Agriculture and Agri-Food Canada Agriculture et Agroalimentaire Canada

Crop Profile for Grape in Canada, 2013

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Preface

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

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

For detailed information on growing grape, the reader is referred to provincial crop production guides and provincial ministry websites listed in the Resources Section at the end of the profile.

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

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The genus *Vitis* belongs to the botanical family *Vitaceae* (grape family), which is composed of 11 genera and 600 species. *Vitis* is the only food-bearing genus in the family. Bunch grapes (*Vitis lubrusca),* originated in North America and make up most of the fresh market varieties. *Vitis riparia* has been crossed to produce hardy rootstock resistant to cold and to the insect phylloxera. *Vitis vinifera* is used in the making of wine and is often referred to as the "Old World" or "European grape". This species originated in the region south of the Caspian Sea in Asia Minor, from where it has been widely disseminated. Grapes are commercially grown between 20° and 51° north latitude and 20° and 40° south latitude.

Early European settlers in North America initially used the native grape species *Vitis labrusca* and *V. riparia* for the making of wine. However the end result was wine of an inferior quality to the European wines made at the time. Early attempts to establish *V. vinifera* grapes were not successful due to the lack of winter hardiness of the European varieties.

The first commercial wineries and vineyards were established in the mid 1800's in Ontario and British Columbia and included plantings of native and *V. vinifera* varieties. However, the lack of winter hardiness continued to be a problem with the *V. vinifera* grapes. Improvements in varieties and viticulture practices, as well as a shift in consumer demand for dry table wines, led to an expansion of the grape and wine industry in the 1980's. In the late 1980's, a federal replant program accelerated the move to *V. vinifera* varieties.

In Quebec, the first commercial orchards were established in the 1980's. However, despite improved production practices and improved varieties, the production area remains low.

Grapes (*Vitis* spp.) are long-lived woody perennial vines, the fruit of which grows in bunches or clusters on the vine and which can be green, red, pink or purple. Grapes, known to be a good source of vitamin C, are eaten fresh, dried into raisins, preserved as jelly and are used for wine and juice. Grapes grown in Canada are primarily used for the making of wine, juice and for sale on the fresh market. Grapes destined for use in wines are judged based on their level of brix (sugar), titratable acids and anthocyanin content.

Crop Production

Industry Overview

Table 1. General production information

Canadian Production (2014)[1]	80, 561 metric tonnes (total)	76,362 metric tonnes (vinifera (wine) grapes)	4,199 metric tonnes (labrusca (table) grapes)
	12, 683 hectares (total)	12,180 hectares (vinifera (wine) grapes)	503 hectares (labrusca (table) grapes)
Farm gate value (2014)[1]	$116 million (total)	$111 million (vinifera (wine) grapes)	$4.9 million (labrusca (table) grapes)
Fresh fruit available in Canada 2014[2]	4.46 kg/ person		
Grape juice available in Canada 2014[2]	2.38 litres/ person		
Wines, population 15 years old and older[2]	15.48 litres/ person		
Exports (2014)[3]	grapes (fresh) 1,77 0 tonnes		
	grape juice 3,450 tonnes		
	wines 63.85 kilolitres		
Imports (2014)[3]	173,440 tonnes (grapes fresh)		
	grape juice 91,060 tonnes		
	wines 384.91 kilolitres		

[1]Statistics Canada. Table 001-0009 - Area, production and farm gate value of fresh and processed fruits, by province, annual CANSIM (database) (accessed 2016-01-29).
[2]Statistics Canada. Table 002-0011 - Food available in Canada CANSIM (database) (accessed 2015-01-29).
[3]Statistics Canada. Table 002-0010 - Supply and disposition of food in Canada CANSIM (database) (accessed 2016-01-29).

Production Regions

Grapes are produced in Ontario (7,596 ha or 60% of national acreage), British Columbia (4,122 ha or 33% of the national acreage), Quebec (575 ha or 5% of the national acreage) and Nova Scotia (356 ha or 3% of the national acreage) (refer *Table 2. Distribution of grape production in Canada*). There is interest in the development of a commercial industry in New Brunswick and Prince Edward Island, but the climate may not be suitable in these areas.

In Ontario, the majority of production occurs within the Niagara Peninsula along the southern shore of Lake Ontario. The remainder is mostly along the northern shore of Lake Erie and in Prince Edward County on the north-east shore of Lake Ontario. In British Columbia, the majority of the production occurs within the southern interior, with the Coastal Areas producing the balance of the commercial grapes in BC.

Table 2. Distribution of grape production in Canada[1]

Production Regions	Total Grapes cultivated area (hectares) (percent national area)	Grapes labrusca (table) cultivated area (hectares) (percent national area)	Grapes, vinifera (wine) cultivated area (hectares) (percent national area)
British Columbia	4,122 (33%)	x	x
Alberta	0	0	0
Saskatchewan	x	0	x
Manitoba	0	0	0
Ontario	7,596 (60%)	433 (86%)	7162 (58%)
Quebec	575 (5%)	x	x
New Brunswick	F	0	F
Nova Scotia	356 (3%)	0	356
Prince Edward Island	x	0	x
Newfoundland and Labrador	0	0	0
Canada	12683 (100%)	503 (100%)	12,180

[1]Statistics Canada. Table 001-0009 - Area, production and farm gate value of fresh and processed fruits, by province, annual CANSIM (database) (accessed 2016-01-29).

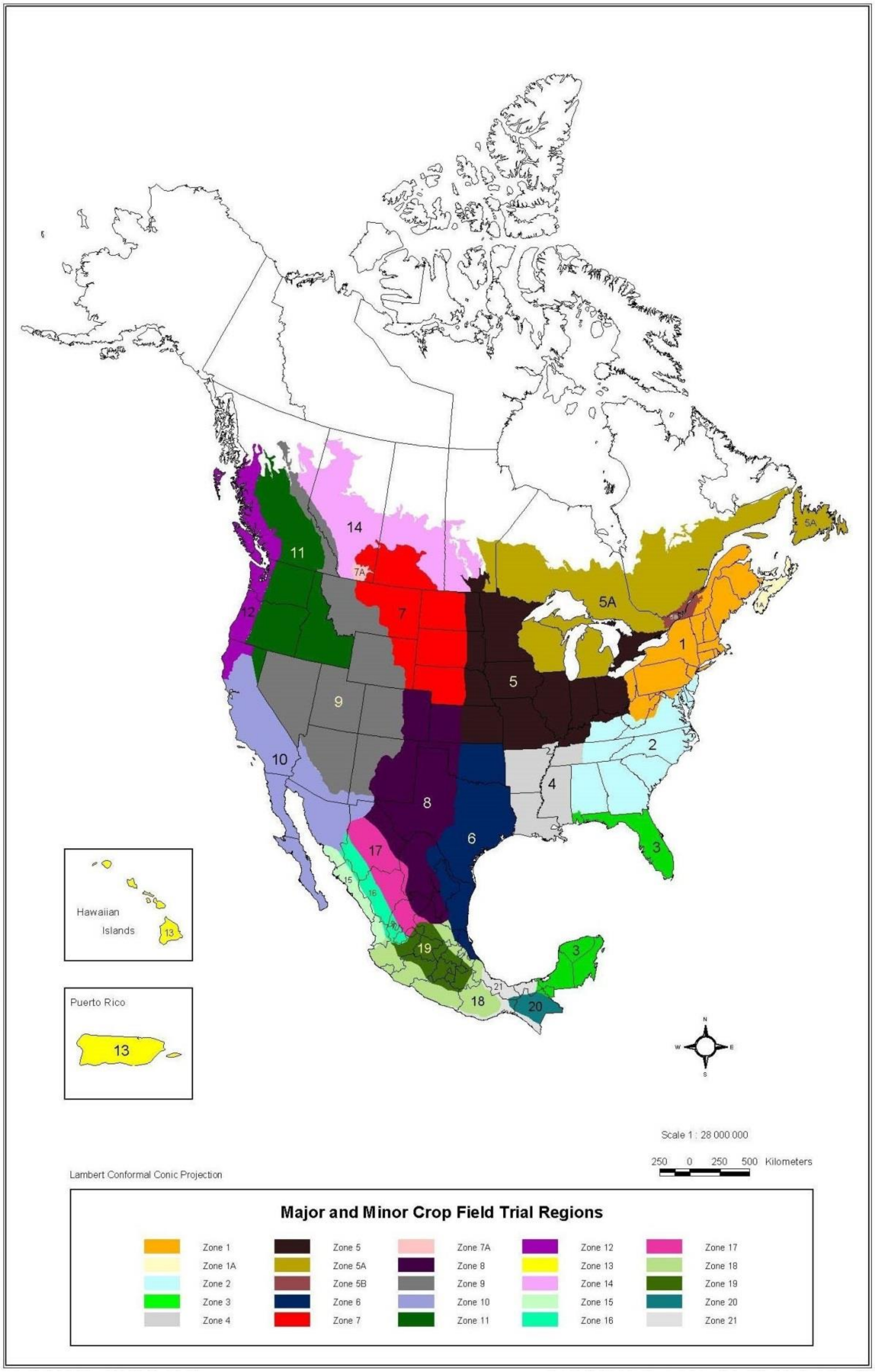
x - Suppressed to meet the confidentiality requirements of the Statistics Act.

F - Too unreliable to be published.

North American Major and Minor Field Trial Regions

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

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



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

Cultural Practices

There are significant production differences in terms of pruning, training, fertilization and irrigation for fresh market and processing grapes. The focus of this profile will be on grapes used for the production of wine and juice, since more than 95% of the grapes produced in Canada are for this purpose.

The planting site for grapes requires careful consideration, as a minor difference in geography may represent a major difference in the local climate and can significantly affect the viability of the vineyard. An ideal site has a slope of 3 to 4%, rows running north-south and full southern exposure. West-facing slopes are more suitable than east- and north-facing slopes, as they receive higher solar radiation. In some areas, south-facing slopes may be too warm for some grape varieties, making variety selection and site selection inter-dependant.

Grapes are grown on a variety of soil types, such as course textured sands, fine gravels and imperfectly drained clay soils, but grow best on well drained soils. Tile drainage may be used to improve productivity and winter hardiness.

Areas with extreme winter cold (temperatures below -24°C for *V. vinifera* grapes and below -30°C for more hardy species) are generally avoided. Snow cover, which serves as a very good insulator, is an important consideration in vineyard establishment in many regions in Quebec. Winter protection systems, such as burying the vines with earth to a depth of 30 cm or positioning the vines along the ground and covering each row with a geotextile, may be used to facilitate the growing of grape varieties outside their hardiness zones.

Grapes require a minimum of 140 to 165 days of consecutive frost free conditions, with sunshine exceeding 1,250 hours during the growing season. Low areas and frost pockets are not suitable for production. The risk of damage from spring frosts can be mitigated by the selection of planting site, the use of overhead sprinklers or the mechanical movement or heating of air. Hail is another climatic risk present in most regions, however few practical means are available to protect against this risk.

Certified virus-free nursery stock should be used when establishing a new vineyard. Soil moisture can be preserved by the use of thick hay mulch. Black plastic mulches can also be used and have the advantage of increasing soil temperature and helping to control weeds.

Grapevines require three years before they produce a crop and do not produce a full crop until the fourth or fifth year. The grape production season, from bloom to harvest, lasts between 70 and 180 days, depending on the variety. Vines are trained into a shape that allows for easy management and care. Canes are spread along a trellis to allow for movement of equipment throughout the vineyard and to facilitate management activities, flow of air and exposure of vines to light. Pruning is used to develop and maintain the shape and vigour of a grape vine, to select buds that are needed to produce fruitful shoots and a balanced yield and to regulate the number of potential shoots. Commercial grape varieties are self-pollinated, but wind and insect activity on blossoms does help to increase fruit set and yield. Pollen grains are very sensitive to pesticides and moisture, with reduced fruit set occurring if flowers are exposed to pesticides, extreme temperatures over 30°C or water.

Grapes grow best when springs are mild and dry, followed by long, warm, dry summers. The amount of water needed by a vineyard varies depending on the weather, soil type, age, type of grape and harvest date. Irrigation systems can be used to alleviate problems due to insufficient moisture. Irrigation is important in British Columbia and is being given more consideration in Ontario, Quebec and Nova Scotia.

Table 3. Grape production and pest management schedule in Canada

Time of Year	Activity	Action
November to March (plants are dormant)	Plant care	Prune and tie vines. Check vines for winter damage.
	Insect and mite control	Monitor overwintering European red mite populations.
April (woody bud stage)	Plant care	Finish tying vines. Prune vines (Quebec).
	Soil Care	Plough under fall planted green manure crop.
	Disease control	Prepare sprayer for early season fungicide applications for phomopsis or anthracnose; spray as needed.
April (bud burst)	Plant care	Irrigate as needed. Remove winter protection, if used.
	Soil care	Plant new green manure crop.
	Disease control	Apply first fungicide spray if needed.
	Weed control	Apply early systemic and pre-emergent herbicides if needed.
May (bud growth)	Plant care	Finish pruning (Quebec).
	Soil care	Apply fertilizers to the soil as needed.
	Disease control	Apply control for early powdery mildew and other diseases.
	Insect and mite control	Apply mating disruption products for grape berry moth; monitor for grape flea beetles.
	Weed control	Apply weed controls if needed.
June (shoot growth)	Soil care	Apply first split application of nitrogen.
	Plant care	Thin clusters, especially of French hybrid wine grapes. Apply foliar nutrients as needed according to leaf analysis.
	Disease control	Survey for diseases and apply preventative or curative fungicide treatments as needed according to weather conditions.
	Insect and mite control	Begin monitoring for leafhoppers and spring feeding caterpillars. Apply controls if needed.
	Weed control	Apply controls if needed or work soil mechanically.
mid-June (pre-bloom, less than 5% cap fall)	Plant care	Irrigate as needed if dry, hot spring; position shoots.
	Disease control	Apply controls for black rot, powdery mildew, downy mildew and bunch rot if wet during bloom.
	Insect control	Continue monitoring for leafhoppers, phylloxera and first generation grape berry moth; apply controls if needed.

