wild blueberry production and pest management schedule

Time of Year	Activity	Action
April	Plant care	Pruning (prune year (PY))
	Weed management	Pruning (PY)
May	Plant care	Pollination and fertilization (PY)
	Disease management	Monitoring and spraying if necessary (crop year (CY))
	Insect & mite management	Monitoring and spraying if necessary (CY & PY)
	Weed management	Pre-emergent herbicides (PY)
June	Plant care	Pollination (CY) and fertilization (PY)
	Disease management	Monitoring and spraying if necessary (CY)
	Insect & mite management	Monitoring and spraying if necessary (CY & PY)
	Weed management	Post-emergent herbicides and spot applications (CY & PY)
July	Plant care	Leaf tissue sampling (tip dieback) (PY)
	Soil care	Soil sampling (same time as leaf sampling) (PY)
	Disease management	Monitoring and spraying if necessary (PY)
	Insect & mite management	Monitoring and spraying if necessary (CY)
	Weed management	Spot herbicide applications and physical control options (PY)
August	Plant care	Harvest (prune later in season or in spring) (CY) Leaf tissue sampling (tip dieback – prune year) (PY)
	Soil care	Soil sampling (same time as leaf sampling) (PY)
	Disease management	Limited
	Insect & mite management	Limited
	Weed management	Limited

Format adapted from BC Crop Profiles 2002-2004, BC Ministry of Agriculture, Food and Fisheries

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 (eg. bumble bees) pollinate wild blueberries; however in most years their populations are low and growers need to use rented pollinators (e.g. honeybees, alfalfa leaf cutter bees). In some areas, sufficient numbers of managed pollinators are unavailable.

Temperature Extremes

Frost and cold temperatures during bloom (June) and prior to harvest later in the summer, can cause yield losses. Cold and windy conditions during the pollination season can also impact

yields. 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 summers can also reduce yields by as much as 50% and affect the quality of the remaining fruit. Recently, irrigation has been explored as a possible solution to this problem.

General Production Issues

1. Compliance with the requirements of international markets with respect to improved quality and reduced chemical use in blueberry production, will facilitate export of the crop.

2. The establishment of a system for "identity preservation" of wild blueberries, so that fruit can be traced back to the field of origin, would facilitate marketing of the crop.

Pest Management Overview

Wild blueberry pests are controlled through an integrated pest management approach. Fields are monitored for pests and diseases in both the sprout and crop years and control measures are implemented if required. Pruning by burning every second year prevents some insect and disease carryover. However as burning can destroy the organic matter in the soil, there has been an increase in the use of flail mowing as a pruning method. This can result in a build up of diseases and insects. Disease controls are usually implemented only in those areas where there is a disease outbreak or in areas that have a history of disease. Weed management is very important in wild blueberry to eliminate competition, facilitate harvesting and improve yields.

The following disease, insect / mite and weeds sections provide detailed information on pests affecting wild blueberry. Pest management issues are presented at the beginning of each section. In each section, the issues are followed by a series of tables that provide information on pest occurrence, chemical controls and IPM practices as follows;

Tables 4, 8 and 12: Disease, insect or weed occurrence and severity and is presented on a provincial basis.

Tables 5, 9 and 13; Integrated pest management information is provided on an individual pest basis.

Tables 6, 10 and 14: All registered fungicides, insecticides and herbicides for wild blueberry are listed.

Tables 7, 11 and 15: All registered pesticides on a disease, insect or weed group basis, are listed along with stakeholder comments on efficacy.

Further information for each pest is provided under individual pest write-ups following the tables in each section.

For detailed information on pest management and growing the crop in specific regions, the reader is referred to provincial crop production guides and provincial ministry websites listed in the Resources Section at the end of this document.

Diseases

Key Issues

- The shift in pruning practices from burning to mowing has resulted in greater insect and disease pressure. New technologies for sanitizing leaf litter after mowing could help reduce pressure by insects and diseases.
- Improved decision making tools for disease management, are needed to improve the efficacy of control measures and reduce the use of chemical fungicides.
- There is insufficient information available on the management of emerging diseases such as red leaf, leaf spot, phomopsis canker, powdery mildew and sprout field disorder. The development of effective control products and modifications to current production practices such as fertilization and sanitation, could reduce the impact of these diseases on the industry.
- There is insufficient information available for accurate forecasting of infection periods of monilinia blight.
- There are insufficient biological controls and other alternatives to conventional chemicals available for the control of monilinia blight. Currently only one product effective in controlling this disease is accepted in export markets.
- There is concern over the wide host range of *Botrytis cinerea* and implications for management, given the significant yield losses that this pathogen can cause.
- The development of forecasting models for botrytis blight is required to improve the management of this disease and reduce it's impact on yield.
- Changes in weather patterns in recent years have resulted in changes in the distribution of botrytis blight and a need to expand the monitoring and controls for this disease outside of traditional botrytis areas.
- There are no effective treatments for diseases such as powdery mildew, redleaf, witches broom, godronia stem canker, septoria leaf spot, leaf rust and valdensinia leaf spot.
- The impact of current production practices such as pruning and fertilization on foliar diseases such as septoria leaf spot, leaf rust, valdensinia leaf spot and powdery mildew, is unknown.
- The timing of fungicide treatments for the control of phomopsis blight is unknown. The timing of application in wild blueberries appears to be different than the timing for highbush blueberries.
- The damage caused by septoria leaf spot may be underestimated.
- The impact of cultural practices such as pruning and fertilization on septoria leaf spot, is not well understood. There is insufficient information available on alternative controls.

Table 4. Occurrence of diseases in Canadian wild blueberry production

	Degree of occurrence					
	QC	**NB - North**	**NB - South**	**NS**	**PE**	**NL**
Anthracnose	DNR	E	E	DNR	DNR	DNR
Botrytis blight	E	E	E	E	DNR	DNR
Brown leaf spot	E	E	E	E	DNR	DNR
Fruit rot	DNR	E	E	DNR	DNR	DNR
Gloesporium stem and leaf spot	DNR	E	E	DNR	DNR	DNR
Godronia stem canker	E	E	E	E	DNR	DNR
Leaf rust	DNR	E	E	E	DNR	DNR
Leaf spot complex	DNR	E	E	DNR	DNR	DNR
Mummyberry (Monilinia blight)	E	E	E	E	DNR	DNR
Powdery mildew	E	E	E	E	DNR	DNR
Red leaf	E	E	E	E	DNR	DNR
Twig blight (Phomopsis canker)	E	E	E	E	DNR	DNR
Valdensinia leaf spot	DNR	DNR	DNR	E	DNR	DNR
Witches broom	E	E	E	E	DNR	DNR

Widespread yearly occurrence with high pest pressure

Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure

Widespread yearly occurrence with low to moderate pest pressure

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure

Pest not present

DNR- Data not reported

E – established

D – invasion expected or dispersing

Source(s): "Canadian Expert Poll on Crop Protection" focus groups for New Brunswick, Nova Scotia and Quebec (2006).

Table 5. Availability and use of disease management approaches for Canadian wild blueberry production

	Practice\ Pest	Valdensinia leafspot	Botrytis blight	Septoria leafspot	Godronia stem canker	Leaf rust	Mummyberry	Powdery mildew	Red leaf	Phomopsis twig blight
Avoidance	Resistant varieties									
	Planting / Harvest Date Adjustment									
	Crop rotation									
	Choice of planting site									
	Use of disease-free seed or transplants									
	Optimizing fertilization									
	Reducing mechanical damage / insect damage									
	Thinning / pruning									
Prevention	Equipment or facility sanitation; use of sterile media									
	Mowing / Mulching / Flaming									
	Removal of alternative or wild hosts									
	Row or plant spacing (plant density)									
	Seeding depth									
	Water / irrigation management									
	Crop residual removal / management									
	Pruning out / elimination of infected plant material									
Monitoring	Scouting									
	Records to track diseases									
	Soil analysis									
	Weather monitoring for disease forecasting									
	Grading out infected produce									
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									
	Calendar spray									
Suppression	Biological pesticides									
	Environmental management (eg. as in greenhouses)									
	Pesticide rotation for resistance management									
	Soil amendments									
	Controlled atmosphere storage									

no indication that the practice is available/used

available/used

available/not used

not available

Source(s): Canadian Expert Poll on Crop Protection focus groups for New Brunswick, Nova Scotia and Quebec (2006).

Table 6. Fungicides registered on wild blueberry in Canada

Regulatory Status as of March 6, 2008[5]				
Active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action / resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**
***Bacillus subtilis* QST 713 (Serenade Max)**	bacteria	unclassified (biological)	BI	Botrytis gray mold or Botrytis blight (*Botrytis cinerea*)
boscalid (Lance WDG Fungicide)	pyridinecarboxamide	respiration C2: complex II - succinatedehydrogenase/ 7	RR	Botrytis gray mold
boscalid / pyraclostrobin (Pristine WG Fungicide)	pyridinecarboxamide/ methoxycarbamate	respiration C2:complex II - succinatedehydrogenase/ 7 and respiration C3: complex III -cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene) / 11	RR	Botrytis gray mold (*Botrytis cinerea*) Anthracnose (*Colletotrichum* spp.) Phomopsis
captan (Captan 50 W Wettable Powder Fungicide)	phthalimide	multi-site activity / M4	R	Fruit Rot Mummy Berry

Regulatory Status as of March 6, 2008[5]				
Active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action / resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**
chlorothalonil (Bravo 500 Agricultural Fungicide)	chloronitrile (phthalonitrile)	multi-site activity / M5	R	Anthranose fruit rot
				Alternaria fruit rot
				Phomopsis canker (*Phomopsis vaccinii*).
				Leaf spot diseases (suppression only) including Septoria leaf spot (*Septoria* sp.), rust (*Naohidemyces vaccinii*) and Valdensinia leaf spot (*Valdensinia heterodoxa*)
cyprodinil / fludioxonil (Switch 62.5)	anilinopyrimidine / phenylpyrrole	amino acids and protein synthesis D1: methionine biosynthesis (proposed) (cgs gene) / 9 and signal transduction E2: MAP/Histidine-Kinase in osmotic signal transduction (os-2, HOG 1) / 12	RR	Anthracnose (*Colletotrichum acutatum*)
				Botrytis fruit rot (*Botrytis cinerea*)
fenhexamid (Elevate 50 WDG Fungicide)	hydroxyanilide	sterol biosynthesis in membranes G3: 3-keto reductase, C4- demethylation (erg27) / 17	R	Botrytis gray mold (*Botrytis cinerea*)
ferbam (Ferbam 76 WDG Fungicide)	dithiocarbamate and relatives	multi-site activity / M3	R	Botrytis blight
				Blossom blight
				Twig blight

Regulatory Status as of March 6, 2008[5]				
Active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action / resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**
propiconazole (Propiconazole 250E Fungicide)	triazole	sterol biosynthesis in membranes G1:C14-demethylase in sterol biosynthesis (erg11/cyp51) / 3	R	Monilinia blight (Mummy berry)
pyraclostrobin (Cabrio EG Fungicide)	methoxycarbmate	respiration C3: complex III - cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene) / 11	R	Anthracnose
				Phomopsis canker
thiophanate-methyl (Senator 70WP Systemic Fungicide)	thiophanate	mitosis and cell division B1:ß-tubuline assembly in mitosis / 1	RE	Twig blight
				Blossom blight
triforine (Funginex DC Fungicide)	piperazine	sterol biosynthesis in membranes G1:C14-demethylase in sterol biosynthesis (erg11/cyp51) / 3	R	Mummy berry

[1]Common trade name(s), if provided in brackets, are for the purpose of product identification only. No endorsement of any product in particular is implied.

[2]The classification and the mode of action group are based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action. The document is under revision and up-to-date information can be found on the following web sites: Herbicides: www.plantprotection.org/HRAC/Bindex.cfm?doc=moa2002.htm; Insecticides: www.irac-online.org/Crop_Protection/MoA.asp#area223; Fungicides: www.frac.info/frac/index.htm

[3] R-full registration (non-reduced risk), RE-under re-evaluation (yellow), DI (red) -discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA, BI-biological, RR-reduced risk (green). Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Individual product labels should be consulted for up to date accurate information concerning specific registration details. The information in these tables should not be relied upon for pesticide application decisions. Consult individual product labels for specific registration details. The following website can be consulted for more information on pesticide registrations: www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php

[4] Please consult the product label on the PMRA web site (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php) for specific listing of pests controlled by each active ingredient.

[5]Source: Pest Management Regulatory Agency

Table 7. Performance and use of fungicides for the control of diseases on wild blueberry in Canada

Pests or Group of Pests targeted	Active ingredient[1]	Resistance group[2]	Stakeholder comments[3,4]	
			Performance[3]	Notes
Alternaria fruit rot	chlorothalonil	M5		
Anthracnose	boscalid; pyraclostrobin	7; 11		
	chlorothalonil	M5		
	cyprodinil; fludioxonil	9; 12		
	pyraclstrobin	11		
Blossom blight	ferbam	M3		
	thiophanate methyl	1		
Botrytis blight	*Bacillus subtilis* QST 713	unclassified		
	boscalid	7	A	Has some systemic activity which may give a larger control window. Newer product that has not had a lot of exposure for this pest yet.
	boscalid; pyraclostrobin	7; 11	A	Price per acre is very restrictive. This is a very new product and has not been extensively used yet. Could provide a broader control spectrum than just botrytis.
	cyprodinil; fludioxonil	9; 12	A	Price per acre is restrictive; new product and has not yet been extensively used.
	fenhexamid	17	A	Not widely used because of price.
	ferbam	M3		
Fruit rot	captan	M5		
Leaf spot diseases (suppression only) including Septoria leaf spot (*Septoria* sp.), rust (*Naohidemyces vaccinii*) and Valdensinia leaf spot (*Valdensinia heterodoxa*)	captan	M5		

Pests or Group of Pests targeted	Active ingredient[1]	Resistance group[2]	Stakeholder comments[3,4]	
			Performance[3]	Notes
Mummy berry	captan	M5		
	propiconazole	3	A	Products vary in price. Less expensive alternative; has kickback action on the disease; application window is small (72 hours).
	triforine	3	A	MRL restrictions in the USA, therefore product is not used widely.
Phomopsis canker	boscalid; pyraclostrobin	7; 11		
	chlorothalonil	M5		
	pyraclstrobin	11		
Twig blight	ferbam	M3		
	thiophanate methyl	1		

[1] List includes all active ingredients registered as of March 6, 2008. Please consult product labels on the PMRA web site (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php) for further information on pesticide use.

[2]The resistance group is based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action. The document is under revision and up-to-date information can be found on the following web sites: Herbicides: www.plantprotection.org/HRAC/Bindex.cfm?doc=moa2002.htm ; Insecticides: www.irac-online.org/Crop_Protection/MoA.asp#area223 ; Fungicides: www.frac.info/frac/index.htm

[3]Based on user perceptions of performance of performance of active ingredient for recommended uses. A^{-} Adequate (green) (the pest control product (PCP), according to recommended use, maintains disease below economic threshold OR provides acceptable control), A^{p} – Provisionally Adequate (yellow) (the PCP, while having the ability to provide acceptable control, possesses qualities which may make it unsustainable for some or all uses), I – Inadequate (red) (the PCP, according to recommended use, does not maintain disease below economic threshold OR provides unacceptable control).

[4]Source(s) - "Canadian Expert Poll on Crop Protection" Focus Groups for New Brunswick, Nova Scotia and Quebec (2006).

Botrytis blight (*Botrytis cinerea*)

Pest Information

Damage: Botrytis blight can be a serious problem during bloom. The pathogen attacks blossoms, fruit and leaves and causes symptoms similar to monilinia blight.

Life Cycle: The fungus overwinters on infected weeds. In the spring, the pathogen produces spores that are blown by wind to blueberry blossoms. Infected tissues turn brown and become covered with a gray mold and spores. Spores are blown by wind to other susceptible tissues where they cause infection. The number of disease cycles and the severity of infection is associated with the number of wet periods during bloom and shortly thereafter. Later, infected petals may drop and establish new infection sites. Infected leaves change colour and develop gray mould that contaminates fruit through direct contact. Early-blooming blueberry clones are the first to be infected and they are the source of spores for later flowering clones. Spore populations reach a peak during spring and remain high throughout the summer, even though blueberry tissues are no longer susceptible. Few spores are produced on blueberry debris from the previous year, making weeds an important source of initial inoculum. Frost and herbicide damage increase the susceptibility of the weeds and the blueberry bushes to the disease.

Pest Management

Chemical Controls: There are several registered products and some that have a reduced risk profile. Fungicides are applied if the disease is evident at mid bloom and wet conditions are predicted. Sprays are conducted at 7-10 day intervals if damp weather persists through the bloom period.

Cultural Controls: Pruning by burning every second or third crop cycle may reduce some overwintering inoculum of *B. cinerea*. Weeds within and around blueberry fields should be controlled. 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.

Resistant Cultivars: Not applicable.

Issues for Botrytis Blight

1. There is concern over the wide host range of *Botrytis cinerea* and implications for management, given the significant yield losses that this pathogen can cause.
2. There are insufficient biological controls or economical alternatives to captan for the control of botrytis blight.
3. Forecasting models for botrytis blight are unavailable.
4. Changes in weather patterns in recent years have resulted in changes in the distribution of botrytis blight and a need to expand the monitoring and controls for this disease outside of traditional botrytis areas.

Godronia Canker (*Godronia cassandrae*)

Pest Information

Damage:. Infections by *Godronia cassandrae* during late May to early June cause tip dieback, stem lesions and dieback of stem parts above the lesion. This is a yield reducing disease and it is believed that there is a direct correlation between the percentage of infected stems and crop losses. Infections during mid-summer (July) lead to the production of undersized fruits.

Life Cycle: The fungus overwinters in cankers on stems and crowns of infected plants as pycnidia. Conidia, produced in the pycnidia, are released and splashed onto healthy stems by rain. The disease cycle starts at about bud-break in the spring and new infections continue to occur throughout the growing season each time it rains, until the fall. Conidia infect current year stems as well as 2-year old stems. Lesions of godronia canker grow larger year by year and may ultimately girdle the stems.

Pest Management

Cultural Controls: Pruning and destroying infected branches is the main control for godronia canker. Monitoring of fruiting fields for godronia is done in early July. Burning as a pruning method destroys diseased stems that are sources for new infections. Mowing should not be done before burning.

Resistant Cultivars: Not applicable.