….continued

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

Time of Year	Activity	Action
late June (80% cap fall, berry set)	Soil care	Apply second split application of nitrogen fertilizer.
	Plant care	Shoot positioning.
	Disease control	Apply controls for black rot, powdery mildew, etc.
	Insect and mite control	Monitor for leafhopper species.
	Weed control	Rarely required at this time.
July (berry set and pea size growth)	Plant care	Irrigate as needed.
	Disease control	Apply controls for bunch rot, powdery mildew, black rot, etc.
	Insect and mite control	Monitor for leafhoppers and apply controls if needed; conventional insecticides timed for egg hatch of grape berry moth.
July (pre-bunch closure)	Plant care	Final shoot positioning and early hedging if growth is vigorous. Remove leaves in fruit-bearing area of the vine.
	Disease control	Apply controls for bunch rot and powdery mildew if needed.
late July (post-bunch closure)	Plant care	Further hedging if needed; further leaf removal around bunches.
	Soil care	Plant green manure crop.
	Disease control	Apply control for powdery mildew if needed to protect leaves.
Mid-August (change of berry colour)	Plant care	Estimate yield; reduce yield by removing a number of clusters per vine.
	Disease control	Apply controls for bunch rot and powdery mildew if needed.
Mid-August to September / October (veraison to harvest)	Plant care	Monitor sugar, acid and pH development; harvest fruit.
	Disease control	Apply controls for bunch rot and powdery mildew if needed.
	Insect and mite control	Monitoring and implementation of controls of spotted wing drosophila, if needed.
September to November (post-harvest)	Plant care	Visually inspect vineyard wood quality. Irrigate as needed.
	Soil care	Take soil samples.
	Disease control	Apply control for powdery mildew; copper sprays if needed.
	Weed control	Mowing of green manure crop to combat weeds and discourage rodents from wintering in vineyard.
November	Plant care	Install winter protection if used.
December to February	Ice wine harvest	Hand and machine picking when temperatures reach 10°C.

Abiotic Factors Limiting Production

Millerandage

Adverse weather conditions during flowering can result in poor pollination of grape flowers, resulting in millerandage, a condition characterized by the uneven development and maturation of berries within a fruit cluster. With some varieties, this can result in “green flavours” in the wine.

Water Limitations and Excesses

Optimizing moisture levels is important during vineyard establishment and throughout the life of the crop. Excess moisture can suffocate roots leading to poor vine performance, poor fruit and poor brix and can contribute to decreased winter hardiness. Hotter and drier summers and insufficient irrigation can result in poor fruit quality at harvest (low brix and low acids) as well as poor winter hardiness.

Diseases

Key issues

Integrated Pest Management (IPM)

- There is significant concern over the development of resistance to available fungicides within pathogen populations, particularly in the case of powdery mildew, botrytis, and downy mildew. There is a need to provide growers with information on resistance management to prolong the efficacy of fungicides with single modes of action. In addition, a national program to monitor resistance development in botrytis populations would be of benefit to ensure that vulnerable regions take all possible steps to avoid insurmountable levels of pathogen resistance.
- There is a need to develop predictive models, or adapt and validate existing models for regional climates and situations, to optimize timing of fungicide sprays for the management of black rot, botrytis bunch rot, downy mildew, phomopsis cane and leaf spot and powdery mildew.
- There is a need for the development and implementation of integrated disease management strategies in general.
- It is important that grape growers have access to nursery stock that is clean and free from viruses, the crown gall pathogen, and phytoplasma disease pathogens.

Emerging Issues

- There is a need for improved understanding of sour rot, an increasing problem on early ripening hybrid and thin skinned vinifera cultivars, including understanding of the importance of drosophila as a vector of the disease. The impact of this disease on wine quality needs to be established.

New disease management products and application technologies

- There is concern that some multi-site of action materials may no longer be available for use in management of black rot, downy mildew, phomopsis cane and leaf spot and botrytis bunch rot due to regulatory re-evaluation. There is a need for the registration of new products with new modes and / or multiple modes of action to continue to combat resistance development in black rot, botrytis bunch rot and powdery mildew pathogen populations.
- There is a need for the evaluation and registration of biopesticides, non-conventional and other pest control products suitable for use in organic production systems for management of powdery mildew, downy mildew and botrytis.
- Given the lack of products available for management of bacterial diseases, there is a need to investigate the use of antagonistic bacteria and mycorrhizae for crown gall.

Table 4. Occurrence of diseases in grape production in Canada

Disease	British Columbia	Ontario	Quebec	Nova Scotia
Angular leaf scorch				
Anthracnose				
Black rot				
Botrytis bunch rot				
Downy mildew				
Phomopsis cane and leaf spot				
Powdery mildew				
Crown gall				
Sour rot (yeast and bacteria)				
Grapevine Leafroll-Associated Virus				
Nematodes				

Widespread yearly occurrence with high pest pressure.

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

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

Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.

Pest is present and of concern, however little is known of its distribution, frequency and importance.

Pest not present.

Data not reported.

[1]Source: Grape stakeholders in reporting provinces.

[2]Please refer to Appendix 1, for a detailed explanation of colour coding of occurrence data.

Table 5. Adoption of disease management practices in grape production in Canada[1]

Practice / Pest		Botrytis bunch rot	Downy mildew	Phomopsis leaf and cane spot	Powdery mildew	Virus diseases
Avoidance	resistant varieties					
	planting / harvest date adjustment					
	crop rotation					
	choice of planting site					
	optimizing fertilization					
	reducing mechanical damage or insect damage					
	thinning / pruning					
	use of disease-free seed, transplants					
Prevention	equipment sanitation					
	mowing / mulching / flaming					
	modification of plant density (row or plant spacing; seeding rate)					
	seeding / planting depth					
	water / irrigation management					
	end of season crop residue removal / management					
	pruning out / removal of infected material before harvest					
	tillage / cultivation					
	removal of other hosts (weeds / volunteers / wild plants)					
Monitoring	scouting - trapping					
	records to track diseases					
	soil analysis					
	weather monitoring for disease forecasting					
	use of portable electronic devices in the field to access pest identification /management information					
	use of precision agriculture technology (GPS, GIS) for data collection and field mapping of pests					

…continued

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

Practice / Pest		Botrytis bunch rot	Downy mildew	Phomopsis leaf and cane spot	Powdery mildew	Virus diseases
Decision-making tools	economic threshold	[green]	[green]	[green]	[green]	
	weather / weather-based forecast / predictive model	[red]	[green]	[red]	[red]	
	recommendation from crop specialist	[green]	[green]	[green]	[green]	[green]
	first appearance of pest or pest life stage	[green]	[green]	[green]	[green]	[green]
	observed crop damage	[green]	[green]	[green]	[green]	[green]
	crop stage	[green]	[green]	[green]	[green]	
Suppression	pesticide rotation for resistance management	[green]	[green]	[green]	[green]	
	soil amendments	[red]			[green]	
	biological pesticides	[green]			[green]	
	controlled atmosphere storage					
	targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)	[green]	[red]	[red]	[red]	
New practices (by province)	canopy management (Ontario)	[green]	[green]		[green]	

This practice is used to manage this pest by at least some growers. [green]
This practice is not used by growers to manage this pest. [red]
This practice is not applicable for the management of this pest. [white]
Information regarding the practice for this pest is unknown. [grey]

[1]**Source: Stakeholders in grape producing provinces (British Columbia and Ontario).**

Table 6. Fungicides and biofungicides registered for disease management in grape in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
Agrobacterium radiobacter	biological	unknown	unknown	N/A	R	crown gall
Aureobasidium pullulans DSM 14940 and DSM 14941	biological	unknown	unknown	N/A	R	grey mould (suppression)
Bacillus subtilis strain QST 713	microbial: *Bacillus* spp. and the fungicidal lipopeptides they produce	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	44	R	sour rot (complex of pathogens), grey mould, powdery mildew
Bacillus amyloliquefaciens strain D747	microbial: *Bacillus* spp. and the fungicidal lipopeptides they produce	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	44	R	powdery mildew (suppression), grey mould (suppression)
Streptomyces lydicus strain WYEC 108	biological	unknown	unknown	N/A	R	powdery mildew (suppression)
ametoctradin	triazolo-pyrimidylamine	C8: respiration	complex III: cytochrome bc1 (ubiquinone reductase) at Qo site, stigmatellin binding sub-site	45	R	downy mildew

…continued

Table 6. Fungicides and biofungicides registered for disease management in grape in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
ametoctradin + dimethomorph	triazolo-pyrimidylamine + cinnamic acid amide	C8: respiration + H5: cell wall biosynthesis	complex III: cytochrome bc1 (ubiquinone reductase) at Qo site, stigmatellin binding sub-site + cellulose synthase	45 + 40	R + RE	downy mildew
benzovindiflupyr	pyrazole-4-carboxamide	C2: respiration	complex II: succinate dehydrogenase	7	R	powdery mildew
benzovindiflupyr + difenoconazole	pyrazole-4-carboxamide + triazole	C2: respiration + G1: sterol biosynthesis in membranes	complex II: succinate dehydrogenase + C14-demethylase in sterol biosynthesis (erg11/cyp51)	7 + 3	R +RE	powdery mildew
BLAD polypeptide	polypeptide (lectin)	multi-site contact activity	multi-site contact activity	M12	R	botrytis bunch rot, gray mould, powdery mildew (suppression)
boscalid	pyridine-carboxamide	C2: respiration	complex II: succinate-dehydrogenase	7	R	powdery mildew
boscalid + pyraclostrobin	pyridine-carboxamide + methoxy-carbamate	C2: respiration + C3: respiration	complex II: succinate-dehydrogenase + complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	7 + 11	R + R	powdery mildew, bunch rot complex, grey mould (suppression), downy mildew (foliar), black rot (fruit), anthracnose (foliar)

…continued

Table 6. Fungicides and biofungicides registered for disease management in grape in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
captan	phthalimide	multi-site contact activity	multi-site contact activity	M4	RE	dead arm (current season's infection), downy mildew, black rot
citric acid + lactic acid	not classified	unknown	unknown	N/A	R	downy mildew
copper hydroxide (different salts)	inorganic	multi-site contact activity	multi-site contact activity	M1	R	downy mildew
copper octanoate	inorganic	multi-site contact activity	multi-site contact activity	M1	R	downy mildew, powdery mildew
copper (present as copper oxychloride)	inorganic	multi-site contact activity	multi-site contact activity	M1	R	downy mildew, powdery mildew
copper sulfate	inorganic	multi-site contact activity	multi-site contact activity	M1	R	dead arm, black rot, downy mildew
cyprodinil	anilino-pyrimidine	D1: amino acids and protein synthesis	methionine biosynthesis (proposed) (cgs gene)	9	RE	botrytis bunch rot

…continued

Table 6. Fungicides and biofungicides registered for disease management in grape in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
cyprodinil + fludioxonil	anilino-pyrimidine + phenylpyrrole	D1: amino acids and protein synthesis + E2: signal transduction	methionine biosynthesis (proposed) (cgs gene) + MAP/histidine-kinase in osmotic signal transduction (os-2, HoG1)	9 + 12	RE + RE	botrytis bunch rot
difenoconazole (except Concord and some non-vinifera hybrids)	triazole	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	3	RES	powdery mildew
dimethomorph	cinnamic acid amide	H5: cell wall biosynthesis	cellulose synthase	40	RE	downy mildew
fenhexamid	hydroxyanilide	G3: sterol biosynthsis in membranes	3-keto reductase, C4-demethylation (erg27)	17	RE	botrytis bunch rot
ferbam	dithiocarbamate and relatives	multi-site contact activity	multi-site contact activity	M3	RE	black rot
fluopicolide	pyridinylmethyl-benzamide	B5: cytoskeleton and motor proteins	B5: delocalisation of spectrin-like proteins	43	R	downy mildew

…continued

Table 6. Fungicides and biofungicides registered for disease management in grape in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
fluopyram (on wine grapes, select varieties)	pyridinyl-ethyl-benzamide	C2: respiration	complex II: succinate-dehydro-genase	7	R	botrytis bunch rot, grey mould
fluopyram + pyrimethanil (on wine grapes, select varieties)	pyridinyl-ethyl-benzamide + anilino-pyrimidine	C2: respiration + D1: amino acid and protein synthesis	complex II: succinate-dehydrogenase + methionine biosynthesis (proposed) (cgs gene)	7 + 9	R + R	botrytis bunch rot, powdery mildew
flutriafol	triazole	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	3	R	powdery mildew
fluxapyroxad	pyrazole-4-carboxamide	C2: respiration	complex II: succinate-dehydro-genase	7	R	powdery mildew, grey mould (suppression)
folpet	phthalimide	multi-site contact activity	multi-site contact activity	M4	RE	dead arm, black rot, downy mildew, powdery mildew
fosetyl-Al	ethyl phosphonate	unknown	unknown	33	RE	downy mildew
garlic powder	biological	unknown	unknown	N/A	R	powdery mildew (suppression)