Chemical Controls: None available

Issues for Godronia Canker

1. There are no chemical treatments available for godronia canker.

Leaf Rust (*Naohidemyces vaccinii, formerly Pucciniastrum vaccinii*)

Pest Information

Damage: Leaf rust is a very common leaf disease of wild blueberry. Severe outbreaks can cause extensive defoliation in sprout fields. 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 appearing on 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: Hemlock (*Tsuga* spp.) serves as an alternate host for this fungus. Leaf rust probably also cycles on blueberry alone since the fungus has been found on blueberry when hemlock has been absent from the area. Symptoms of leaf rust can be observed in sprout fields from late July through September.

Pest Management

Cultural Controls: None identified

Resistant Cultivars: Not applicable, although there is clonal variation in susceptibility.

Chemical Controls: None available.

Issues for Leaf Rust

1) There are no effective chemical controls for leaf rust.

2) The impact of current production practices such as pruning and fertilization on leaf rust, is unknown.

Monilinia Blight (*Monilinia vaccinii-corymbosi*)

Pest Information

Damage: Monilinia blight is common in many production areas and can be destructive in seasons with extended wet periods. Fields with heavy soil or poor drainage are prone to the disease. The pathogen infects leaves, blossoms and fruit, causing leaves to wilt and blossom clusters to shrivel. Infected fruit shrivel and harden several weeks before harvest, developing into black fungal masses known as mummy berries.

Life Cycle: The fungus overwinters in the form of mummy berries. Field frost, even for an hour, dramatically increases the susceptibility of buds to infection. During bud break, mummy berries germinate to produce apothecia, structures that develop primary spores (ascospores). Under cool and wet conditions, these spores infect the vegetative and floral buds, with symptoms appearing in 10-20 days. Secondary spores (conidia) produced on the diseased tissues are then carried by wind or pollinating insects to infect new plants. Fruits 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. Flail mowing does not destroy the mummies and may result in increased levels of the disease. A strategy has been developed based on air temperature and leaf wetness that rates the likelihood of infection during different periods of time. Monitoring temperature and leaf wetness and spraying only when the risk of infection is high is recommended.

Resistant Cultivars: Not applicable.

Chemical Controls: The decision to spray depends almost entirely on the past history of the disease in a particular field. If growers have experienced a problem with monilinia blight in the past, they monitor for the disease and apply chemical controls if required. Spray programs target ascospore infections which reduces the production of conidia and secondary spread.

Issues for Monilinia Blight

1. There is insufficient information available for accurate forecasting of infection periods of monilinia blight.
2. There are insufficient biological controls and other alternatives to conventional chemicals available for the control of monilinia blight. Currently only one product is effective in controlling this disease and is also accepted in export markets.

Phomopsis Canker (*Phomopsis vacinii*)

Pest Information

Damage: Phomopsis canker is found in sprout fields from late July until the end of September. Disease lesions appear as elongated, flattened cankers on stem bases and cause the stems to drop off. Phomopsis can be devastating to bushes in low areas where winter injury and

spring frosts are a problem. However, the disease is not as common in fruiting fields, where it might be confused with godronia canker.

Life Cycle: Conidia are spread by splashing rain throughout the growing season from bud break through September. Injuries from mechanical damage, winter stresses or spring frost are necessary for phomopsis infection because wounded tissues serve as entry points for conidia. Wounds from mechanical harvesting or pruning may also facilitate infections. Stems infected in the growing season wilt during the summer months.

Pest Management

Cultural Controls: Monitoring of fields for phomopsis is done in early September of the sprout year. Pruning by burning is assumed to reduce disease incidence. Careless pruning, cultivating and fertilization late in the summer should be avoided to minimize mechanical injury to the plants. Keeping the plants well watered through prolonged periods of dry weather in the summer and avoiding stress also helps to prevent this disease.

Resistant Cultivars: Not applicable.

Chemical Controls: Pyraclostrobin is registered for the control of phomopsis canker.

Issues for Phomopsis Canker

1. The proper timing of fungicide application is unknown. The timing of application in wild blueberries appears to be different than the timing for highbush blueberries.

Powdery Mildew (*Microsphaera penicillata var. vaccinii*)

Pest Information

Damage: Powdery mildew is very common and 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 probably overwinters in infected leaves. First symptoms appear in early July, resulting from infections that took place 2-3 weeks previously. Further infections occur as the season progresses. Powdery mildew tends to be more serious 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.

Resistant Cultivars: Not applicable. There is clonal variation in susceptibility to powdery mildew.

Chemical Controls: None available.

Issues for Powdery Mildew

1) There are no effective treatments for the control of powdery mildew.
2) The impact of current production practices including pruning and fertilization on powdery mildew is unknown.

Red Leaf (*Exobasidium vacinii*)

Pest Information

Damage: Red leaf has a systemic distribution within the plant tissues and results in reduced 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 field infections through spores only take place 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.

Resistant Cultivars: Not applicable.

Chemical Controls: In fields where red leaf is a problem, diseased plants should be eradicated by spot spraying with a recommended herbicide in the sprout year. Even a low incidence of red leaf is often sufficient for the spread of the disease throughout the field.

Issues for Red leaf

1. There is no effective treatment for redleaf.

Septoria Leaf Spot (*Septoria* sp.)

Pest Information

Damage: Symptoms 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 on leaf surfaces. Septoria may cause defoliation in both crop and sprout fields. This affects fruit bud development in the sprout year and reduces yield in the crop year.

Life Cycle: The fungus overwinters on infected leaves and twigs. Spores are released from late May to the end of June (in Nova Scotia). Septoria leaf spot severity is dependent upon the number of wet periods that occur during this time. There may be more than one species involved with this disease.

Pest Management

Cultural Controls: Pruning by burning reduces inoculum.

Resistant Cultivars: Not applicable, although there is clonal variation in susceptibility to septoria leaf spot.

Chemical Controls: None available.

Issues for Septoria Leaf Spot

1) The damage caused by septoria leaf spot may be underestimated.

2) The impact of cultural practices such as pruning and fertilization on septoria leaf spot, is not well understood. There is insufficient information on alternative controls.

Valdensinia Leaf Spot (*Valdensinia heterodoxa)*

Pest Information

Damage: This leaf spot has recently been identified in Nova Scotia and PEI. It is relatively common and during very wet seasons, may cause severe defoliation in both crop and sprout fields. The fungus produces large, reddish-brown spots up to 1cm or more in diameter. Infected leaves drop soon after symptom development.

Life Cycle: The fungus overwinters as sclerotia in infected leaves. In the spring, tiny apothecial cups form on infected leaves and release ascospores during wet conditions. Infected leaves drop quickly. Secondary infections are caused by large conidia that spread to the foliage canopy from fallen, infected leaves. Often a single spore can be seen in the middle of a necrotic spot. This fungus can be spread from field to field on equipment, boots, etc. Other hosts of valdensinia have been found around blueberry fields. These 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.

Resistant Cultivars: There has been no clonal variation in susceptibility observed.

Chemical Controls: None available.

Issues for Valdensinia Leaf Spot

1) Chemical control products for valdensinia leaf spot are unavailable.
2) The impact of current production practices including pruning by mowing and fertilization on valdensinia leaf spot is unknown.

Witches' broom (*Pucciniastrum goeppertianum*)

Pest Information

Damage: Infected plants 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. New, infected growth is produced each spring.

Life Cycle: From mid May to late June, rust spores (teliospores) develop on infected shoots and germinate to produce another type of spore (basidiospore). These spores are carried by wind to balsam fir trees that serve as alternate hosts and where another type of spore (aeciospore) is formed. These spores are then wind-blown back to the blueberry plants where they germinate on leaves and stems, stimulating the production of lateral buds that develop into the characteristic, broom-like swollen shoots. This phase takes place during mid to late summer. 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. As infected plants have been reported in areas remote from balsam fir, basidiospores produced on blueberry may directly infect other

blueberry plants without the need for an alternate host. However, this hypothesis is yet to be confirmed.

Pest Management

Cultural Controls: Infected blueberry plants are removed. 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 400-500 yards of blueberry fields may be effective, but may not be practical as yield losses from the disease are very small.

Resistant Cultivars: Not applicable.

Chemical Controls: Infected blueberry plants are killed with a systemic herbicide to prevent the spread of the disease.

Issues for Witches' Broom

1. There is no effective fungicide treatment for witches broom.

Insects and Mites

Key Issues

- The shift in pruning practices from burning to mowing has resulted in greater insect and disease pressure. New technologies for sanitizing leaf litter after mowing could help reduce pressure by insects and diseases.
- Further research on the management of insects in the sprout year using alternative techniques such as field sanitation, biological controls and reduced risk products, especially for blueberry flea beetle and blueberry maggot, would be of benefit to the wild blueberry industry.
- Thresholds for treatment decisions for pests including blueberry flea beetle, blueberry maggot, and blueberry spanworm, need further work to improve the accuracy of spray timings.
- Education and training of field scouts and promotion is needed to facilitate the adoption of this practice.
- The industry has a very limited selection of reduced risk products for major insect pests. The replacement of organophosphate insecticides with effective, reduced risk products including biological controls, with lower toxicity to pollinators is required.
- There is a need to establish the biology and potential impact of hill fireworm, a new pest in wild blueberry.
- There is a need for the development of a reduced risk approach to the management of blueberry flea beetle including pollinator friendly, reduced risk products, biological controls and a predictive model for blueberry flea beetle adults.

Table 8. Occurrence of insect pests in Canadian wild blueberry production.