…continued

Table 6. Fungicides and biofungicides registered for disease management in grape in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
iprodione	dicarboximide	E3: signal transduction	MAP/ histidine-kinase in osmotic signal transduction (os-1, Daf1)	2	RE	botrytis bunch rot
kresoxim-methyl	oximino-acetate	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	RE	powdery mildew, downy mildew, black rot
lime sulphur (calcium polysulphide)	inorganic	multi-site contact activity	multi-site contact activity	M2	R	powdery mildew
mancozeb	dithiocarbamate and relatives	multi-site contact activity	multi-site contact activity	M3	RE	downy mildew, black rot
mancozeb + metalaxyl-m	dithiocarbamate and relatives + acylalanine	multi-site contact activity + A1: nucleic acid synthesis	multi-site contact activity + RNA polymerase I	M3 + 4	RE + R	downy mildew
mancozeb + zoxamide	dithiocarbamate and relatives + toluamide	multi-site contact activity + B3: cytoskeleton and motor proteins	multi-site contact activity + ß-tubulin assembly in mitosis	M + 22	RE + R	downy mildew

…continued

Table 6. Fungicides and biofungicides registered for disease management in grape in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
mandipropamid	mandelic acid amide	H5: cell wall biosynthesis	cellulose synthase	40	R	downy mildew
metiram	dithio-carbamate and relatives	multi-site contact activity	multi-site contact activity	M3	RE	downy mildew, black rot
methyl bromide (fumigant, pre-plant soil application)	alky halide[4]	miscellaneous non-specific (multi-site) inhibitor[4]	miscellaneous non-specific (multi-site) inhibitor[4]	8A[4]	PO	damping-off organisms (fusarium, pythium and rhizoctonia), insects, nematodes, weed seeds
metrafenone	benzophenone	unknown	actin disruption (proposed)	U8	R	powdery mildew
myclobutanil	triazole	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	3	R	powdery mildew, black rot
phosphites (mono and dibasic sodium, potassium and ammonium phosphite)	not classified	unknown	unknown	N/A	R	downy mildew

…continued

Table 6. Fungicides and biofungicides registered for disease management in grape in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
phosphorous acid (mono and di-potassium salts of phosphorous acid	phosphonate	unknown	unknown	33	R	downy mildew
potassium bicarbonate	not classified	diverse	unknown	N/A	R	powdery mildew
pyrimethanil	anilino-pyrimidine	D1: amino acids and protein synthesis	methionine biosynthesis (proposed) (cgs gene)	9	R	botrytis bunch rot
quinoxyfen	aryloxyquinoline	E1: signal transduction	signal transduction (mechanism unknown)	13	R	powdery mildew
Reynoutria sachalinensis (extract)	complex mixture, ethanol extract	P5: host plant defence induction	P5	P5	R	powdery mildew (suppression)
spiroxamine (wine grapes)	spiroketal-amine	G2: sterol biosynthesis in membranes	reductase and isomerase in sterol biosynthesis (erg24, erg2)	5	R	powdery mildew
sulphur	inorganic	multi-site contact activity	multi-site contact activity	M2	R	powdery mildew

…continued

Table 6. Fungicides and biofungicides registered for disease management in grape in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Target Site[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
tea tree oil) *(Melaleuca alternifolia)*	terpene hydrocarbon and terpene alcohos	F7: lipid synthesis and membrane integrity	cell membrane disruption (proposed)	46	R	powdery mildew, downy mildew (suppression)
tetraconazole	triazole	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	3	R	powdery mildew, black rot
trifloxystrobin (do not apply to Concord grapes)	oximino-acetate	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	11	R	powdery mildew, black rot

[1]Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of February 29, 2016. The product label is the final authority on pesticide use and should be consulted for application information. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

[2]Source: Fungicide Resistance Action Committee. *FRAC Code List 2015: Fungicides sorted by mode of action (including FRAC code numbering)* (www.frac.info/) (accessed February 8, 2016).

[3]PMRA re-evaluation status: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review, as published in PMRA *Re-evaluation Note REV2016-07, Pest Managment Regulatory Agency Re-evaluation and Special Review Workplan 2015-2020*, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA as published in PMRA *Re-evaluation Decision document RRD2004-01, Re-evaluation of Methyl Bromide*.

[4]Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (Version 8.0; december 2015)* (www.irac-online.org) (accessed February 15, 2016).

Angular leaf scorch (*Pseudopezicula tetraspora*)

Pest Information

Damage: Early symptoms of angular leaf scorch are light yellow spots on the leaves. The spots become reddish-brown and develop yellow or reddish margins as they mature and are delimited by leaf veins. Severe infections result in leaf death and drop. Infections may develop on fruit stems resulting in shrivelling of fruit.

Life Cycle: During wet weather in the spring, spore producing bodies (apothecia) are produced in the fallen leaves remaining from the previous season. The apothecia release spores which infect new leaves. Leaf symptoms become apparent three to four weeks after infection. There is usually only one infection cycle in the spring.

Pest Management

Cultural Controls: The destruction of overwintered leaf litter prior to bud break and the removal of susceptible wild species near the vineyard, will reduce the potential for disease development in the spring. Pruning to improve air circulation in the vineyard and facilitate drying of the foliage will help to prevent infections.

Resistant cultivars: Susceptibility to disease varies greatly among cultivars.

Chemical Controls: Refer to *Table 6. Fungicides and biofungicides registered for disease management in grape in Canada* for fungicides registered for the management of angular leaf scorch.

Issues for Angular Leaf Scorch

1. There are no fungicides currently registered for angular leaf scorch, although mancozeb, applied to manage other diseases has some effect. There is a need to register effective products for both organic and conventional production systems, as mancozeb is under review.

Anthracnose (*Elsinoe ampelina*)

Pest Information

Damage: Anthracnose causes circular spots on leaves, petioles, fruit stems, young shoots and berries of grape. Young leaves may become deformed if infection occurs before they are fully expanded. Lesions on fruit can cause fruit cracking. Anthracnose reduces fruit quality, vigour of the vines and yield.

Life Cycle: The fungus overwinters in infected shoots as resting bodies called sclerotia. Sclerotia germinate in the spring to produce conidia which cause new infections when they are spread by splashing rain to new tissues. Asexual spore producing structures called acervuli develop in infected tissues and give rise to conidia which serve to further spread the disease.

Pest Management

Cultural Controls: The removal of affected plant tissues while the canes are dormant and the removal of wild grapes in the vicinity of the vineyard will reduce sources of infection. Pruning to open the canopy and facilitate drying of the canopy will result in conditions less favourable for disease development.

Resistant Cultivars: The susceptibility to this disease varies with variety.

Chemical Controls: Fungicides registered for the control of anthracnose are listed in *Table 6. Fungicides and biofungicides registered for disease management in grape in Canada*.

Issues for Anthracnose

1. There is a need for the registration of protectant products that can be used early season when infection from anthracnose typically occurs and that are safe to use (i.e. do not cause foliar burning) on sensitive hybrid cultivars.

Black Rot (*Guignardia bidwellii*)

Pest Information

Damage: Infected berries initially turn brown and become covered with pin-head size, black spherical spore producing structures called pycnidia. Eventually the berries become mummified, remaining attached to the fruit cluster stems (rachis).Young leaves may develop small brown spots up to 10 mm in diameter that are encircled by a ring of pycnidia. Lesions may also develop on shoots.

Life Cycle: The pathogen has a limited host range. It overwinters as pycnidia and pseudothecia (sexual spore producing bodies) on infected canes and mummified berries. Spores produced within cane lesions can cause infection starting at bud break. However spores produced within mummified fruit on the ground and canes are a greater source of disease in the spring, being present two to three weeks after bud break and reaching peak levels one to two weeks before bloom. Mummified fruit in the trellis release both rain-splashed conidia (asexual spores) and airborne ascospores (sexual spores) throughout the summer. Berries are very susceptible to infection for the first two to three weeks after bloom and become more resistant over time.

Pest Management

Cultural Controls: The removal of infected, mummified fruit during pruning is very important. Management of cane vigour and the canopy can impact berry-to-berry spread by reducing the duration of wetness.

Resistant cultivars: Most varieties are considered to be very susceptible to the disease.

Chemical Controls: Refer to *Table 6. Fungicides and biofungicides registered for disease management in grape in Canada* for fungicides registered for the control of black rot.

Issues for Black Rot

1. The development of a predictive model is required for growers to more accurately time fungicide applications for black rot.
2. With the potential loss of ethylenebis dithiocarbamate (EBDC) fungicides (especially mancozeb), there may be no registered materials with multi-site activity available for early season black rot protection in the future. There is a need to ensure access to efficacious, sustainable, and multi-site pest management tools that are economical and can be used as resistance management tools.

Botrytis Bunch Rot (*Botrytis cinerea*)

Pest Information

Damage: Botrytis causes a blight of blossoms, leaves and shoots, as well as fruit rot which can result in significant economic loss, particularly on tight-clustered cultivars. Botrytis predisposes fruit to infection by secondary organisms, such as *Penicillium* spp. and *Acetobacter* spp. and will also attract secondary insect problems.

Life Cycle: The pathogen has a wide host range. It overwinters in debris on the vineyard floor or on the vine. Prolonged periods of wetness and high humidity with moderate temperatures (18° to 24°C) favour spore production and infection in the spring. Berries may be infected in the spring, with infections becoming latent until fruit starts to ripen in the fall. Ripe berries are susceptible to direct attack and are particularly susceptible to infection through wounds caused by insects, hail or cracking. Wounds caused by the grape berry moth are particularly common sites of infection.

Pest Management

Cultural Controls: Any practice that improves air circulation and reduces humidity in the canopy will have a significant impact against the development of bunch rot. Canopy management by positioning shoots, thinning, hedging and removing leaves, will modify the microclimate around bunches and reduce botrytis bunch rot. These practices also promote better fungicide coverage. When planting new vineyards it is important to avoid heavily wooded areas and sites prone to fog. Fertilizer applications in quantities that do no cause excessive vegetative growth will result in less disease development. The use of clones or viticultural techniques that provide loose flower and fruit clusters also may significantly reduce the development of the pathogen.

Resistant cultivars: There are no resistant varieties, but some are less susceptible.

Chemical Controls: Refer to *Table 6. Fungicides and biofungicides registered for disease management in grape in Canada* for fungicides registered for the management of botrytis bunch rot.

Issues for Botrytis Bunch Rot

1. The development of pathogen resistance to pesticides is always a significant concern. The registration of new products with different and multiple modes of action, to be used as resistance management tools for botrytis bunch rot control, is required. It is important that all new products developed, have pre-harvest intervals that are feasible under current production systems. The establishment of a structured, national program, for early detection and to monitor fungicide resistance in botrytis would be welcomed by growers.
2. Currently available models that predict the need and timing for sprays for botrytis require validation for use under conditions of high disease pressure for some growing regions. Improved control options are required for botrytis management in organic production systems.
3. There is anecdotal evidence that calcium helps to prevent berry split and subsequent botrytis infections. Further studies on the effect of calcium on botrytis development are required. The plant hormone gibberellic acid can be used to reduce fruit set, resulting in improved air circulation within fruit clusters. Further study is required to determine the effect of the use of gibberellic acid on botrytis bunch rot development.

Downy Mildew (*Plasmopara viticola*)

Pest Information

Damage: Downy mildew attacks leaves, shoots, fruit and fruit stems. Early symptoms develop as yellow spots on leaves. Infected shoot tips and fruit clusters become twisted, and infected tissues eventually become covered with a fluffy white growth of fungal mycelia and spores. Infected fruit of red cultivars develop colour prematurely while fruit of white cultivars become mottled. Infected fruit does not mature properly, remaining hard while the uninfected fruit are softening. When foliar infections are severe, the disease can cause direct fruit loss, uneven fruit maturity, reduced sugar content and reduced plant vigour.

Life Cycle: The pathogen overwinters as oospores (sexual spores) in infected tissues and in soil on the vineyard floor. The oospores germinate in the spring producing sporangia that are blown by wind to susceptible tissue where they release zoospores (motile spores) that cause primary infections. Primary infections require 10 mm of rain and temperatures above 10°C for 24 hours, to occur. Infected leaves develop yellow, oily appearing spots (oilspots) with sporangia within seven to fourteen days of infection, which then act as a source of secondary spread. The disease develops quickly at temperatures between 20° and 25°C and can reach epidemic proportions in a very short period under these conditions. Young leaves are more susceptible than older leaves.

Pest Management

Cultural Controls: Practices that improve air circulation and hasten drying within the canopy of the vines will help reduce downy mildew. These practices also improve the penetration of fungicide sprays into the canopy. Cultivation can be used to bury fallen infected leaves from previous years and will help reduce early season disease pressure.

Resistant cultivars: Although there are varietal differences in terms of susceptibility, all varieties require fungicide applications to prevent infection.

Chemical Controls: Refer to *Table 6. Fungicides and biofungicides registered for disease management in grape in Canada* for fungicides registered for the control of downy mildew.

Issues for Downy Mildew

1. Fungicides with broad spectrum, multi-site activity are important management tools for downy mildew. There is concern that products, such as copper, captan and the ethylene-bis dithiocarbamate (EBDC) fungicides, currently under re-evaluation by the PMRA, may have their registration removed. Growers are in need of broad spectrum, cost effective products for the control of downy mildew in both conventional and organic production systems.
2. Models for improved timing of fungicide treatments for downy mildew (eg. DMCast, Dmodel, RIMpro) have been developed. There is a need to evaluate these models and to validate the most suitable for use in Canada.

Phomopsis Cane and Leaf Spot *(Phomopsis viticola)*

Pest Information

Damage: Petioles, rachises (central fruit stems), shoots and fruit can be affected by phomopsis. Phomopsis causes small dark spots, with yellow margins, on leaves. Rachis infection restricts the movement of water and nutrients to developing berries and results in withered fruit clusters. Fruit infection is sporadic, but can cause serious losses. Infected canes may be more susceptible to winter kill. Girdled shoots can break off easily and fewer new shoots and bunches are produced as plant vigour is reduced.

Life Cycle: The pathogen has a narrow host range. It overwinters as pycnidia (asexual fruiting bodies) in infected one and two year old canes. In the spring spores ooze from the pycnidia and are dispersed through rain-splashing to susceptible, young green tissue. The severity of subsequent infections depends on temperature, as cool weather delays the maturity of plant tissue, making plants susceptible for longer periods of time. Fruit infection requires extended periods of rain and wetness during bloom and early post-bloom. Spores are released only early in the spring and once the initial flush of spores is exhausted there is no further spread of the disease for the season.

Pest Management

Cultural Controls: Removal of infected shoots by pruning will reduce disease incidence.

Resistant cultivars: There are no resistant varieties. Some varieties, such as ‘de Chaunac’ and ‘Elvira’ are more susceptible than others.

Chemical Controls: Refer to *Table 6. Fungicides and biofungicides registered for disease management in grape in Canada* for fungicides registered for the management of phomopsis cane and leaf spot.

Issues for Phomopsis Cane and Leaf Spot

1. The potential loss of the registrations of captan and folpet as a result of re-evaluation is of concern as they are the two most effective products available for phomopsis control. The registration of new products is required.
2. There is a requirement for validation of available phomopsis predictive models for use in the grape growing provinces. Cultivar susceptibilities would be an important consideration in the validation of these models.

Powdery mildew (*Uncinula necator*, *Erysiphe necator*)

Pest Information

Damage: Powdery mildew produces patches of white fungal growth on the surface of foliage, fruit, flowers and canes. Severe infections can result in deformed foliage, reduced fruit set and fruit russet. Low levels of infected fruit can give off-flavours to wine.

Life Cycle: In the spring, ascospores (sexual spores) produced on plant material from the previous growing season, initiate new infections. These infections give rise to patches of powdery growth of fungal strands and conidia (asexual spores) which are spread by wind to new tissues where new infections can occur.

Pest Management

Cultural Controls: Disease development is favoured by low light conditions so pruning to facilitate air circulation and light penetration will help to reduce disease development. Irrigation and fertilization must be managed to avoid excessive vegetative growth which also favours disease development.

Resistant cultivars: Cultivars vary in their susceptibility to powdery mildew.

Chemical Controls: Fungicides registered for the control of powdery mildew are listed in *Table 6. Fungicides and biofungicides registered for disease management in grape in Canada*

Issues for Powdery Mildew

1. Resistance management in powdery mildew is of great concern. Strains of powdery mildew resistant to sterol inhibiting and strobilurin fungicides have been well documented. There is a need for the registration of new, broad spectrum products with different modes of action, to continue the battle against resistance development.
2. It is important to provide growers with information on resistance management so that they may select use patterns that prolong the efficacy of fungicides with single sites of action.
3. An effective management strategy that includes biopesticides is required for powdery mildew control in organic vineyards.
4. Disease prediction models developed in other jurisdictions need to be validated for their applicability to Canadian conditions.

5. Further research is needed to determine the effects on hydrogen sulfide levels in the finished wine of late season sulphur applications against powdery mildew. There is currently a 21 day pre-harvest interval for sulphur products applied on wine grapes.

Crown Gall (*Agrobacterium vitis*)

Pest Information

Damage: This bacterial disease results in fleshy galls on the lower trunk near the soil line and at budding and grafting sites. Large galls can develop rapidly and completely girdle young canes in one season. Galled canes produce inferior shoot growth and portions of the cane above the galls may die. Galls can prevent graft and bud healing.

Life Cycle: Although the pathogen can survive in the soil on infected root material, it is generally not present where grapes have not been previously grown. The bacterium is systemically present in the majority of grape vines, but remains latent unless the vine is injured. Budding and grafting injuries can occasionally elicit disease development, but cold injury is by far the most important predisposing factor.

Pest Management

Cultural Controls: The use of clean planting stock is important, as infected plants can remain symptomless until winter occurs. Galls can be removed by pruning below the affected tissue. Following pruning, the vine may be 'renewed' by training a new shoot as the trunk. Management practices that minimize the risk of cold injury are currently the only practical technique for managing the disease (e.g. site selection or hilling above the union graft). The use of multiple trunk vines and the yearly replacement of dead trunks with renewal vines help to keep the disease at tolerable levels.

Resistant cultivars: V. vinifera varieties are generally more susceptible than *V. labrusca* to crown gall due to their relative higher susceptibility to cold damage. Varieties that are less susceptible to winter injury will be less susceptible to the disease.

Chemical Controls: There are no registered bactericides for this disease.

Issues for Crown Gall

1. The crown gall pathogen invades tissues injured by cold winter temperatures and can be quite severe under Canadian conditions. The development of management practices that contribute to winter hardiness of vines and thereby minimize the risk of crown gall injury is required. The development of resistant rootstocks is needed for managing crown gall.
2. A nursery stock certification system is needed to ensure the production and distribution of disease-free stock.
3. It is important that information on best management practices be made available to growers to minimize problems due to crown gall.

Sour rot (yeasts and bacteria)

Pest Information

Damage: Sour rot results in a soft, watery breakdown of fruit close to harvest. Breakdown products include acetic acid and ethyl acetate. Entire clusters can be destroyed. The use of berries affected by sour rot for wine making can result in an off-flavour in the finished product.

Life Cycle: Sour rot is caused by secondary rot organisms that invade fruit damaged by disease, insects, hail and other physiological factors. Fruit produced in tight clusters on vigorous grape vines are also susceptible. Warm temperatures and rain during the pre-harvest period, favour disease development. Fruit flies are attracted to damaged fruit and can spread the sour rot pathogens. Under favourable conditions of moisture and temperature, severe disease outbreaks can develop rapidly.

Pest Management

Cultural Controls: To minimize the chances for sour rot development, it is important to minimize wounding and to control diseases and insects that damage fruit. Pruning to thin the canopy and promote drying of foliage will result in a crop microclimate that is less suitable for sour rot development. The removal of infected clusters will help reduce further spread of the disease.

Resistant cultivars: None available.

Chemical Controls: There are no fungicides registered for the control of sour rot, although treatments for other diseases and pests indirectly hinder the development of this disease.

Issues for Sour Rot

1. Sour rot has been an ongoing (and increasing) problem on early ripening hybrid and tight clustered, thin skinned, vinifera cultivars, especially when the pre-harvest period is warm and wet. There is a need for the development of control materials that are effective in slowing down or providing protection against this disease complex.
2. There is a need for increased understanding of the epidemiology of sour rot and the importance of fruit flies as disease vectors.
3. The development of an effective management approach, including product registrations, is required for sour rot.
4. Further information is required on the impact of sour rot on wine quality.

Grapevine Leafroll-Associated Virus (GLRaV strains I - 4 and 7)

Pest Information

Damage: Leaves of grapes cultivars susceptible to GLRaV turn red or purple (red grape varieties) or light-green to yellow (green grape varieties) in the late summer, with the discolouration often accompanied by a downward rolling of the leaf margins. All or only some leaves on a shoot may show symptoms. Fruit maturity is delayed and sugar content of fruit is reduced in virus infected plants. Infected vines are weakened, eventually reaching the point that they are no longer fit for production. Some varieties can be infected yet show no negative symptoms, but when grafted to a susceptible rootstock eventually die.

Life Cycle: The virus is spread primarily through the movement of infected propagation material. It can be e transmitted locally from plant to plant by mealybugs and soft scale insects.

Pest Management

Cultural Controls: When establishing new vineyards, the use of vines that have been certified virus–free is important to prevent the introduction of virus diseases. In established plantings, monitoring for leafroll is best done in the late summer when foliar symptoms are present. Suspect plants confirmed to be infected through laboratory testing must be removed to prevent further spread of the disease. Insect vectors including soft scales and mealybugs, must be controlled to help limit virus spread.

Resistant cultivars: None available.

Chemical Controls: None available.

Issues for GLRV

1. There is a need to ensure that grape planting stock received from offshore has been screened thoroughly for virus diseases and is disease free.
2. It is important to ensure that propagation material from domestic sources is free of virus diseases.
3. There is an immediate need to determine if the grapevine red blotch virus, a newly reported virus disease of grape in Canada, is transmitted via insect vectors. At this time only transfer through propagation is known.
4. There is a need to develop best management practices for vineyards where virus diseases have been identified.

Nematodes: dagger nematode (*Xiphinema americanum*), other Xiphinema spp., northern root-knot nematode (*Meloidogyne hapla*) and root lesion nematode (*Pratylenchus penetrans*)

Pest Information

Damage: Nematodes feed on vine roots by piercing plant cells with their needle-like mouthparts and sucking-out cell contents. Feeding can reduce vine vigour, growth and yield. Root knot nematodes induce the formation of galls at their feeding sites which reduce the uptake of water and nutrients by the plant. Dagger nematodes are vectors of virus diseases. Nematode damage usually appears in patches throughout the vineyard although entire blocks of vines can be uniformly affected.

Life Cycle: In general, most plant pathogenic nematodes develop from eggs, through four larval stages to become adults. Adult nematodes mate and lay eggs within the host or in soil in the vicinity of host roots. Some nematodes such as *Xiphinem*a spp. feed and develop completely external to the plant. Others, including *Pratylenchus* spp. and *Meloidogyne* spp. spend a part of their life cycle within plant roots.

Pest Management

Cultural Controls: Soil testing may be carried out prior to planting a new vineyard to determine whether plant parasitic nematodes are present.

Resistant cultivars: Nematode resistant rootstocks are available.

Chemical Controls: Refer to *Table 6. Fungicides and biofungicides registered for disease management in grape in Canada* for fumigants registered for the management of nematodes in grape.

Issues for Nematodes

1. The expansion of vineyards into lighter soils can potentially result in a greater nematode presence. There is a need to investigate the impact of nematodes on early vine development and on long term productivity of the vines.

Insects and Mites

Key issues

Integrated Pest Management (IPM)

- There is a need for information about economic damage and the development of action thresholds for the management of spotted-wing drosophila (SWD), Comstock and grape mealybugs, leafhoppers, climbing cutworms and flea beetles.
- Information on the toxicity of pest control products (insecticides and fungicides) to specific predatory mites is required by growers and advisors, at time of pesticide registration. This information would enable them to select the best management practices to conserve natural enemies.
- Effective, integrated management strategies need to be developed for SWD, leafhoppers, lady beetles, mites and climbing cutworms. Such strategies should incorporate a number of tactics such as the use of sticky traps, beneficial insects and mites, vegetation management, companion planting, and attract and kill approaches.

Emerging Issues

- The brown marmorated stinkbug (BMSB), a new insect species in Ontario with the potential to feed on many fruit crops including grapes, is of great concern, given the levels of damage seen in many fruit crops where the pest has become established in the United States. Careful monitoring of established colonies and the development of effective IPM strategies is urgently required.
- With the de-registration of the broad-spectrum, organophosphate insecticides there is concern that previously minor pests, such as some spring feeding caterpillars and the Comstock mealybug, may increase in prevalence. The Comstock mealybug is of concern as it may vector viruses in tree fruits and grapes.
- The cottony maple scale is a vector of leafroll virus in grape, a disease which is on the rise in Ontario. There is a need for more information on the prevalence of this disease in Canadian vineyards. Control strategies for the vector need to be developed and grower education is required as this is a relatively new problem.

….continued

Key Issues (continued)

New insect and mite pest management products and application technologies

- With concerns about resistance development and the potential de-registration of uses due to concerns about toxicity to bees, there is a need to register products. Products with efficacy against SWD, grape mealybug, mites and grape phylloxera, compatible with pollinators are needed.
- There is a need for the registration of effective pest control products with short pre-harvest intervals for management of mites and lady beetles including the multicoloured Asian lady beetle. There is a need for wineries to agree upon a standard acceptable number of beetles present in harvested grapes. Current tolerances may be lower than is supported by research, resulting in greater use of pesticides than necessary.
- There is a need for the registration of more pest control options compatible with organic production systems for the management of pests including leaf hoppers and cutworms.

Table 7. Occurrence of insect pests in grape production in Canada

Insect	British Columbia	Ontario	Quebec	Nova Scotia
Grape berry moth				
Spotted wing drosophila				
Western flower thrips				
Brown marmorated stinkbug				
Grape mealybugs				
Leafhopper complex				
Potato leafhopper				
Grape leafhopper				
Threebanded leafhopper				
Virginia creeper leafhopper				
Western grape leafhopper				
Tarnished plant bug				
Multicoloured Asian lady beetle				
Sevenspotted lady beetle				
Mites				
European red mite				
Two-spotted spider mite				
Grape erineum mite				
McDaniel spider mite				
Grape leaf rust mite				
Grape phylloxera				
Flea beetles				
Grape flea beetle				
Japanese beetle				
Cutworms				
Scale insects				
European fruit lecanium				
Cottony maple scale				

Widespread yearly occurrence with high pest pressure.
Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.
Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pressure.
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.
Pest is present and of concern, however little is known of its distribution, frequency and importance.
Pest not present.
Data not reported.

[1]Source: Grape stakeholders in reporting provinces.

[2]Please refer to Appendix 1 for a detailed explanation of colour coding of occurrence data.