	Degree of occurrence					
Major Insects	**QC**	**NB - North**	**NB - South**	**NS**	**PE**	**NL**
Blueberry case beetle	DNR	E	E	E	DNR	DNR
Blueberry flea beetle	E	E	E	E	DNR	DNR
Blueberry leaf beetle	DNR	E	E	DNR	DNR	DNR
Blueberry leaftier	DNR	E	E	E	DNR	DNR
Blueberry maggot	E	E	E	E	DNR	DNR
Blueberry sawfly	DNR	E	E	E	DNR	DNR
Blueberry spanworm	E	E	E	E	DNR	DNR
Blueberry stem gall wasp	DNR	E	E	DNR	DNR	DNR
Blueberry thrips	DNR	E	E	E	DNR	DNR
Grasshoppers	DNR	E	E	DNR	DNR	DNR
Hill fireworm	DNR	DNR	D	DNR	DNR	DNR
Redstriped fireworm	DNR	E	E	E	DNR	DNR
Strawberry rootworm	DNR	E	E	DNR	DNR	DNR
White marked tussock moth	DNR	E	E	E	DNR	DNR

Widespread yearly occurrence with high pest pressure

Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure

Widespread yearly occurrence with low to moderate pest pressure

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure

Pest not present

DNR - data not reported

E – established

D – invasion expected or dispersing

Source(s): "Canadian Expert Poll on Crop Protection" focus groups for New Brunswick, Nova Scotia and Quebec (2006).

Table 9. Availability and use of insect pest management approaches for Canadian wild blueberry production.

	Practice\ Pest	Blueberry maggot	Blueberry case beetle	Blueberry flea beetle	Blueberry leaftier	Blueberry Sawfly	spanworm	Blueberry thrips	Redstriped fireworm
Avoidance	Resistant varieties								
	Planting / Harvest Date Adjustment								
	Optimizing fertilization								
	Reducing mechanical damage								
	Thinning / pruning								
	Trap Crops / perimeter spraying								
	Repellents								
Prevention	Equipment sanitation								
	Mowing / Mulching / Flaming								
	Removal of alternative hosts (weeds / volunteers)								
	Row or plant spacing (plant density)								
	Seeding depth								
	Water / irrigation management								
	Crop residual removal / management								
	Pruning out / removal of infested material								
Monitoring	Scouting - trapping								
	Records to track pests								
	Soil analysis								
	Weather monitoring for degree day modelling								
	Grading out infected produce								
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								
	Calendar spray								
Suppression	Biological pesticides								
	Environmental management (eg. as in greenhouses)								
	Pesticide rotation for resistance management								
	Soil amendments								
	Ground Cover / physical barriers								
	Pheromones (eg. mating disruption)								
	Sterile mating technique								
	Beneficial organisms and habitat management								
	Trapping								

no indication that the practice is available/used

available/used

available/not used

not available

Source(s): Canadian Expert Poll on Crop Protection focus groups for New Brunswick, Nova Scotia and Quebec (2006).

Table 10. Insecticides registered on wild blueberry in Canada.

Regulatory Status as of March 6, 2008[5]				
Active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action / resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**
Bacillus thuringiensis Berliner sub.sp. *kurstaki* (Foray 48BA Low Volume Aqueous Concentrate)	*B.t.* sub.sp. *kurstaki*	microbial disruptors of insect midgut membranes / 11B2	BI, RE	whitemarked tussock moth
carbaryl (Sevin Brand XLR Carbaryl Insecticide, Sevin SL Carbryl Insecticide Liquid Suspension)	carbamate	acetylcholine esterase inhibitors / 1A	RE	blueberry maggot
				cherry fruitworm
				cranberry fruitworm
				lecanium scale
				leafrollers
				Bruce spanworm
deltamethrin (Decis 5EC Insecticide)	pyrethroid	sodium channel modulators / 3	R	leaf tier
				Bruce spanworm
dimethoate (Cygon 480 Systemic Insecticide)	organophosphate	acetylcholine esterase inhibitors / 1B	RE	blueberry maggot
malathion (Malathion 25W Wettable Powder Insecticide, Malathion 85E)	organophosphate	acetylcholine esterase inhibitors / 1B	RE	blueberry maggot
				thrips
				cherry fruitworm
				cranberry fruitworm
				spider mites
				aphids
				leafhoppers
				leafrollers
				rose chafers
				strawberry root weevil adults (BC only)

Regulatory Status as of March 6, 2008[5]				
Active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action / resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**
permethrin (Ambush 500EC)	pyrethroid	sodium channel modulator / 3	R	thrips
phosmet (Imidan 50 WP Instapak)	organophosphate	acetylcholine esterase inhibitor / 1B	RE	blueberry maggot
				blueberry spanworm
potassium salts of fatty acids (Neudosan Commercial)	unclassified	unclassified	R	aphids
				mealybugs
				mites
				scale insects
spinetoram (RADIANT SC INSECTICIDE)	spinosyn	nicotinic acetylcholine receptor agonist (allosteric) / 5	RR	blueberry spanworm
spinosad (GF-120NF Naturalyte Fruit Fly Bait)	spinosyn	nicotinic acetylcholine receptor agonist (allosteric) / 5	RR	blueberry maggot
				blueberry flea beetle
trichlorfon (Dylox 420 Liquid Insecticide, Dylox 80% Soluble Powder Insecticide)	organophosphate	acetylcholine esterase inhibitor / 1B	RE	blueberry casebeetle
				flea beetle larvae
				whitemarked tussock moth
				currant spanworm
				blueberry fleabeetle
				blueberry spanworm
				blueberry sawfly

[1]Common trade name(s), if provided in brackets, are for the purpose of product identification only. No endorsement of any product in particular is implied.

[2]The classification and the mode of action group are based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action. The document is under revision and up-to-date information can be found on the following web sites: Herbicides: www.plantprotection.org/HRAC/Bindex.cfm?doc=moa2002.htm; Insecticides: www.irac-online.org/Crop_Protection/MoA.asp#area223; Fungicides: www.frac.info/frac/index.htm

[3] R-full registration (non-reduced risk), RE-under re-evaluation (yellow), DI (red) -discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA, BI-biological, RR-reduced risk (green). Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Individual product labels should be consulted for up to date accurate information concerning specific registration details. The information in these tables should not be relied upon for pesticide application decisions. Consult individual product labels for specific registration details. The following website can be consulted for more information on pesticide registrations: www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php

[4] Please consult the product label on the PMRA web site (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php) for specific listing of pests controlled by each active ingredient.

[5]Sources: Pest Management Regulatory Agency

Table 11. Performance and use of insecticides for the control of insect pests of wild blueberry in Canada.

Pests or Group of Pests targeted	Active ingredient[1]	Resistance group[2]	Stakeholder comments[3,4]	
			Performance[3]	Notes
Aphids	malathion	1B		
	potassium salts of fatty acids	Unclassified		
blueberry case beetle	trichlorfon	1B	A	Can be applied in cropping or non-cropping years.
Flea beetle larvae	trichlorfon	1B	A	Not to be applied on fields where berries are destined for the US market as there is no MRL established. Low toxicity to bees; incidentally controls spanworm; can be applied in either the cropping or non-cropping years.
Blueberry flea beetle	spinosad	5		
	trichlorfon	1B		
blueberry leaftier	deltamethrin	3	A	Rare pest; application timing is critical to get control before larvae burrow into floral buds.
blueberry maggot	carbaryl	1A	A^P - A	Has a short pre-harvest interval; cost effective.
	dimethoate	1B	A	Mostly used as a border spray as the mature flies move into the field from the exterior; toxic to non-targets.
	malathion	1B		
	phosmet	1B	A	Mostly used as a border spray; toxic to non-target organisms.
	spinosad	5		
Blueberry Sawfly	trichlorfon	1B	A	No MRL in USA; safer on pollinators than other options.
Blueberry spanworm	phosmet	1B	A	
	spinetoram	5		
	trichlorfon	5		
Bruce spanworm	carbaryl	1A		
	deltamethrin	3	A	Can be applied in cropping or non-cropping years.

Pests or Group of Pests targeted	Active ingredient[1]	Resistance group[2]	Stakeholder comments[3,4]	
			Performance[3]	Notes
Cherry fruitworm	carbaryl	1A		
	malathion	1B		
Cranberry fruitworm	carbaryl	1A		
	malathion	1B		
Currant spanworm	trichlorfon	1B		
Leafhoppers	malathion	1B		
Leafrollers	carbaryl	1A		
	malathion	1B		
Lecanium scale	carbaryl	1A		
Mealybugs	potassium salts of fatty acids	Unclassified		
Mites	potassium salts of fatty acids	Unclassified		
Rose chafers	malathion	1B		
Scale insects	potassium salts of fatty acids	Unclassified		
Spider mites	malathion	1B		
Strawberry root weevil adults (BC only)	malathion	1B		
Thrips	malathion	1B		
	permethrin	3		
Whitemarked tussock moth	*Bacillus thuringiensis* Berliner ssp. Kurstaki	11B2	A	Only works on second instars so timing is critical; not always available.
	trichlorfon	1B	A	Restrictions around harvest in crop years.

[1] List includes all active ingredients registered as of March 6, 2008. Please consult product labels on the PMRA web site (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php) for further information on pesticide use.

[2]The resistance group is based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action. The document is under revision and up-to-date information can be found on the following web sites: Herbicides: www.plantprotection.org/HRAC/Bindex.cfm?doc=moa2002.htm ; Insecticides: www.irac-online.org/Crop_Protection/MoA.asp#area223 ; Fungicides: www.frac.info/frac/index.htm

[3]Based on user perceptions of performance of active ingredient for recommended uses. A – Adequate (green) (the pest control product (PCP), according to recommended use, maintains disease below economic threshold OR provides acceptable control), A^p – Provisionally Adequate (yellow) (the PCP, while having the ability to provide acceptable control, possesses qualities which may make it unsustainable for some or all uses), I – Inadequate (red) (the PCP, according to recommended use, does not maintain disease below economic threshold OR provides unacceptable control).

[4]Source(s) - "Canadian Expert Poll on Crop Protection" Focus Groups for New Brunswick, Nova Scotia and Quebec (2006).

Blueberry Case Beetle (*Neochlamisus cribripennis*)

Pest Information

Damage: The blueberry case beetle can cause considerable damage to wild blueberry fields. Both adults and larvae feed on leaves and if present in large numbers can cause severe defoliation. 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, 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 10 days and emerging larvae feed mostly on the leaves of blueberries. Larvae go through three instars 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 4 to 5 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. Although action thresholds have not been established, a level of 20 larvae per sample should prompt control measures.

Resistant Cultivars: Not applicable.

Chemical Controls: Insecticide treatment may be required if populations become high. The larval stage is the easiest to control.

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 sprouting year. If not controlled, these outbreaks can cause severe losses in plant emergence in the sprout year and growth, affecting plant height.

Life Cycle: The eggs of the flea beetle overwinter in leaf litter and hatch in May when the leaves begin to unfold. The larvae go through three instars 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. In both crop and sprout fields, weekly samplings using a sweep net should be done. Although an action threshold has not been established, 3-5 larvae per sweep should prompt a subsequent check for signs of defoliation and may signal the need for control measures.

Resistant Cultivars: Not applicable.

Chemical Controls: Trichlorfon is registered for the control of blueberry flea beetle, but generally not used as there is no MRL in the US. As most outbreaks occur during the bloom period, the safety of pollinators must be taken into account and sprays need to be timed so that beneficial insects are not harmed.

Issues for Blueberry Flea Beetle

1. There is insufficient information available on the management of blueberry flea beetle.
2. Pollinator friendly, reduced risk products, including biological controls for the blueberry flea beetle, are unavailable. The only product available for blueberry flea beetle control (trichlorfon) is an organophosphate and has no US import tolerance.
3. A predictive emergence model for blueberry flea beetle adults is unavailable. Larvae which are present during bloom and pollination are currently targeted with control treatments.

Blueberry Fruit Fly (maggot) (*Rhagoletis mendax*)

Pest Information

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

Life Cycle: Adult flies emerge from soil from late June to early August, and live for approximately 30 days. Females can each lay up to 100 eggs, usually leaving only one egg per berry. Larvae develop inside fruits, causing them to shrivel and drop prematurely. A small portion of the infested berries remain on the plant and are harvested. The pupa is formed in the soil and typically emerges the following year, with some emerging 2-4 years later.

Pest Management

Cultural Controls: Dividing fields into crop and non-crop sections should be avoided as the majority of adult flies emerge during the non-crop year in a two-year cropping system. Debris from winnowing piles should be destroyed or buried, especially if field cleaning is done. Heavily infested berries should not be left unpicked, but disposed of to reduce re-infestation. Weed control around the outer edges of the field forces the fruit fly to lay eggs away from the field and decreases the overall fly population. Monitoring is done using yellow coloured sticky traps placed in the outer margin of the field. Traps should be checked three times a week and records should be kept throughout the season. The action threshold has been set at one captured fly due to the intolerance for the pest in the export markets. Monitoring should continue after the threshold has been reached to allow for the evaluation of the effectiveness of the insecticide spray and to determine the need for a second spray application.

Resistant Cultivars: Not applicable.

Chemical Controls: Insecticides are applied within 7-10 days, once the action threshold is reached. A second spray is occasionally necessary.

Issues for Blueberry Fruit Fly

1. Reduced risk alternatives, including biological controls are unavailable for blueberry fruit fly.

2. The blueberry fruit fly is a quarantine pest because of the low tolerance for larvae in export markets.
3. There are insufficient products registered with different activities to be used for resistance management of blueberry fruit fly.
4. There is concern about the potential loss of registered products.

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% of the buds being affected. Older larvae cause damage by feeding on leaves and flowers. Defoliation can be close to 100% if the outbreak is severe, however the pest is rarely of economic concern.

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 moth numbers in the sprout year. Pheromone traps for adults have been developed to determine if a field requires a spray to control larvae the following spring. However, this pheromone is not available commercially.

Resistant Cultivars: Not applicable.

Chemical Controls: Deltamethrin is used to control the larval stages. Application is timed according to flower bud development stage, which corresponds to egg hatch in the field.

Issues for Blueberry Leaftier

None identified.

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 young and mature foliage until late June. Then 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 will 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 (Ichneumonid) are active in blueberry fields and help to keep the populations of sawfly low. Parasites may not control an outbreak early enough to reduce economic damage. Weekly sampling in crop fields using a sweep net should be done. Although no action threshold has

been established, 3-5 larvae per sweep should prompt a check for signs of defoliation and may indicate that control measures are needed.

Resistant Cultivars: Not applicable.

Chemical Controls: Trichlorfon is registered to control the blueberry sawfly (but generally not used as there is no MRL established for the US). As most outbreaks occur during the bloom period, safety of pollinators must be taken into account and sprays need to be timed to avoid harm to beneficial insects.

Issues for Blueberry Sawfly

1) There are insufficient alternative controls for the blueberry sawfly.

Blueberry Spanworm (*Itame argillacearia*) and other spanworms

Pest Information

Damage: Caterpillars of several species of spanworm moths feed on the foliage of wild blueberry. Plants can be completely defoliated if the outbreak is severe. In fields that are sprouting, the pest can consume the new growth. In the past, these insects have been kept under control as the overwintering eggs were destroyed by burning. Recently, mowing has replaced burning and the number of spanworm outbreaks has increased.

Life Cycle: The pest overwinters as eggs in the litter around the base of plants. The eggs hatch and larvae emerge when the new sprouts begin to grow in late May. The larvae feed most actively on leaves and buds at night. During the day, the larvae drop to the ground and hide in leaf litter. Feeding continues until late June or early July at which time the larvae pupate in the soil. Adult moths emerge in late July and lay eggs on leaves or on the ground.

Pest Management

Cultural Controls: Burning can reduce the number of spanworms in the field. Several species of parasitic wasp attack the blueberry spanworm and help to control the population. Weekly monitoring is done during May and June using a sweep net. Action thresholds have been set at 7 spanworms per 25 sweeps on sprout fields and 12 spanworms per 25 sweeps on crop fields.

Resistant Cultivars: Not applicable.

Chemical Controls: Insecticide treatments are necessary when the level of spanworms exceeds the action threshold.

Issues for Blueberry Spanworm

1) Alternative and reduced risk control options are unavailable for the blueberry spanworm.

Blueberry Stem Gall Wasp (*Hemadas nubilipennis*)

Pest Information

Damage: Blueberry stem gall is caused by the reaction of the plant to egg laying and larval feeding of a chalcid wasp. Galls appear as irregular growths on the stems of the plant. 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. This type of damage has become more of a concern in recent years. The build up of galls over several years can lead to a more serious impact.

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 growth of the plant tissue. Eventually a gall is formed around several feeding larvae. The larvae overwinter inside the gall, pupate the following spring and emerge from the galls as adults. Most of the galls (up to 70%) are found on stems within the leaf litter and only a few of them are formed on stems above the surface.

Pest Management

Cultural Controls: Burning of the plants may have some effect. There are a number of species of wasps, including parasitic wasps, which use the galls formed by the blueberry stem gall wasp. The effect of these wasps on stem gall wasp populations is not known, although high levels of parasitism (more than 50%) have been recorded.

Resistant Cultivars: Not applicable.

Chemical Controls: None available.

Issues for Blueberry Stem Gall

None identified.

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 the following spring on leaves that remain attached to the plant. In crop fields, growing 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. Yields may be reduced by 50% or more.

Life Cycle: The two species attacking wild blueberries have a similar appearance and life cycle. The adult females of the second generation 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 and adults feed on blueberry leaves by sucking sap, causing the leaves to curl. These curled leaves provide shelter for the thrips population. The pre-pupal and pupal stages are inactive. Adults of the first generation appear in late July and a second generation starts two weeks later.

Pest Management

Cultural Controls: It is recommended that curled leaves be burned as soon as they are noticed in the spring. Burning later in the summer is less effective as the thrips may have left the plants. Inspections for the presence of thrips and damage should begin in early June. Infested areas should be treated the following spring, when the plants are small and the overwintered adults first appear.

Resistant Cultivars: Not applicable.

Chemical Controls: Registered products to control thrips include permethrin and malathion. The timing of application is very important.

Issues for Thrips

None identified.

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 are present until mid October. They begin egg laying shortly after they emerge. The eggs are loosely attached to the underside of leaves of the host plant. In blueberry fields, sweet fern (*Comptonia peregrina*) is the preferred host plant, but other plants are utilized if sweet fern is not present. The eggs overwinter and begin hatching in early June. The newly hatched larvae skeletonize the leaves. As the larvae become larger, the entire leaf is eaten. There are five larval instars. Pupation takes place in the leaf litter from August to early September and takes between 32 and 48 days to complete.

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 *Etomophthora aulicae* and a multi-cupsid nuclear-polyhedrosis virus (MVPV) have also been noted as natural controls.