Table 8. Adoption of insect pest management practices in grape production in Canada[1]

	Practice / Pest	Grape berry moth	Leafhopper complex	Lady beetle complex	Flea beetles	Mites
Avoidance	resistant varieties					
	planting / harvest date adjustment					
	crop rotation					
	choice of planting site					
	optimizing fertilization					
	reducing mechanical damage					
	thinning / pruning					
	trap crops / perimeter spraying					
	physical barriers					
Prevention	equipment sanitation					
	mowing / mulching / flaming					
	modification of plant density (row or plant spacing; seeding rate)					
	seeding depth					
	water / irrigation management					
	end of season crop residue removal / management					
	pruning out / removal of infested material before harvest					
	tillage / cultivation					
	removal of other hosts (weeds / volunteers / wild plants)					
Monitoring	scouting / trapping					
	records to track pests					
	soil analysis					
	weather monitoring for degree day modelling					
	use of portable electronic devices in the field to access pest identification /management information					
	use of precision agriculture technology (GPS, GIS) for data collection and field mapping of pests					

…continued

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

Practice / Pest		Grape berry moth	Leafhopper complex	Lady beetle complex	Flea beetles	Mites
Decision-making tools	economic threshold	Green	Green	Green	Green	Green
	weather / weather-based forecast / predictive model (eg. degree day modelling)	Green	Red	White	White	Red
	recommendation from crop specialist	Green	Green	Green	Green	Green
	first appearance of pest or pest life stage	Red	Red	Red	Red	Red
	observed crop damage	Green	Green	Green	Green	Green
	crop stage	Green	Green	Green	Green	Green
Suppression	pesticide rotation for resistance management	Green	Green	Green	Green	Green
	soil amendments	Red	Red	Red	Red	Red
	biological pesticides	Green	Red	Red	Red	Red
	arthropod biological control agents	Green	Green	Green	Green	Green
	beneficial organisms and habitat management	Red	Green	Red	Red	Green
	ground cover / physical barriers	Red	Green	Red	Green	Green
	pheromones (eg. mating disruption)	Green	Red	Red	Red	Red
	sterile mating technique	Red	Red	Red	Red	Red
	trapping	Red	Red	Red	Red	Red
	targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)	Green	Green	Green	Red	Green

This practice is used to manage this pest by at least some growers. (Green)

This practice is not used by growers to manage this pest. (Red)

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

Information regarding the practice for this pest is unknown. (Grey)

[1]Source: Stakeholders in grape producing provinces (British Columbia and Ontario).

Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
abamectin	avermectin, milbemycin	glutamate-gated chloride channel (GLUCL) allosteric modulator	6	RE	two spotted spider mite, European red mite
acetamiprid	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	R	leafhoppers, grape berry moth, Japanese beetle, grape phyloxera (aerial form only)
Bacillus thuringiensis subsp. *kurstaki* strain ABTS-351	*Bacillus thuringiensis* and the insecticidal proteins they produce	microbial disruptor of insect midgut membranes	11A	R	grape berry moth, leafrollers, bagworms
Bacillus thuringiensis subsp. *kurstaki* strain EVB113-19	*Bacillus thuringiensis* and the insecticidal proteins they produce	microbial disruptor of insect midgut membranes	11A	R	grape berry moth, bagworms, fruittree leafroller, European leafroller, obliquebanded leafroller, threelined leafroller
Bacillus thuringiensis subsp. aizawai Strain ABTS-1857	*Bacillus thuringiensis* and the insecticidal proteins they produce	microbial disruptor of insect midgut membranes	11A	R	grape berry moth, grape leaf-folder, grape leafroller, grapeleaf skeletonizer, obliquebanded leafroller, omnivorous leafroller
bifenazate	bifenazate	mitochondrial complex III electron transport inhibitor	20D	R	two spotted spider mite, European red mite
carbaryl	carbamate	acetylcholinesterase (AChE) inhibitor	1A	RES*	grape berry moth, leafhoppers

…continued

Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
chlorantraniliprole	diamide	ryanodine receptor modulator	28	R	grape berry moth, climbing cutworm, Japanese beetle (suppression)
clothianidin	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	RES	leafhoppers, grape phylloxera, mealybug, thrips, brown marmorated stink bug (suppression)
cyflumetofen	beta-ketonitrile derivative	mitochondrial complex II electron transport inhibitor	25	R	European red mite, two spotted spider mite, McDaniel spider mite
cypermethrin	pyrethroid, pyrethrin	sodium channel modulator	3A	RE	multicoloured Asian lady beetle, yellow jacket wasps, grape leafhopper, grape berry moth
ferric phosphate	not classified	unknown	N/A	R	slugs, snails
ferric sodium ethylenediamine tetra acetic acid (EDTA)	not classified	unknown	N/A	R	slugs, snails
flupyradifurone	butenolide	nicotinic acetylcholine receptor (nAChR) competitive modulator	4D	R	leafhoppers
imidacloprid	neonicotinoid	nicotinic acetylcholine receptor (nAChR) competitive modulator	4A	RES*	leafhoppers

…continued

Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
kaolin	not classified	unknown	N/A	R	leafhoppers (including eastern grape leafhopper, potato leafhopper, three banded leafhopper, Virginia creeper leafhopper and western grape leafhopper (reduction in damage)
malathion	organophosphate	acetylcholinesterase (AChE) inhibitor	1B	R	aphids, leafhoppers, mealybugs, scale crawlers, spider mites, grape phyloxera (nursery stock), multi-coloured Asian lady beetle, brown marmorated stinkbug (suppression)
methoxyfenozide	diacylhydrazine	ecdysone receptor agonist	18	R	grape berry moth, climbing cutworm
methyl bromide (fumigant, pre-plant soil application)	alky halide[4]	miscellaneous non-specific (multi-site) inhibitor[4]	8A	PO	damping-off organisms (fusarium, pythium and rhizoctonia), insects, nematodes, weed seeds
mineral oil	not classified	unknown	N/A	R	mites (suppression)
permethrin	pyrethroid, pyrethrin	sodium channel modulator	3A	RE	grape berry moth, multicolored Asian lady beetle, yellow jacket wasps, grape leafhopper, climbing cutworm

…continued

Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
phosmet	organophosphate	acetylcholinesterase (AChE) inhibitor	1B	RE	grape berry moth, eastern tent caterpillar, elm spanworm, gypsy moth, Japanese beetle, spring cankerworm, spotted wing drosophila
potassium salts of fatty acids (wine grapes only)	not classified	unknown	N/A	R	aphids, mealybugs, mites, scale insects
pyrethrin	pyrethroid, pyrethrin	sodium channel modulator	3A	RE	aphids, leafhoppers
pyridaben	METI acaricide and insecticide	mitochondrial complex I electron transport inhibitor	21A	RE	European red mite, two spotted spider mite, McDaniel spider mite
spinetoram	spinosyn	nicotinic acetylcholine receptor (nAChR) allosteric modulator	5	R	grape berry moth (suppression)
spinosad	spinosyn	nicotinic acetylcholine receptor (nAChR) allosteric modulator	5	R	western flower thrips (suppression), grape berry moth (suppression)
spirodiclofen	tetronic and tetramic acid derivative	inhibitor of acetyl CoA carboxylase.	23	R	European red mite, two spotted spider mite, McDaniel spider mite

…continued

Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
spirotetramat	tetronic and tetramic acid derivative	inhibitor of acetyl CoA carboxylase	23	R	whiteflies, mealybugs, phylloxera, lecanium scale (suppression)
sulfoxaflor	sulfoximine	nicotinic acetylcholine receptor (nAChR) competitive modulator	4C	R	leafhoppers (suppression)
sulphur (not on Concord grapes and other sensitive varieties)	sulphur	compound of unknown or uncertain mode of action	N/A	R	grape erineum mite

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

[2]Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (Version 8.0; December 2015)* (www.irac-online.org) (accessed February 15, 2016).

[3]PMRA re-evaluation status: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review, as published in PMRA *Re-evaluation Note REV2016-07, Pest Managment Regulatory Agency Re-evaluation and Special Review Workplan 2015-2020*, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA as published in PMRA *Re-evaluation Decision document RRD2004-01, Re-evaluation of Methyl Bromide*.

Grape Berry Moth (*Paralobesia viteana*)

Pest Information

Damage: First generation larvae of the grape berry moth feed on flowers and newly set fruit. Damaged berries wither and often drop to the ground before they reach pea size. Later generation larvae bore into fruit and feed internally. A larva may complete its development in a single fruit, but it typically moves between many berries in a cluster causing greater crop loss. Some berries may drop, shrivel or rot depending on the extent of the larval feeding. Wound sites are ideal for the entry of other insects and pathogens. Late season infestations are often the most serious as they lead to botrytis infection, resulting in serious losses.

Life Cycle: The pest is native to eastern North America where it feeds exclusively on wild grape and cultivated wine grape and juice grape. The insect overwinters as pupae in debris on the vineyard floor. Adults emerge in the spring, mate and lay eggs on buds, stems and newly forming berries. Eggs hatch and larvae begin to feed on the fruit. When larvae are mature, pupal chambers are constructed on leaves or in fruit clusters where the larvae had been feeding. The larvae pupate and adults emerge and lay eggs of the next generation on the fruit. There may be up to three generations of active, feeding larvae each year in Ontario.

Pest Management

Cultural Controls: The removal of wild hosts near a vineyard will reduce a source of moths migrating into vineyards in the spring. Spring cultivation to bury leaves from the previous season, will reduce the number of moths emerging. Low temperatures in winter help reduce overwintering populations, especially in the absence of snow. Records of injury levels in specific areas of a vineyard or on specific cultivars can assist in determining control measures in subsequent years. Mating disruption technology is available. Pheromone traps are effective tools for timing conventional chemical insecticides and providing early alert as to the effectiveness of mating disruption technology.

Resistant cultivars: Varieties with tighter bunches may have more severe infestations.

Chemical Controls: Refer to *Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada* for pesticides registered against grape berry moth.

Issues for Grape Berry Moth

1. Mating disruption technology has not been cost effective for growers as insecticides must still be applied for other pests such as leafhoppers, Japanese beetle and multicoloured Asian lady beetle.
2. There is a need to re-examine the effectiveness of pheromones in trapping grape berry moth under growing conditions in Quebec. There is some concern that the pheromones do not effectively attract this insect.

Spotted Wing Drosophila (SWD) (*Drosophila suzukii*)

Pest Information

Damage: Spotted Wing Drosophila (SWD) is a serious pest of soft fruit and berries including raspberry, blackberry, blueberry, strawberry, cherry, peach, nectarine, apricot and plum as well as numerous wild hosts. Although SWD has been found in grape production areas, there has not been any damage observed on grapes. The potential for damage in grape is currently unknown. Unlike other fruit flies, in known hosts, spotted wing drosophila attacks sound fruit. Larvae feed within fruit causing softening and breakdown of flesh which makes the fruit unmarketable. Wounds caused by egg-laying serve as entry points for disease.

Life Cycle: The insect overwinters as adult flies. In the spring the flies mate and lay eggs under the skin of ripening fruit. Larvae feed and develop within the fruit. The entire life cycle from eggs, through larval and pupal stages to adult, varies between seven days at 28˚C to 50 days at 12˚C. Due to the short generation time and extended period of egg laying there can be several, overlapping generations each year. The insect is spread short distances by wind and can be carried to new areas through the movement of infested fruit.

Pest Management

Cultural Controls: In other fruits, strict sanitation measures in the field and in processing areas are important. The frequent harvest of all ripe fruit and removal of unmarketable fruit culls help to reduce the chances of the fly infesting the fruit and reduces sources of continued infestations. Flies can be monitored using apple-cider vinegar traps.

Resistant Cultivars: None identified.

Chemical Controls: Fruit must be protected throughout the ripening period. Insecticides registered for spotted wing drosophila are listed in *Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada*.

Issues for Spotted Wing Drosophila

1. The potential for damage from SWD in grape needs to be established, ideally for each variety. It is important to establish economic thresholds for treatment. Careful monitoring of this pest is required until the damage potential is known.
2. An effective management strategy that includes best management practices, effective chemicals and chemical rotations, must be developed before this pest becomes a problem. There is a need to assess mass trapping methods as an approach to control, and to develop effective attractants and trapping methods to enable the effective monitoring of this insect.
3. The development of pesticide resistance must be monitored closely given the short reproductive cycle of SWD and the frequency of insecticide applications required.

Western Flower Thrips (*Frankliniella occidentalis*)

Pest Information

Damage: Adults and nymphs of the western flower thrips feed on flower and fruit tissue of grape from bloom to the beginning of fruit set. Feeding causes berry scarring and russetting. Females cause fruit spotting as they insert their eggs into young fruit. Cracking and deformation of fruit occurs and is particularly destructive to grapes sold as fresh fruit.

Life Cycle: Western flower thrips overwinter in plant debris on the soil surface and move into vineyards in the spring when alternative food plants begin senescence. Eggs are inserted into developing plant tissues in the spring. Following hatch, the nymphs feed on flowers, fruit and foliage and develop into adults. There may be several generations per year.

Pest Management

Cultural Controls: Mowing or the destruction of ground cover in the week prior to and during bloom to fruit set should be avoided so that thrips are not compelled to move to the vines. The presence of thrips can be confirmed by shaking flower or fruit clusters or leaves onto a white surface.

Resistant cultivars: None available.

Chemical Controls: Refer to *Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada* for insecticides registered for the control of western flower thrips.

Issues for Western Flower Thrips

None identified.

Brown Marmorated Stinkbug (BMSB) (*Halymorpha halys*)

Pest Information

Damage: Although the brown marmorated stinkbug (BMSB) has not yet been identified as a pest in crops in Canada, it has caused significant crop injury in other jurisdictions where it is established in agricultural crops. This insect has a broad host range including tree fruit, berries, grapes, ornamentals, grain crops, tomatoes, peppers and sweet corn. Injury is caused by feeding of adults and nymphs. The insect injects saliva with digestive enzymes into the plant and ingests the liquefied plant material. Each feeding puncture results in crop injury.

Life Cycle: The insect spreads through natural means and also as a "hitchhiker" in cargo and vehicles. It has been intercepted in many provinces over the years and in 2012 an established population was identified in the Hamilton, Ontario area. It readily moves among host crops throughout the growing season. BMSB overwinters as adults. In the spring, adults mate and lay eggs on host plants. Both nymphs and adults feed on host plants. Adults are long-lived and females may lay several hundred eggs over an extended period of time. In the fall, the adults move back to protected overwintering sites. They have frequently entered structures in the fall where they are a nuisance pest.