Resistant Cultivars: Not applicable.

Chemical Controls: There are no chemicals registered for this pest.

Issues for Chainspotted geometer

1. There is a lack of pollinator friendly, reduced risk products registered for the control of the chainspotted geometer.

Whitemarked Tussock Moth (*Orgyia leucostigma*)

Pest Information

Damage: The whitemarked tussock moth is primarily a forest pest, but is a general feeder and can attack any type of vegetation. Larvae feed on the foliage of wild 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 2 to 3 years at a time in Nova Scotia. The caterpillars are covered with easily dislodged hairs that can cause irritation and possible

allergic reactions in humans when they come in contact with the skin. In addition, the hairs can become airborne and may cause problems if inhaled.

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 or in cracks and crevices. The pupal stage lasts for about 2 weeks and adults emerge from mid-August to September. Females lay eggs in masses of 50-100 which are protected by a coating of white foam. Eggs are normally laid on or near the cocoon from which the female emerged. 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. Monitoring for the hatching of caterpillars must be conducted in both crop and sprout fields in early July to time the 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. Monitoring of the feeding patterns should be conducted and immediate action is recommended when apparent feeding damage is observed. The bacterium *Bacillus thuringiensis* subspecies *kurstaki*, strain HD-1 is registered as a biological control for this pest. 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.

Resistant Cultivars: Not applicable.

Chemical Controls: Spraying should be delayed until larval dispersal is complete. Registered products include trichlorfon.

Issues for Whitemarked Tussock Moth

1. Additional reduced risk alternatives are required for whitemarked tussock moth.

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 wild 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 1- 2 weeks and following mating, the female moth lays eggs back on the blueberry plants. Female moths are flightless so eggs are often laid in the vicinity of the pupation site. There is one generation per year.

Pest Management

Cultural Controls: None identified.

Resistant Cultivars: Not applicable.

Chemical Controls: *Bacillus thuringiensis* is registered for the control of gypsy moth.

Issues for gypsy moth

1. None identified.

Redstriped fireworm (*Aroga trialbamaculella*)

Pest Information

Damage: The redstriped fireworm occasionally causes severe damage in some fields. This insect is more prevalent in sprout fields but will also be found in crop fields. The larvae web leaves together and feed within the webbed leaves. They may also web together fruit, which may affect fruit size and interfere with harvest.

Life Cycle: The redstriped fireworm overwinters as mature larvae in the leaf litter. Pupation and adult emergence occurs in the spring, with adults being present into the summer, when eggs are laid on the blueberry plants.

Pest Management

Cultural Controls: None identified.
Resistant Cultivars: Not applicable.
Chemical Controls: None available.

Issues for fireworms

1. The red striped fireworm is an emerging problem as growers move away from burning to pruning by mowing.

Weeds

Key Issues

- In general, weeds are becoming increasing problems in wild blueberry production.
- The availability of reduced risk herbicides for all groups of weeds is limited. The registration of additional reduced risk products is needed to enable product rotation to reduce the potential of resistance development.
- Currently, hexazinone (Velpar) is the only broad spectrum herbicide product registered for use in blueberry production.
- Research on reduced application rates and decision making tools for hexazinone (Velpar) may promote a more efficient use of this herbicide.
- The development of a broader range of reduced risk, broadleaf control products would allow for more precise herbicide applications and decrease the need for broad spectrum pre-emergent herbicides.
- Fluazifop-p-butyl (Venture L) is the only post emergent grass herbicide available and there are some concerns about its efficacy. Due to its long pre-harvest interval of 60 days, it is difficult to control late emerging grasses with this herbicide. The registration of reduced risk products with shorter PHI's, would be of benefit.
- The impact of fertilization on the vigour of annual broadleaf weeds is not well understood.

Table 12. Occurrence of weed pests in Canadian wild blueberry production.

	Degree of occurrence					
Weeds	**QC**	**NB-North**	**NB-South**	**NS**	**PE**	**NL**
Annual grasses	E	E	E	E	DNR	DNR
Witch grass	DNR	DNR	DNR	E	DNR	DNR
Annual broadleaf weeds	E	E	E	E	DNR	DNR
Lamb'quarters	DNR	DNR	DNR	E	DNR	DNR
Red root pigweed	DNR	DNR	DNR	E	DNR	DNR
Hemp-nettle	DNR	DNR	DNR	E	DNR	DNR
Cow wheat	DNR	DNR	DNR	E	DNR	DNR
Perennial Grasses	E	E	E	E	DNR	DNR
Poverty oatgrass	DNR	DNR	DNR	E	DNR	DNR
Narrow leaf or sheep fescue	DNR	DNR	DNR	E	DNR	DNR
Ticklegrass	DNR	DNR	DNR	E	DNR	DNR
Poa spp.	DNR	DNR	DNR	E	DNR	DNR
Sedges and Rushes	E	E	E	E	DNR	DNR
Perennial broadleaf weeds (herbaceous)	E	E	E	E	DNR	DNR
Sheep sorrel	DNR	DNR	DNR	E	DNR	DNR
Goldenrod	DNR	DNR	DNR	E	DNR	DNR
Vetch	DNR	DNR	DNR	E	DNR	DNR
St. John's wort	DNR	DNR	DNR	E	DNR	DNR
Bunchberry	E	DNR		E	DNR	DNR
Black medic	DNR	DNR	DNR	E	DNR	DNR
Fleabane	DNR	DNR	DNR	E	DNR	DNR
Yellow loostrife	DNR	DNR	DNR	E	DNR	DNR
Spreading dogbane	DNR	DNR	DNR	E	DNR	DNR
Woody plants	E	E	E	E	DNR	DNR
Barrenberry	DNR	DNR	DNR	E	DNR	DNR
Small trees	DNR	DNR	DNR	E	DNR	DNR
Huckleberry	DNR	DNR	DNR	E	DNR	DNR

Widespread yearly occurrence with high pest pressure

Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure

Widespread yearly occurrence with low to moderate pest pressure

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure

Pest not present

DNR – Data not reported

E – established

D – invasion expected or dispersing

Source(s): Canadian Expert Poll on Crop Protection focus groups for New Brunswick, Nova Scotia and Quebec (2006).

Table 13. Availability and use of weed pest management approaches for Canadian wild blueberry production.

	Practice\ Pest	Annual broadleaf weeds	Annual grasses	Perennial broadleaf weeds	Perennial grasses	Sedges and rushes	Woody plants
Avoidance	Planting / harvest date adjustment						
	Crop rotation						
	Choice of planting site						
	Use of weed-free seed						
	Optimizing fertilization						
Prevention	Equipment sanitation						
	Mowing / mulching / flaming						
	Row or plant spacing (plant density)						
	Seeding depth						
	Water / irrigation management						
	Weed management on 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						
	Grading of grain / produce for weed contamination						
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						
	Calendar spray						
Suppression	Biological pesticides						
	Habitat / environment management						
	Pesticide rotation for resistance management						
	Soil amendments						
	Ground Cover / physical barriers						
	inter-row cultivation						
	mechanical weed control						

no indication that the practice is available/used

available/used

available/not used

not available

Source(s): Canadian Expert Poll on Crop Protection focus groups for New Brunswick, Nova Scotia and Quebec (2006).

Table 14. Herbicides registered on wild blueberry in Canada

Regulatory Status as of March 6, 2008[5]				
Active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action / resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**
bentazon (Basagran Liquid Herbicide, Basagran Forte Liquid Herbicide)	benzothiadiazole	inhibition of photosynthesis at photosystem II site B / 6	RE	broadleaf weeds and yellow nutsedge
carfentrazone-ethyl (Aim EC)	triazolinone	inhibition of protoporphyrinogen oxidase / 14	R	broadleaf weeds and defoliate/desiccate crop as a harvest aid
clopyralid (Lontrel 360 Herbicide)	carboxylic acid	synthetic auxin / 4	RE	tufted vetch
dicamba (Banvel Herbicide)	benzoic acid	synthetic auxin / 4	RE	sweet fern and lambkill (sheep laurel)
ethephon (Ethrel Liquid Plant Growth Regulator)	unclassified [plant growth regulator (PGR)]	unclassified (PGR)	R	black barrenberry
fluazifop-p-butyl (Venture L Herbicide)	aryloxyphenoxy propionate	inhibition of acetyl CoA carboxylase (ACCase) / 1	R	annual and perennial grasses
glyphosate (Roundup Original Liquid Herbicide)	glyphosate	inhibition of EPSP synthase / 9	R	annual and perennial weeds woody brush and trees
hexazinone (Velpar Herbicide)	triazinone	inhibition of photosynthesis photosystem II site A / 5	RE	grasses and broadleaf weeds as well as woody weeds such as trailing blackberry, lamb-kill, hardhack and poplar
napropamide (Devrinol 50 DF Selective Dry Flowable Herbicide)	acetamide	inhibition of synthesis of very long-chain fatty acids / 15	RE	annual grasses and broadleaf weeds
nicosulfuron/ rimsulfuron (Ultim Herbicide 75% DF Herbicide)	sulfonylurea / sulfonylurea	inhibition of acetolacate synthases (ALS) or acetohydroxyacid synthases (AHAS) / 2	RE	black bulrush

Regulatory Status as of March 6, 2008[5]				
Active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action / resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**
propyzamide (Kerb 50 WSP Selective Herbicide)	benzamide	inhibition of microtubule assembly / 3	RE	annual and perennial grasses
simazine plus related triazines (Princep Nine-T Herbicide)	triazine	inhibition of photosynthesis at photosystem II site A / 5	R	annual grasses and broadleaf weeds, perennial species starting from seeds
terbacil (Sinbar Herbicide Wettable Powder)	uracil	inhibition of photosynthesis at photosystem II site A / 5	R	annual grasses and broadleaf weeds
tribenuron-methyl (Spartan Herbicide Water Dispersible Granular)	sulfonylurea	inhibition of acetolacate synthases (ALS) or acetohydroxyacid synthases (AHAS) / 2	R	broadleaf weeds bunchberry, yellow loosestrife, speckled alder, wild rose and bracken fern
triclopyr (Garlon 4 Herbicide)	carboxylic acid	synthetic auxins / 4	R	woody plant control for lowbush blueberry site preparation

[1]Common trade name(s), if provided in brackets, are for the purpose of product identification only. No endorsement of any product in particular is implied.

[2]The classification and the mode of action group are based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action. The document is under revision and up-to-date information can be found on the following web sites: Herbicides: www.plantprotection.org/HRAC/Bindex.cfm?doc=moa2002.htm; Insecticides: www.irac-online.org/Crop_Protection/MoA.asp#area223; Fungicides: www.frac.info/frac/index.htm

[3] R-full registration (non-reduced risk), RE-under re-evaluation (yellow), DI (red) -discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA, BI-biological, RR-reduced risk (green). Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Individual product labels should be consulted for up to date accurate information concerning specific registration details. The information in these tables should not be relied upon for pesticide application decisions. Consult individual product labels for specific registration details. The following website can be consulted for more information on pesticide registrations: www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php

[4] Please consult the product label on the PMRA web site (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php) for specific listing of pests controlled by each active ingredient.

Table 15. Performance and use of herbicides for the control of weeds in wild blueberry in Canada

Pests or Group of Pests targeted	Active ingredient[1]	Type of Treatment[1]	Resistance group[2]	Stakeholder comments[3,4]	
				Performance[3]	Notes
Annual broadleaf weeds	bentazon	foliar	6		
	hexazinone	soil application- in sprout or crop year	5	A	Broad spectrum herbicide that controls most weeds. Late emerging annual weeds not controlled by pre-emergent treatments. This product is essential to blueberry production. There are environmental concerns with the use of this herbicide and growers have some concerns about efficacy.
	napropamide	soil	15		
	simazine plus related active triazines	soil	5	A	Limited control spectrum. Primarily used for lamb's quarters but provides limited control of perennial grass and goldenrod. May be some triazine resistance.
Annual grasses	terbacil	soil application, non-crop year	5	A^P	WP formulation can cause mixing challenge. Late emerging annuals may escape pre-emergent applications.
	fluazifop-p-butyl	ground application - in crop and prune year		A^P	Provides no residual activity; some perennial grasses escape control. Assists mechanical harvesting.
	hexazinone	soil application- in sprout and crop years	5	A^P	Broadspectrum; has been in use for 20+ years and there is concern of the potential loss of efficacy. Chemical is moved by heavy rains.
	napropamide	soil	15		Registered for use on germinating annual grasses.
	propyzamide	soil application- early spring or late fall.	3	A^P	Mainly targets witch grass; expensive in comparison to alternatives.
	simazine plus related active triazines	soil application - early spring or late fall	5	A^P	Not widely used. True efficacy in wild blueberry has not been determined.
	terbacil	soil application- non-crop year	5	A^P	Requires some rain to make application effective. There is some evidence that soil type can affect efficacy.

Pests or Group of Pests targeted	Active ingredient[1]	Type of Treatment[1]	Resistance group[2]	Stakeholder comments[3,4]	
				Performance[3]	Notes
Fern	diacmba present as acid, as diethanolamine salt	foliar	4		
Perennial broadleaf weeds (herbaceous)	clopyralid	spot application in non-bearing (prune) year	4	A	Controls tufted vetch; if applied too late in June, it may reduce crop yield the following year.
	diacmba present as acid, as diethanolamine salt	foliar application- used in fall before pruning	4	A[P]	Typically tank mixed with 2,4-D ester to reduce cost and crop injury. When mixed with 2,4-D, some injury will occur. Only used in fall before pruning.
	glyphosate acid	spot treatments or wick wiping in sprout year	9	A	Applied only in vegetative year. Broad spectrum, non-selective product can cause crop loss if applicator is not cautious.
	hexazinone	soil application - in crop or sprout year	5	A	Some naturally tolerant species are becoming more prominent. Some perennials (ie. goldenrod) seem less susceptible than in the past.
	terbacil	soil application- non crop year	5	A	Can be used in place of hexazinone, but is weak on goldenrod.
	tribenuron methyl	foliar application- in sprout year	2	A	Controls several weeds that are not easily controlled with hexazinone. Narrow application window. Can be used as a spot spray. Provides some control of woody species.
Tufted vetch	clopyralid	spot application in non-bearing, prune year	4		

Pests or Group of Pests targeted	Active ingredient[1]	Type of Treatment[1]	Resistance group[2]	Stakeholder comments[3,4]	
				Performance[3]	Notes
Perennial grasses	hexazinone	soil application-in sprout and in crop year	5	A^P	Does not control late emerging grasses. There is concern about efficacy towards some perennials.
	propyzamide	soil application-late fall oe early spring application	3	A	Mainly used for sheep and narrow leaf fescue control. Is the only available product effective for fescue grasses tolerant of hexazinone. Warm temperatures can cause loss through volatilization, hence the application timings.
	terbacil	soil application in sprout year	5	A - A^P	Mainly used for perennials but provides some control of annual grasses; some concerns about efficacy.
Perennial species starting from seed	simazine plus related active triazines	broadcast treatment when blueberries are dormant	5		
Sedges and rushes	glyphosate acid	spot treatments and wick wiping	9	A	
	nicosulfuron; rimsulfuron	foliar application - in sprout year, small area treated	2; 2	A	
Black bulrush	nicosulfuron; rimsulfuron	Used in non-bearing year.	2;2		
Yellow nutsedge	bentazon	foliar	6		

Pests or Group of Pests targeted	Active ingredient[1]	Type of Treatment[1]	Resistance group[2]	Stakeholder comments[3,4]	
				Performance[3]	Notes
Woody plants	glyphosate acid	wick wiping-or spot treatments sprouting year	9	A	Care must be taken when applying product to avoid crop damage
	glyphosate acid	spot treatment, applied during non-crop year	9	A	Mainly for woody plant control although will only control weeds above blueberry canopy. Cost effective. Care must be taken when applying product in order to limit crop damage.
	hexazinone	soil	5	A	Broadspectrum herbicide that controls most weeds. Some natural tolerance noted.
	triclopyr butoxyethyl ester	foliar	4	A	Used for woody plant control for blueberry site preparation.
	triclopyr butoxyethyl ester	basal bark treatment - stump year	4	A	Used in developing fields only on woody stumps. Will kill blueberry plants if they come in contact with chemical. Generally used in fields that are more than two years from producing a crop.
	triclopyr butoxyethyl ester	foliar	4	A	Expensive but effective.
Black Barrenberry	ethephon	foliar	Unclassified		
Sheep laurel	diacmba present as acid, as diethanolamine salt	foliar, apply after blueberry leaf drop	4		

[1]List includes all active ingredients registered as March 6, 2008. Please consult product labels on the PMRA web site (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php) for further information on pesticide use.

[2]The resistance group is based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action. The document is under revision and up-to-date information can be found on the following web sites: Herbicides: www.plantprotection.org/HRAC/Bindex.cfm?doc=moa2002.htm ; Insecticides: www.irac-online.org/Crop_Protection/MoA.asp#area223 ; Fungicides: www.frac.info/frac/index.htm

[3]Based on user perceptions of performance of active ingredient for recommended uses; A – Adequate (green) (the pest control product (PCP), according to recommended use, maintains disease below economic threshold OR provides acceptable control), A^p – Provisionally Adequate (yellow) (the PCP, while having the ability to provide acceptable control, possesses qualities which may make it unsustainable for some or all uses), I – Inadequate (red) (the PCP, according to recommended use, does not maintain disease below economic threshold OR provides unacceptable control)

[4]Source(s) - "Canadian Expert Poll on Crop Protection" Focus Groups for New Brunswick, Nova Scotia and Quebec (2006).

Weeds

The majority of weeds in wild blueberry fields are species of the native flora that are promoted by the production methods used and include herbaceous annuals and perennials and woody plants. Weeds that prefer low pH soils and a similar habitat to that of blueberries thrive when not controlled.

Annual Broadleaf Weeds

Pest Information

Damage: Annual broadleaf weeds are an increasing problem. Lamb's quarters (*Chenopodium album*), pigweed (*Amaranthus* sp.) and hempnettle (*Galeopsis tetrahit*) are causing increasing problems. Competition for space and nutrients reduces blueberry plant vigour. These weeds can also cause harvesting challenges.

Life Cycle: These weeds are generally summer annuals and tend to germinate in late June. This delayed emergence allows them to escape most of the pre-emergent herbicides, especially in wet years. They are prolific seed producers and can spread quickly in a field.

Pest Management

Cultural Controls: Pruning by burning can have some effect on these weeds. Field and equipment sanitation are important to prevent seed spread. Weed pulling and cutting can prevent seed dispersal. Fertility management is critical, as these weeds require high amounts of nitrogen. Soil pH adjustment (decreasing soil pH) may help control these weeds.