Pest Management

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

Resistant cultivars: None available.

Chemical controls: Refer to *Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada* for insecticides registered for the control of BMSB in grape.

Issues for Brown Marmorated Stinkbug

1. The presence of BMSB in Ontario is of great concern. Careful monitoring, for the early detection of damage, is required where this pest is established.
2. Currently, there are only two products registered for use on BMSB, one of which is a neonicotinoid material which is under re-evaluation due to concerns of bee toxicity. The registration of additional non-neonicotinoid materials would be of benefit to ensure this pest can be responsibly managed if it becomes a problem in grape.
3. There is a need for the development of an effective management strategy for BMSB in grape.

Lady Beetle Complex: Multicoloured Asian Lady Beetle (MALB) (*Harmonia axyridis*) and Sevenspotted Lady Beetle (*Coccinella septempunctata*)

Pest Information

Damage: The beetles migrate into the vineyard during the fruit ripening and harvesting period. The beetles do not cause physical damage to bunches, but will feed as a secondary pest after berry splitting or after bunch breakdown caused by botrytis bunch rot, bird damage or grape berry moth. The presence of beetles during harvest and the wine making process can lead to the release of methoxypyrazine, a chemical which imparts a serious, sensory taint to wine, making it unmarketable. There is zero tolerance for these insects in juice and wine grapes.

Life Cycle: Aphids are the primary food of the beetles. The beetles are opportunistic and both adults and larvae feed on aphids in field crops (eg. soybean aphids), ornamental plants, grasses and other crops. The beetles overwinter as adults in protected areas. The beetle can travel over 70 km and may congregate in vineyards, orchards or berry crops in the fall before moving to overwintering sites. Reasons for their congregation in these areas are not well understood, but could be due to the late-season food source (fruit sugars) or other volatile chemicals, such as terpenes.

Pest Management

Cultural Controls: Grape bunches which are kept healthy and intact and free of injury from other insects, birds and disease are less prone to damage from lady beetles. Harvesting by hand and mechanically separating beetles from harvested grapes can be done.

Resistant Cultivars: Some varieties tend to be more attractive to the beetles than others, possibly due to their susceptibility to botrytis bunch rot and the production of volatiles that attract beetles during the ripening process.

Chemical Controls: Applications of insecticides provide quick knock down, but re-infestation under high population pressure may require frequent applications resulting in pre-harvest application interval issues. Pesticides registered for lady beetle control are listed in *Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada.*

Issues for Lady Beetles

1. Due to the potential impact on wine, there is great concern when lady beetles are present at harvest. Additional products with short pre-harvest intervals that will kill as well as repel lady beetles are required for use by growers throughout the harvest period.
2. There is a need for wineries to establish a standard number of beetles acceptable per tonne of harvested grapes.
3. There is a need to investigate alternative management strategies for lady beetles, including the use of trap plants and attractants / repellents along vineyard borders, to deter the insects from entering the vineyard.

Grape Mealybugs (*Pseudococcus maritimus*)

Pest Information

Damage: The grape mealybug feeds by sucking plant sap from leaves, shoots and fruit. The insect produces a liquid waste called honeydew that supports the growth of sooty moulds and stains the fruit. Mealybugs transmit some strains of the leafroll virus.

Life Cycle: Females lay eggs under cottony masses, in protected areas of the bark of grapevines in the fall. The mealybugs overwinter as eggs or as dormant crawlers. In the spring, the crawlers disperse to new shoots to feed. They mature by mid-summer and a second generation is produced.

Pest Management

Cultural Controls: Crawler activity can be monitored with the use of sticky tapes on vines. It is especially important to monitor vigorous vines with thick canopies, the preferred sites for mealybug. Avoiding fertilizer applications at levels that stimulate lush growth will result in canopy conditions that are less favourable for mealybug populations.

Resistant cultivars: None available.

Chemical Controls: Pesticides registered for the control of mealybug are listed in *Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada.*

Issues for Grape Mealybugs

1. There are concerns that there will be an increase in grape mealybug populations with the decline in use of broad spectrum insecticides (especially the organophosphates).
2. This insect is the major vector of grapevine leafroll virus (GLRV) and at this time there are very few materials available for control of this pest. There is a need to register additional, pollinator-friendly materials effective on this pest.
3. The development of economic thresholds is required to enable growers to apply timely treatments and minimize feeding damage and virus spread.

Potato Leafhopper (*Empoasca fabae*)

Pest Information

Damage: The potato leafhopper feeds by sucking plant juices from the leaves and young stems of grape. While feeding, the insect injects a toxin that blocks the grape’s vascular system reducing movement of nutrients, photosynthesis and plant vigour. Leaves turn yellow and curl upwards, with severe infestations causing leaves to turn brown and die. The effects of the pest are most severe in newly planted vineyards. However, leaf symptoms do occur in plantings older than five years when they are under moisture stress. This leads to a reduction in the brix levels and quality of grapes.

Life Cycle: The pest has a wide host range of more than 200 different species of plants, including grape, apple, strawberry and potato. It does not overwinter in Canada and is blown in each year from the United States, arriving in early June. Leafhoppers move into the vineyard with the harvest of other hosts. Females lay eggs in the upper canopy. Following hatch, nymphs feed on foliage and develop through five instars to the adult stage. There can be up to four generations per year.

Pest Management

Cultural Controls: Yellow sticky traps and visual inspection of shoots can be used to detect potato leafhopper. Practices that prevent or reduce vigorous shoot growth, a preferred food source of leafhoppers, will indirectly reduce leafhopper populations. Stresses due to diseases, other pests and the environment must be taken into account when deciding whether to treat, as these factors could affect the plants' susceptibility to leafhopper feeding.

Resistant cultivars: There are some indications that the pest prefers certain varieties.

Chemical Controls: Pesticides registered for the control of the potato leafhopper are listed in *Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada*

Issues for Potato Leafhopper

1. There is a need to establish thresholds to determine when control treatments are required for leafhoppers in vineyards under both non-stressful and stressful growing conditions. The development of alternative, non-chemical approaches to leafhopper control is required for use in organic vineyards, including approaches such as the use of anti-feedants and repellents (eg. garlic and hot pepper), biological controls, sticky traps and companion planting.
2. The registration of control materials suitable for use in organic systems is required. While kaolin clay is registered, it is known to delay sugar development in the fruit and for this reason, is suitable for use only on early varieties.
3. The American grapevine leafhopper, *Scaphoideus titanus*, is not a pest of grape but can carry phytoplasma diseases and is of concern. There is a need for more information on the distribution of this leafhopper in Canada.

Grape Leafhopper (*Erthroneura comes*) and Threebanded Leafhopper (*E. tricincta*)

Pest Information

Damage: The grape and threebanded leafhoppers feed on the underside of leaves by sucking sap. The tissue around the punctures created by the insects turns pale white and eventually dies. Feeding injury is first seen along veins, but eventually spreads to the entire leaf. Heavy feeding can result in premature leaf drop, lowered sugar content, increased acid and poor colouring of the fruit and reduced growth the following season. Ripening fruit is often stained by the sticky excrement of the hoppers, which affects appearance and supports the growth of sooty molds. Damage to the vine can be serious if infestations are allowed to persist unchecked for two or more years.

Life Cycle: Overwintering adults emerge from hibernation in mid-spring and begin feeding on various plants such as strawberry and other berries, catnip, Virginia creeper, burdock, beech, and sugar maple. They mate and migrate into the vineyard where they lay eggs under the epidermis of the lower surface of leaves. The pests are found in the vineyard into the fall, with migration to overwintering sites beginning in late October and continuing into December.

Pest Management

Cultural Controls: Cultivation in the fall and clean-up of adjacent weedy land eliminates favourable overwintering sites. Cold and wet weather in the spring and fall are damaging to pest populations, as are wet winters. Stresses due to diseases, other pests and the environment must be taken into account when deciding whether to treat the vineyard as these factors could affect the plants' susceptibility to leafhopper feeding damage.

Resistant cultivars: None available.

Chemical Controls: Pesticides registered for leafhopper control are listed in *Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada*.

Issues for Grape Leafhopper and the Threebanded Leafhopper

1. There is a need to establish thresholds to determine when control treatments are required for leafhoppers in vineyards under both non-stressful and stressful growing conditions.
2. The development of alternative, non-chemical approaches to leafhopper control is required for use in organic vineyards. Approaches such as the use of anti-feedants and repellents (e.g. garlic and hot pepper), biological controls, sticky traps and companion planting require investigation.
3. The registration of control materials suitable for use in organic systems is required. While kaolin clay is registered, it is known to delay sugar development in the fruit and for this reason, is suitable for use only on early varieties.

Virginia Creeper Leafhopper *(Erythroneura ziczaz)* and Western Grape Leafhopper (*Erythroneura elegantula*)

Pest Information

Damage: Adults and nymphs feed by piercing leaves and sucking sap. Light feeding results in stippling of the leaves. However heavy feeding causes the leaves to become brown and dry and to fall prematurely, resulting in yield losses and reduced fruit quality. Table grapes, particularly light-coloured varieties, can become spotted and unsightly with excrement. Adult leafhoppers can be a nuisance during harvest.

Life Cycle: The biology and life cycles of the two species are very similar, both having two generations per year and overwintering as adults in plant debris in and around the vineyard. With warm temperatures in the spring, adults move to grape vines where eggs are laid on lower leaf surfaces. First generation nymphs are present from early summer to the end of July and second generation nymphs appear in August. The nymphs develop through five stages to become winged adults.

Pest Management

Cultural Controls: Fall or spring disking between rows destroys overwintering adults. Removing leaves in the fruiting zone when eggs of the first generation are present can reduce populations. Maintaining moderate vigour with irrigation and fertilization is important. Stresses due to diseases, other pests and the environment must be taken into account when deciding whether to treat as these factors could affect the plants' susceptibility to leafhopper feeding. Estimates of the numbers of overwintering adults can be obtained from monitoring with yellow sticky traps in the spring and can be used to identify potential problem areas for monitoring more closely throughout the season. Early season feeding by leafhoppers is tolerated by established grapevines due to their rapid growth. However, sprays may be required when populations exceed about 20 to 25 nymphs per leaf in the more infested areas of the vineyard later in the season. The presence of natural enemies can result in higher treatment thresholds. Leafhoppers have several natural enemies, including birds, spiders, insect predators, parasites and diseases. A small egg parasite (*Anagrus daanei)* can effectively control Virginia creeper leafhopper in some vineyards, with parasitism of the second brood approaching 100%.

Resistant cultivars: None available.

Chemical Controls: Pesticides registered for leafhopper control are listed in *Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada*.

Issues for Virginia Creeper Leafhopper and Western Grape Leafhopper

1. There is a need to establish thresholds to determine when control treatments are required for leafhoppers in vineyards under both non-stressful and stressful growing conditions.
2. The development of alternative, non-chemical approaches to leafhopper control is required for use in organic vineyards. Approaches such as the use of anti-feedants and repellents (eg. garlic and hot pepper), biological controls, sticky traps and companion planting require investigation.
3. The registration of additional control materials is required.

Tarnished Plant Bug (TPB) (*Lygus lineolaris*)

Pest Information

Damage: The tarnished plant bug is a general feeder on many wild and cultivated herbaceous plants. It feeds by piercing the plant and sucking sap. On grape, feeding in early spring on buds and developing fruit can result in fruit drop.

Life Cycle: Adult TPB overwinters under bark, plant debris and in other protected sites. With the onset of warm weather in the spring, the adults become active and begin to feed. The adults move to herbaceous plants in late spring and lay eggs. Following hatch, TPB nymphs develop through 5 stages to become adults.

Pest Management

Cultural Controls: The management of weeds in and around the vineyard will eliminate feeding sites for the TPB. The elimination of crop debris in the fall will help reduce overwintering sites.

Resistant Cultivars: None available.

Chemical Controls: Refer to *Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada* for insecticides registered for tarnished plant bug.

Issues for Tarnished Plant Bug

None identified.

Grape Phylloxera *(Daktulosphaira vitifoliae)*

Pest Information

Damage: Phylloxera feed by sucking sap from leaves, stems and roots. While feeding, phylloxera inject a toxin that induces the formation of galls on leaves and roots. Severe infestations cause defoliation, reduced shoot growth and delayed fruit ripening. Fruit may have reduced sugar levels at harvest. Winter hardiness of the vine is reduced. Root galls interfere with the uptake of moisture and nutrients by the vine. Galls may be invaded by root diseases which further contribute to the decline of the grape vine. Affected vines may eventually die.

Life Cycle: Two 'forms' of grape phylloxera are recognized: the leaf form and the root form. The leaf form overwinters as an egg under the bark of the grapevine. Eggs hatch in the spring and the young nymphs move to expanding leaves where they feed and induce gall formation. When mature, female phylloxera lay eggs within the galls. Leaf-form phylloxera can have as many as seven generations per year. The second or 'root form' of phylloxera overwinters as first instar (stage) nymphs on roots. These nymphs feed and mature on the roots and the new adults lay eggs back on the roots. There may be as many as nine generations per season. In early summer, some adult root phylloxera move to the soil surface. Eggs laid by mature females in the vines give rise to male and female phylloxera. Following mating the next generation females lay the overwintering egg of the leaf phylloxera.

Pest Management

Cultural Controls: The best line of defense against phylloxera, are rootstocks developed from grapes native to North America, which are resistant to grape phylloxora. Planting vines certified free from grape phylloxera is an important practice to prevent the introduction of this pest into non-infested areas. Dormant, well-matured grape cuttings and grape plants may be treated against the pest by washing all soil from the cuttings and / or roots and treating them with hot water. Monitoring the leaf feeding cycle of the pest depends on timely visual observations. Common predator species, including lacewing nymphs, minute pirate bugs and predatory fly larvae, help control populations.

Resistant cultivars: The genetic make-up of hybrid grape varieties must be taken into account when managing this insect as some hybrid grape varieties have a large proportion of *V. vinifera* in their genetic composition which could increase their vulnerability to the grape phylloxera. Vinifera grapes are especially susceptible to phylloxera. Varieties highly susceptible to leaf feeding forms include: 'DeChaunac', 'Foch', 'Ventura', 'Baco Noir', 'Villard Noir', 'Le Commandant' and 'Chelois'

Chemical Controls: Pesticides registered for phylloxera control are listed in *Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada*.

Issues for Grape Phylloxera

1. Additional pest control products that can provide a quick knockdown of this pest and that are safe for pollinators are required.
2. Predictive models for grape phylloxera need to be validated for use under Canadian conditions to help time treatment decisions for this insect.
3. There is a need for the development of an improved management strategy for grape phylloxera.

European Red Mite (*Panonychus ulmi*), Two Spotted Spider Mite (*Tetranychus urticae*), Grape Erineum Mite (*Colomerus vitis*) and McDaniel Spider Mite (*T. mcdanieli*)

Pest Information

Damage: Adult and immature mites feed on plant sap. Light infestations result in small, chlorotic spots on leaves. Heavy infestations cause bronzing of the leaves and premature leaf drop. The McDaniel spider mite produces dense webs on foliage that may interfere with spray penetration. The grape erineum mite produces white, felt-like galls on lower leaf surfaces and can be a major stress to young vines. Severe stress can result in early drop of heavily infested leaves and slow establishment of new plantings.

Life Cycle: Mites overwinter on grapevines: the European red mite as eggs, two spotted spider mite as fertilized females and the erineum mites as adults under the bud scales. The McDaniel spider mite overwinters as masses of adult, diapausing females under bark scales or in dense webbing in debris at the base of grapevines. The mites become active in the spring and feed on young foliage. All species have several generations per season. Hot and dry conditions are conducive to the rapid build-up of mite populations.

Pest Management

Cultural Controls: Predatory mites and insects play an important role in the natural control of mites. The careful selection and use of pesticides is important to minimize their impact on natural controls. The use of mixed ground covers in the vineyard will reduce dust levels which favour mite populations and also provide a habitat for beneficial insects and predaceous mites. Irrigation to alleviate drought stress will result in conditions less favourable to the build-up of mite populations.

Resistant cultivars: None available.
Chemical Controls: Pesticides registered for the control of mites are listed in *Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada*.

Issues for European Red Mite, Two-Spotted Spider Mite, Grape Erineum Mite and McDaniel Spider Mite

1. The impact of fungicides and insecticide products on mite populations is of concern. Many are toxic to or repel beneficial and predatory mites. There is a need for control products that are compatible with beneficial mite species. Studies to develop criteria for the selection of pesticides that do not adversely affect beneficial mite species are required.
2. There is concern over the rapid development of resistance in mite populations to miticides. The registration of additional miticides with short pre-harvest intervals and new modes of action is required.
3. There is a need for additional research to determine the role of dormant oil applications, beneficial organisms and ground cover management in controlling mite populations.
4. There is a need for grower education on the use of purchased predator mites for mite control.
5. The expansion of the labels of registered miticides to include grape erineum mite is of importance. There has been a build-up of this mite in select vineyards and damage has now begun to impact crop yield. Although routine applications of sulphur have provided suppression of this pest in previous years, there are now vineyards that require a stronger material to effectively reduce the populations as crop loss and vine health is being affected.

Soft Scale Insects (Coccidae): European Fruit Lecanium (*Parthenolecanium corni*) and Cottony Maple Scale (*Pulvinaria innumerabilis*)

Pest Information

Damage: Adults and nymphs feed by sucking plant fluids from shoots and vines. Under heavy infestations, fruit, leaves and vines can become covered with honeydew excreted by the scales. The honeydew supports the growth of black sooty moulds and together can render the fruit unmarketable. The cottony maple scale is a vector of leafroll virus in grape. Feeding by scales weakens shoots and vines.
Life Cycle: Scales overwinter as immature scales on grape canes. Females mature in early summer and lay eggs beneath the scale covering. Crawlers that hatch from the eggs disperse to leaves on which they feed until the fall, after which they move back on the current year's canes and secrete the hardened shell covering to overwinter.

Pest Management

Cultural Controls: As healthy vines are less attractive to scales, following good cultural practices that minimize stress on the vines will reduce the likelihood of a scale infestation. The presence of scale insects can be detected through the use of sticky tape when crawlers are active.

Resistant cultivars: None available.

Chemical Controls: Refer to *Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada* for insecticides registered for the control of scale insects.

Issues for Soft Scales

None identified.

Grape Flea Beetle (*Altica chalybea*)

Pest Information

Damage: In the spring, adult flea beetles bore into swelling buds and hollow-out the inside. Buds become less susceptible to attack as they elongate. Flea beetle larvae and summer adults feed on tender leaf tissues but avoid the leaf veins. Feeding on the primary buds is by far the more serious damage caused by this insect resulting in yield loss and stunted growth from secondary or tertiary buds. There is no fruit development on canes where the primary and secondary buds are destroyed. Injury is more severe in years when bud development is prolonged by unfavourable weather conditions.

Life Cycle: Grape flea beetle overwinters as adults in protected locations in the and around the vineyard. In the spring, females lay eggs on the canes of the grapevine. After hatching, larvae feed on leaves and when fully grown, drop to the ground to pupate. Adults emerge and feed on grape leaves until the fall when they seek overwintering sites.

Pest Management

Cultural Controls: The elimination of plant debris from the vineyard and surrounding area will reduce overwintering sites. It is important to monitor the vineyard as buds swell in the spring for signs of flea beetle damage. Disking to control weeds between grape rows can expose pupae to desiccation.

Resistant cultivars: None identified.

Chemical Controls: Refer to *Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada* for insecticides registered for the control of grape flea beetle. Insecticide treatments applied post bloom against the grape berry moth will also help reduce grape flea beetle populations.

Issues for Grape Flea Beetle

1. Corn flea beetles (*Chaetochnema pulicaria*) are becoming more prevalent in southwestern Ontario, while the redheaded flea beetle (*Systena frontalis*) regularly attacks newly planted grape vines in Quebec. There is a need for the registration of products for the control of these insects.
2. The development of economic thresholds to determine the need for treatments for flea beetles is required.

Rose Chafer (*Macrodactylus subspinosus*)

Pest Information

Damage: Rose chafers feed on flowers, fruit and foliage of many plants including grape. In the spring, adult rose chafers feed on buds, flowers and foliage of grape, resulting in the destruction of blossoms and no fruit set and skeletonization of leaves. Larvae are found in the soil and feed on roots of a variety of plants. Rose chafers are more prevalent in areas with sandy soils.

Life Cycle: Rose chafers overwinter as larvae in the soil. Pupation and adult emergence occurs in the spring. Adults live for only a few weeks and following mating, lay eggs in the soil. Following hatch, larvae (white grubs) feed on roots of grass and weeds. There is one generation per year.

Pest Management

Cultural Controls: Cultivation of the soil between the rows will help destroy pupae. Visual monitoring for this pest can be done in late May through June.

Resistant Cultivars: None available.

Chemical Controls: Refer to *Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada* for insecticides registered for the management of rose chafer.

Issues for Rose Chafer

1. The rose chafer is becoming a problem in the production of grapes in Quebec. There is a need for the development of a management strategy for this insect that includes chemical and non-chemical approaches.

Japanese Beetle (*Popillia japonica*)

Pest Information

Damage: Japanese beetle adults are general feeders and will attack over 300 different plants. They feed on tender leaf tissues of grape, leaving a network of veins and causing browning of severely affected leaves. The impact of the feeding injury on grape is dependent on its severity and the health of the vine.

Life Cycle: The Japanese beetle has a one year life cycle. Adult beetles emerge from the soil in early summer, feed on plant foliage and mate and lay eggs in the soil. Following hatching, the larvae, known as white grubs, feed on plant roots in the upper 10 to 12 cm of soil. The larvae continue to feed on plant roots into the fall, overwinter, resume feeding in early spring, then pupate and emerge as adults.

Pest Management

Cultural Controls: Monitoring for adult beetles and damage can be done by visual inspection of plants from late June through August. Traps baited with attractants are available for monitoring Japanese beetles; however this approach may attract more beetles into the area than are subsequently controlled.

Resistant Cultivars: None available.

Chemical Controls: Insecticides registered for the control of Japanese beetle are listed in *Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada*.

Issues for Japanese Beetle

1. The use of biological controls for the management of Japanese beetle in grapes requires further investigation.
2. The registration of additional chemistries that can provide quick knockdown and a repellency effect for Japanese beetle is required.

Climbing Cutworms: Noctuidae

Pest Information

Damage: A number of species of climbing cutworms feed on buds and young leaves in the spring. Many buds on a single shoot may be destroyed.

Life Cycle: Cutworms overwinter as eggs or young larvae. In the spring, the cutworms feed on weeds and other vegetation. If weeds are destroyed from mid-May to mid-June, cutworms will have no source of food other than the grapevines. When mature, larvae pupate in soil, with adult moths emerging in the summer. Female moths are attracted to tall weeds and grasses where they lay their eggs in the soil. There is one generation per year.

Pest Management

Cultural Controls: Proper vegetation management will discourage egg-laying by the moths and deprive young cutworms of food hosts. Destroying weeds during the period from mid-May to mid-June should be avoided so the cutworms are not forced to feed on the vines. Vines should be examined daily during this period for signs of feeding. Cutworms feed at night, so they can only be detected visually during this period. Weed control in the fall, before new vineyards are planted, will help to minimize problems due to cutworms the following spring.

Resistant cultivars: None available.

Chemical Controls: Insecticides registered for the management of climbing cutworms are listed in *Table 9. Pesticides and biopesticides registered for the management of insect and mite pests of grape in Canada*.

Issues for Climbing Cutworm

1. Approaches to determining the need for treatment for climbing cutworm, including economic thresholds, require further development. The evaluation and registration of reduced risk materials including biopesticides, as sprays to groundcover, to grape foliage and as baits, is needed for cutworm control.
2. There is a need for continued work on vegetation management focusing on the use of different ground cover crops for cutworm management.
3. Problem cutworm species need to be identified in the field and specified on pesticide labels to ensure the effective use of pest control products.

Weeds

Key Issues

- There is a need for registration of broad spectrum contact herbicides with different modes of action in order to slow the development of glyphosate tolerance within weed populations, and to mitigate the impacts of resistant weed species including Canada fleabane.
- There is a need to investigate additional pre-emergent residual herbicides that are safe to use around young plantings and vines retaining suckers for trunk re-establishment.
- Weed management in low growing, semi-hardy varieties of grapes used in Quebec is difficult given the sensitivity of the vines to herbicides. There is a need to register new herbicides that are not toxic to the grape plants.
- There is a need for the development of organic weed control approaches for grape, and for grower education on these approaches.

Table 10. Occurrence of weeds in grape production in Canada

Weed	British Columbia	Ontario	Quebec	Nova Scotia
Annual broadleaf weeds	Red	Red	Red	Red
Perennial broadleaf weeds	Red	Grey	Red	Red
Canada thistle	Orange	Red	Orange	White
Dandelion	Red	Yellow	Red	Red
Field bindweed	Red	Red	Red	White
Plantain	White	White	Yellow	Orange
Vetch	Orange	Red	Red	Red
Wild grape	White	Grey	Yellow	White
Annual grass weeds	Red	Red	Red	Red
Perennial grass weeds	Red	Grey	Red	Red
Quackgrass	Orange	Red	Red	Red
Biennial weeds	Red	White	Red	Orange
Buttercup	Orange	White	Yellow	Red
Common burdock	Orange	White	Yellow	Orange
Common pepper-grass	Black	White	Yellow	White
Wild carrot	Black	Orange	Orange	Orange
Yellow rocket	Black	White	Yellow	White

- (Red) Widespread yearly occurrence with high pest pressure.
- (Orange) Widespread yearly occurrence with moderate pest pressure OR localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure.
- (Yellow) Widespread yearly occurrence with low pest pressure OR widespread sporadic occurrence with moderate pressure OR sporadic localized occurrence with high pressure.
- (White) Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low pressure OR localized sporadic occurrence with low to moderate pest pressure OR pest not of concern.
- (Black) Pest not present.
- (Grey) Data not reported.

[1]Source: Grape stakeholders in reporting provinces.

[2]Please refer to Appendix 1, for a detailed explanation of colour coding of occurrence data.

Table 11. Adoption of weed management practices in grape production in Canada[1]

	Practice / Pest	Annual broadleaf weeds	Perennial broadleaf weeds	Annual grass weeds	Perennial grass weeds	Biennial weeds
Avoidance	planting / harvest date adjustment					
	crop rotation					
	choice of planting site					
	optimizing fertilization					
	use of weed-free seed					
Prevention	equipment sanitation					
	mowing / mulching / flaming					
	modification of plant density (row or plant spacing; seeding)					
	seeding / planting depth					
	water / irrigation management					
	weed management in non-crop lands					
	weed management in non-crop years					
	tillage / cultivation					
Monitoring	scouting - field inspection					
	field mapping of weeds / record of resistant weeds					
	soil analysis					
	use of portable electronic devices in the field to access pest identification /management information					
	use of precision agriculture technology (GPS, GIS) for data collection and field mapping of pests					

…continued

Table 11. Adoption of weed management practices in grape production in Canada[1] (continued)

Practice / Pest		Annual broadleaf weeds	Perennial broadleaf weeds	Annual grass weeds	Perennial grass weeds	Biennial weeds
Decision-making tools	economic threshold					
	weather / weather-based forecast / predictive model					
	recommendation from crop specialist					
	first appearance of weed or weed growth stage					
	observed crop damage					
	crop stage					
Suppression	pesticide rotation for resistance management					
	soil amendments					
	biological pesticides					
	arthropod biological control agents					
	habitat / environment management					
	ground cover / physical barriers					
	mechanical weed control					
	targeted pesticide applications (banding, perimeter sprays, variable rate sprayers, GPS, etc.)					
This practice is used to manage this pest by at least some growers.						
This practice is not used by growers to manage this pest.						
This practice is not applicable for the management of this pest.						
Information regarding the practice for this pest is unknown.						