Chemical Controls: The efficacy of pre-emergent herbicides is variable depending on weed pressure, weather conditions after application and soil conditions.

Issues for Annual Broadleaf Weeds

1. Annual broadleaf weeds, are becoming more of a problem in wild blueberry.
2. The impact of fertilization on the vigour of annual broadleaf weeds is not well understood.

Perennial Broadleaf and Woody Weeds

Pest Information

Damage: Perennial weeds represent the largest group of weeds in wild blueberry production system. Most are forest succession plants that grow naturally with wild blueberry. If allowed to grow, most of these weeds will out-compete the wild blueberry for space, reducing yields and ease of harvest of the crop.

Life Cycle: Perennial and woody weeds vary in their life cycle, but all plants can exist for more than two years if left unmanaged.

Pest Management

Cultural Controls: Cutting and pulling of weeds can help reduce the influence of these weeds. Fertility management is important.

Chemical Controls: There are several post-emergent herbicides and several pre-emergent herbicides that have an effect on many weeds in this group. Wick wiping with Round-Up is a common practice that helps to control many of these species.

Issues for Perennial Broadleaf and Woody Weeds

1. The perennial broadleaf weeds sheep sorrel (*Rumex acetosella*) (also grows as an annual) and goldenrod (*Solidago* spp.) are a major concern.
2. The development of a broader range of reduced risk broadleaf weed control products would allow for more precise herbicide applications and decrease the need for broad spectrum pre-emergent herbicides.
3. St. John's wort (*Hypericum perforatum*), spreading dogbane (*Apocynum androsaemifolium*) and spreading blackberry (*Rubus fruticosus)* are weed species that are particularly challenging to control.
4. The availability of reduced risk, broadleaf weed control products is limited.

Annual Grasses

Pest Information

Damage: Annual grasses can cause significant problems in wild blueberry production as a result of their fast growth and ability to compete for necessary resources. Crop losses in terms of growth and yield can be very high if annual grasses are not controlled. Annual grasses can often shade the crop causing poor bud formation in the sprout year and low harvesting efficiency in the crop year.

Life Cycle: Witch grass (*Panicum capillare*) is the main annual grass weed for this crop. This is a late germinating grass which emerges in late June or early July. Witch grass does not mature until early fall. At maturity it releases its' panicle, which can act like a tumble weed and spread seed.

Pest Management

Cultural Controls: Pruning by burning can have some effect. Harvester and mower sanitation between fields can help to reduce weed spread.

Chemical Controls: Post-emergent chemical controls are difficult to use in the cropping year as the days to harvest for the only graminicide is too short. Also, due to late emergence in the spring, the efficacy of pre-emergent herbicides that could have an effect on weeds tends to be reduced, especially in wet years.

Issues for Annual Grasses

1. Annual grasses are becoming more of a problem in wild blueberry.
2. There are insufficient post-emergent grass herbicides available. Fluazifop-p-butyl (Venture L) is the only post emergent grass herbicide available and there are some concerns about its efficacy. Due to its long pre-harvest interval of 60 days, it is difficult

to control late emerging grasses with this herbicide. The registration of reduced risk products with shorter PHI's, would be of benefit.

Perennial Grasses

Pest Information

Damage: Grasses compete with blueberry plants for resources and space. They can also cause harvesting difficulties in the cropping year.

Life Cycle: Perennial grasses are common in most blueberry fields. Most of these grasses can act as annuals but will re-grow from their root systems. Poverty oat grass (*Danthonia spicata*), fescues, (*Festuca* spp.), rough hair grass and bluegrasses (*Poa* spp.) are the main species. Not all species emerge at the same time and more than one species may be present in a field. This is critical to know when applying a post-emergent grass herbicide.

Pest Management

Cultural Controls: Pruning by burning can have some effect on perennial grasses. Field and equipment sanitation are important to prevent seed spread. Fertility management is important to minimize grass expansion.

Chemical Controls: There is only one post-emergent herbicide but there are several pre-emergent herbicides available that have varying efficacy on different grass species. Fescues are tolerant of post-emergent grass herbicides and several species appear to be developing tolerances to pre-emergent herbicides.

Issues for Perennial Grasses

1. Perennial grasses are becoming an increasing problem. The registration of additional reduced risk products would allow for product rotation and reduce the chances of resistance development.

Vertebrate Pests

Birds

Several species of birds feed on ripening fruit and can significantly reduce crop yield before harvest. The most important birds include seagulls, crows, robins and blackbirds.
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 laying 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.

Issues for Bear

1) Bear populations are on the rise in eastern Canada. Repellent border sprays are required to discourage bears from attacking bee hives and damaging ripe fields.

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 Wild blueberry in Canada

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Wild Blueberry Factsheets, General Production www.nsac.ns.ca/wildblue/facts/

Wild Blueberry Insect and Disease Management Schedule (2006) (AgraPoint International)
www.extensioncentral.com/index.php?option=com_docman&task=cat_view&gid=95&Itemid=32

Wild Blueberry Research Centre
www.nsac.ns.ca/envsci/research/blueberry/centre/

Wild Blueberry Network Information Centre www.nsac.ns.ca/wildblue.

Provincial Wild Blueberry Crop Specialists and Provincial Minor Use Coordinators

Province	Ministry	Fruit or Berry Specialist	Minor Use Coordinator
Ontario	Ontario Ministry of Agriculture and Food	Pam Fisher (pam.fisher@ontario.ca)	Jim Chaput (jim.chaput@ontario.ca)
Quebec	Ministére d'Agriculture, Pêcheries et Alimentation du Québec	Luc Urbain (Luc.urbain@mapaq.gouv.qc.ca); Joseph Savard (Joseph.savard@mapaq.gouv.qc.ca)	Marie Garon (marie.garon@mapaq.gouv.qc.ca)
New Brunswick	New Brunswick Department of Agriculture and Aquaculture	Michel Melanson (michel.melanson@gnb.ca)	Kelvin Lynch (kelvin.lynch@gnb.ca)
Nova Scotia	Nova Scotia Department of Agriculture and Fisheries	Peter Burgess (p.burgess@agrapoint.ca)	Lorne Crozier (crozielm@gov.ns.ca)
Prince Edward Island	Prince Edward Island Department of Agriculture, Fisheries and Aquaculture	Chris Jordan (cwjordan@gov.pe.ca)	Brian Beaton (bwbeaton@gov.pe.ca)
Newfoundland and Labrador	Resources, Government of Newfoundland and Labrador	Jane White (janewhite@gov.nl.ca)	Ruth-Anne Blanchard (ruthanneblanchard@gov.nl.ca)

National and Provincial Wild 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 Inc

Wild Blueberry Research Centre
www.nsac.ns.ca/envsci/research/blueberry/centre/

Research contacts for wild blueberry in Canada

Name	Organization	Pest type	Specific pests	Type of research
Guy Boivin	Agriculture and Agri-Food Canada, (AAFC) St-Jean-sur-Richelieu (Québec)	Insects	blueberry fruit fly	Population ecology and pest management
G. Brewster	Nova Scotia Agricultural College (NSAC), NS	-	Agronomy	Integrated crop management / soil
P. Burgess	AgraPoint International			Pest management
N. Crowe	NSAC	-	Agronomy	Food processing / storage,
C. Cutler	NSAC		insects	
Eve-Catherine Desjardins	Centre de Recherche Les Buissons (Québec)	Insects	pollinators	Integrated crop management/ pollination biology
L. Eaton	NSAC	-	Agronomy	Integrated crop management / mineral nutrition
P. Hildebrand	AAFC Kentville, NS	Diseases	Monilinia and Botrytis foliar blights	Integrated disease management

Name	Organization	Pest type	Specific pests	Type of research
J. Kemp	University of Prince Edward Island, PEI	-	Agronomy	Integrated crop management / floral, fruit and pollination biology
P. Kevan	University of Guelph, ON	-	Agronomy	Pollination biology
Jean Lafond	AAFC Sainte-Foy (Québec		Agronomie	Integrated crop management/ fertilization and soils
K. MacKenzie	AAFC, (Kentville, NS)		insects	
D. Murr	University of Guelph, ON	-	Abiotic disorders	Integrated crop management / post-harvest physiology
R. Olson	NSAC	-	Agronomy	Integrated crop management / floral biology
G. Patterson	AAFC Charlottetown, PEI	-	Agronomy	Integrated crop management / yield monitoring tools
D. Percival	NSAC		Diseases	
J. P. Privé	AAFC Bouctouche, NB	-	Agronomy	Integrated crop management
J. Proctor	University of Guelph, ON	-	Agronomy	Integrated crop management / physiology
G. Sampson	NSAC	Weeds	All	Integrated weed management / biological control
K. Sanderson	AAFC Charlottetown, PEI	-	Physiological disorders	Integrated crop management / nutrition
G. Stratton	NSAC	-	Agronomy	Integrated crop management / nutrition
F. Tardiff	University of Guelph, ON	Weeds	All	Integrated weed management / herbicide resistance
J. Traquair	AAFC London, ON	Diseases	Monilinia and Botrytis foliar blights	Integrated disease management
R. Olson	NSAC	-	Agronomy	Integrated crop management / floral biology

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www.wildblueberries.com/health_benefits/
Accessed on May 21, 2007

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

Wild Blueberry Research Centre
www.nsac.ns.ca/envsci/research/blueberry/centre/

Wild Blueberry Network Information Centre
www.nsac.ns.ca/wildblue