[1]Source: Stakeholders in grape producing provinces (British Columbia and Ontario).

Table 12. Herbicides and bioherbicides registered for the control of weeds in grape in Canada

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
carfentrazone-ethyl (hooded sprayer application)	triazolinone	inhibition of protoporphyrinogen oxidase (PPO)	14	R	broadleaf weeds
dichlobenil (established plantings)	nitrile	inhibition of cell wall (cellulose) synthesis	20	RES	many annual grasses, broadleaf weeds and certain perennial weeds
dimethenamid-p	chloroacetamide	inhibition of VLCFA (inhibition of cell division)	15	R	foxtail (green, yellow, giant), crabgrass (smooth, large), old witchgrass, barnyard grass, fall panicum, redroot pigweed, eastern black nightshade
diuron (vineyards established three years or more) (band application)	urea	inhibition of photosynthesis at photosystem II	7	R	annual weeds
fluazifop-p-butyl	aryloxyphenoxy-propionate 'FOP'	inhibition of acetyl CoA carboxylase (ACCase)	1	RES	grass weeds
flumioxazin (vineyards established two years or more)	N-phenylphthalimide	inhibition of protoporphyrinogen oxidase (PPO)	14	R	annual broadleaf weeds, green foxtail, dandelion

…continued

Table 12. Herbicides and bioherbicides registered for the control of weeds in grape in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
glufosinate ammonium (vineyards established three years or more) (eastern Canada only)	phosphinic acid	inhibition of glutamine synthetase	10	R	annual weeds
glyphosate	glycine	inhibition of EPSP synthase	9	RE	annual and perennial weeds, woody brush and trees
indaziflam	alkylazine	cellulose inhibitor	29	R	annual grasses and broadleaf weeds
methyl bromide (fumigant, pre-plant soil application)	alky halide[4]	miscellaneous non-specific (multi-site) inhibitor[4]	8A[4]	PO	damping-off organisms (fusarium, pythium and rhizoctonia), insects, nematodes, weed seeds
napropamide (established vineyards)	acetamide	inhibition of VLCFA (inhibition of cell division)	15	R	annual grasses and broadleaf weeds

…continued

Table 12. Herbicides and bioherbicides registered for the control of weeds in grape in Canada (continued)

Active Ingredient[1]	Classification[2]	Mode of Action[2]	Resistance Group[2]	Re-evaluation Status[3]	Targeted Pests[1]
paraquat (under grape vines established on trellises)	bipyridylium	photosystem-I-electron diversion	22	RES	grasses and broadleaf weeds
sethoxydim	cyclohexanedione 'DIM'	inhibition of acetyl CoA carboxylase (ACCase)	1	R	annual grasses, wild oats, volunteer cereals, quackgrass
simazine and related triazines (vineyards established three years or more, eastern Canada only)	triazine	inhibition of photosynthesis at photosystem II	5	RES	annual weeds, most perennial species starting freshly from seed

[1]Source: Pest Management Regulatory Agency label database (www.hc-sc.gc.ca/cps-spc/pest/registrant-titulaire/tools-outils/label-etiq-eng.php). The list includes all active ingredients registered as of March 2, 2016. The product label is the final authority on pesticide use and should be consulted for application information. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The information in this table should not be relied upon for pesticide application decisions and use.

[2]Source: Herbicide Resistance Action Committee (HRAC). *Classification of Herbicides According to Site of Action* (www.hracglobal.com) (accessed February 12, 2016). Herbicide resistance groups are based on the Weed Science Society of America classification system as reported by HRAC.(www.hracglobal.com).

[3]PMRA re-evaluation status: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review, as published in PMRA *Re-evaluation Note REV2016-07, Pest Managment Regulatory Agency Re-evaluation and Special Review Workplan 2015-2020*, DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA as published in PMRA *Re-evaluation Decision document RRD2004-01, Re-evaluation of Methyl Bromide*.

[4]Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (Version 8.0; december 2015)* (www.irac-online.org) (accessed February 15, 2016).

All weeds

Pest Information

Damage: Weeds compete with grapevines for moisture and nutrients, may harbour disease and insect pests and can provide shelter for problematic rodents. New vines can lose a year's growth if there is significant weed competition and may die if water or nutrients are a limiting factor. On older vines, weed competition can result in crop loss through the production of smaller fruit and reduced fruit bud set for the following growing season.

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

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

Perennial weeds: Perennial weeds are plants that live for many years. They spread through seeds as well as through the expansion of various types of root systems and other vegetative means.

Pest Management

Cultural Controls: The cultivation, fallowing or mowing of surrounding fields, ditches and road areas, will prevent weeds from flowering and producing seed that could potentially be blown into the vineyard. In the vineyard, a biodegradable plastic mulch or straw mulch can be used for weed control in the planting strip. A green manure crop of rye-grass or Sudan grass planted the year before establishing the vineyard, combined with fallow periods, can stimulate weed seed germination and deplete the weed seed bank in the soil. Mulch and manure used in the vineyard which is free from weed seeds will prevent the introduction of new weeds. Planting grapevines into established sod that has been chemically killed before planting will also reduce the need for herbicides in the year of planting. Although helpful, mowing alone will not eliminate weeds. Establishing vigorous sod between rows reduces weed pressure. Hand removal of new weed species or resistant biotypes may be an important method of stopping new problem weeds from becoming established.

Resistant cultivars: None available.

Chemical Controls: Refer to *Table 12. Herbicides and bioherbicides registered for the control of weeds in grape in Canada.*

Issues for Weeds

1. There is concern that heavy reliance on glyphosate herbicides has led to resistance in Canada fleabane, select thistle species, henbit and other weed species. As well, weed species that are tolerant to glyphosate are becoming more prevalent (e.g. field bindweed and vetch). There is a need to register additional contact herbicides that are effective on a wide range of broadleaf weeds and grasses, to reduce the reliance on glyphosate based herbicides.
2. Additional, pre-emergent, residual herbicides, that are safe to use around young plantings and vines retaining suckers for trunk re-establishment, are required,
3. There is concern that newly developed, 2, 4-D ready seed will result in more 2, 4-D applied to field crops within grape production areas. As grapes are extremely sensitive to this herbicide, there is concern that there will be an increase in injury to grapes from herbicide drift.
4. There is a need for the development and communication to growers of organic approaches to weed control in grape.
5. The use of low growing, semi hardy varieties in Québec makes the use of herbicides for weed control difficult. There is a need to register new herbicides that are not toxic to the grape plants.

Resources

IPM/ICM resources for production of Grape in Canada

Agri-Réseau, www.agrireseau.qc.ca

British Columbia Wine Council. *2010 Best Practices Guide for Grapes for British Columbia Growers*
www.bcwgc.org/best-practices-guide

British Columbia Ministry of Agriculture. Grape Factsheets and Publications
www.al.gov.bc.ca/grape/factsheets.htm

Health Canada, Pest Management Regulatory Agency
www.hc-sc.gc.ca/cps-spc/pest/index-eng.php

Odile, Carisse, Réjean Bacon, Jasques Lasnier and Wendy McFadden-Smith. 2006 . *Identification Guide to the Major Diseases of Grapes*. Agriculture and Agri-Food Canada, Publication 10092E. Catalogue No. A52-74/2006E-PDF
http://publications.gc.ca/site/eng/home.html

Ontario Ministry of Agriculture, Food and Rural Affairs. *Guide to Fruit Production*, 2014-15, Publication 360. 310 pp.
www.omafra.gov.on.ca/english/crops/pub360/p360toc.htm

Ontario Ministry of Agriculture, Food and Rural Affairs. *Grapes in Ontario (Factsheets, Infosheets and Publications)* www.omafra.gov.on.ca/english/crops/hort/grape.html

Ontario Ministry of Agriculture, Food and Rural Affairs
Ontario Grape IPM, www.omafra.gov.on.ca/IPM/english/grapes

Perennia. Fruit Production grape (factsheets, management guides, other)
http://perennia.ca/fruit.php

Saguez, Julien, Chrystal Olivier, Jacques Lasnier, Andy Hamilton, Lorne Stobbs and Charles Vincent. 2015. *Biology and integrated management of leafhoppers and phytoplasma diseases in vineyards of eastern Canada*. Agriculture and Agri-Food Canada, AAFC No. 12429E. Catalogue No. A59-32/2015E-PDF
http://publications.gc.ca/site/eng/home.html

Provincial Crop Specialists and Provincial Minor Use Coordinators

<table>
<tr><th>Province</th><th>Ministry</th><th>Crop Specialist</th><th>Minor Use Coordinator</th></tr>
<tr><td>British Columbia</td><td>British Columbia Ministry of Agriculture
www.gov.bc.ca/agri</td><td>Jim Campbell, Industry Specialist - Tree Fruit and Grape
jim.g.campbell@gov.bc.ca</td><td>Caroline Bédard
caroline.bedard@gov.bc.ca</td></tr>
<tr><td>Ontario</td><td>Ontario Ministry of Agriculture, Food and Rural Affairs
www.omafra.gov.on.ca/english/index.html</td><td>Wendy McFadden-Smith, Tender Fruit and Grape IPM Specialist
wendy.mcfadden-smith@ontario.ca</td><td>Jim Chaput
jim.chaput@ontario.ca</td></tr>
<tr><td>Quebec</td><td>Ministère de l'Agriculture, Pêcheries et de l'Alimentation du Québec
www.mapaq.gouv.qc.ca</td><td>Karine Bergeron
karine.bergeron@mapaq.gouv.qc.ca</td><td>Luc Urbain
luc.urbain@mapaq.gouv.qc.ca</td></tr>
<tr><td rowspan="2">Nova Scotia</td><td>Nova Scotia Department of Agriculture
www.novascotia.ca/agri</td><td>N/A</td><td rowspan="2">Jason Sproule
sprouljm@gov.ns.ca</td></tr>
<tr><td>Perennia
www.perennia.ca</td><td>Rachel Cheverie, Horticulture Crop Specialist
rcheverie@perennia.ca</td></tr>
</table>

National and Provincial Grape Grower Organizations

British Columbia Grape Growers Association (www.grapegrowers.bc.ca/)

Canadian Horticultural Council (www.hortcouncil.ca)

Grape Growers Association of Nova Scotia (www.agriguide.ca/organization/grape-growers-association-of-nova-scotia)

Grape Growers of Ontario (www.grapegrowersofontario.com/growers

L'Association des vignerons du Québec (http://vinsduquebec.com/)

Ontario Fruit and Vegetable Growers Association (www.ofvga.org)

Appendix 1

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

Information on the occurrence of disease, insect and mite and weed pests in each province is provided in Tables 4, 7 and 10 of the crop profile, respectively. The colour coding of the cells in these tables is based on three pieces of information, namely pest distribution, frequency and pressure in each province as presented in the following chart.

<table>
<tr><th>Presence</th><th colspan="4">Occurrence information</th><th rowspan="2">Colour Code</th></tr>
<tr><td rowspan="15">Present</td><td rowspan="13">Data available</td><th>Frequency</th><th>Distribution</th><th>Pressure</th></tr>
<tr><td rowspan="6">Yearly - Pest is present 2 or more years out of 3 in a given region of the province.</td><td rowspan="3">Widespread - The pest population is generally distributed throughout crop growing regions of the province. In a given year, outbreaks may occur in any region.</td><td>High - If present, potential for spread and crop loss is high and controls must be implemented even for small populations.</td><td>Red</td></tr>
<tr><td>Moderate - If present, potential for spread and crop loss is moderate: pest situation must be monitored and controls may be implemented.</td><td>Orange</td></tr>
<tr><td>Low - If present, the pest causes low or negligible crop damage and controls need not be implemented.</td><td>Yellow</td></tr>
<tr><td rowspan="3">Localized - The pest is established as localized populations and is found only in scattered or limited areas of the province.</td><td>High - see above</td><td>Orange</td></tr>
<tr><td>Moderate - see above</td><td>White</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="6">Sporadic - Pest is present 1 year out of 3 in a given region of the province.</td><td rowspan="3">Widespread - as above</td><td>High - see above</td><td>Orange</td></tr>
<tr><td>Moderate - see above</td><td>Yellow</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="3">Localized - as above</td><td>High - see above</td><td>Yellow</td></tr>
<tr><td>Moderate -see above</td><td>White</td></tr>
<tr><td>Low - see above</td><td>White</td></tr>
<tr><td rowspan="2">Data not available</td><td colspan="3">Not of concern: The pest is present in commercial crop growing areas of the province but is causing no significant damage. Little is known about its population distribution and frequency in this province; however, it is not of concern.</td><td>White</td></tr>
<tr><td colspan="3">Is of concern: The pest is present in commercial crop growing areas of the province. Little is known about its population distribution and frequency of outbreaks in this province and due to its potential to cause economic damage, is of concern.</td><td></td></tr>
<tr><td>Not present</td><td colspan="4">The pest is not present in commercial crop growing areas of the province, to the best of your knowledge.</td><td>black</td></tr>
<tr><td>Data not reported</td><td colspan="4">Information on the pest in this province is unknown. No data is being reported for this pest.</td><td>grey</td></tr>
</table>

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