Crop Profile for Grape in Canada, 2016

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Pest Management Program

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Preface

National crop profiles are developed by the Pest Management Program of Agriculture and Agri-Food Canada (AAFC). 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 here 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 more recently in Quebec, 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.

Nova Scotia's first commercial vineyard was planted in 1978. There, the industry relies heavily on hybrid varieties, however it continues to grow and evolve and is experimenting with more *V. vinifera* varieties.

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. Fresh grapes are high in Vitamin C, potassium and phosphorous minerals.

Crop Production

Industry Overview

In 2016, total grapes, including table and wine grapes, ranked 3rd in farm gate production among all fruits grown in Canada (Statistics Canada, CANSIM database, Table 001-0009). Total farm gate value for grapes reached $162 million for the country.

Canadian exports of fresh grapes, including a small fraction of raisins, reached $3.8 million. Grape juice exports, including high and low Brix juice, were $7 million. Canadian wine exports increased to $90.5 million for a grand total of $101 million value for Canadian grape related exports.

Wine grape production totaled 76,362 metric tons on 12,180 hectares for a farm gate value of $111 million (Table 1).

Vintners Quality Alliance (VQA) Standards are applied in Ontario and British Columbia, and are regulated by the Vintners Quality Alliance of Ontario and the British Columbia Wine Institute, respectively. These types of certifications are gaining ground across Canada, allowing growers to obtain a premium for the production of high quality grapes. For example, Ontario VQA standards for wines request a minimum of 17 Brix degrees (except for sparkling wine).

Canada's wine sector is growing, with the industry generating revenues of $1.2 billion in 2016 and employing over 5,600 people. The new Canadian Grapevine Certification Network will further support growth of the sector through pan-Canadian, coordinated research activities related to grapevine health, and fruit and wine quality.

Table 1. General production information in Canada, 2016

	Grapes
Canadian Production[1]	105,802 metric tonnes 12,627 hectares
Farm Gate Value[1]	$162 million
Fresh Grape Consumption[2] **Grape Juice Consumption[2]** **Wines, Population 15 years old and older[2]**	4.29 kg/ person 3.33 litres/ person 16.30 litres/ person
Grape and Wine Exports	Grapes (fresh[3]): $3.8 million Grape juice (low[4] and high[5] brix): $7.0 million Wines: $90.5 million **Total Exports: $101.3 million**
Grape and Wine Imports	Grapes (fresh[3]): $652.6 million Grape Juice (low[4] and high[5] brix): $66.8 million Wines: $2.4 billion **Total Imports: $3.1 billion**

[1] Statistics Canada. Table 32-10-0417-01 (Formerly CANSIM Table 004-0214) - Fruits, berries and nuts (database, accessed 2018-071-05).
[2] Statistics Canada. Table 32-10-0053-01 (Formerly CANSIM Table 002-0010) - Supply and disposition of food in Canada (database, accessed 2018-07-05).
Statistics Canada. Trade Data Online (Reports): [3] HS 806-Grapes-Fresh or Dried; HS 2204-Grapes-Wines; [4] HS 200961-Low Brix-Grape Juice; [5] HS 200969-High Brix-Grape Juice (Database accessed 2018-07-12).

Production Regions

Grapes are produced in Ontario (7,540 ha or 60% of national acreage), British Columbia (3,918 ha or 31% of the national acreage), Quebec (755 ha or 6% of the national acreage) and most recently, Nova Scotia reported 341 ha or 3% of the national acreage) (refer *Table 2. Distribution of grape production in Canada*). There is also an interest in the development of a commercial industry in New Brunswick and Prince Edward Island, but the climate may not be as suitable in these areas.

In Ontario, the majority of production occurs within the Niagara Peninsula (87%) along the southern shore of Lake Ontario. The remainder is mostly along the northern shore of Lake Erie and on Pelee Island (8%) 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, in the Okanagan Valley (84%), followed by the Coastal Areas producing the balance of the commercial grapes in BC. In Quebec, the Eastern Townships are the main area of production.

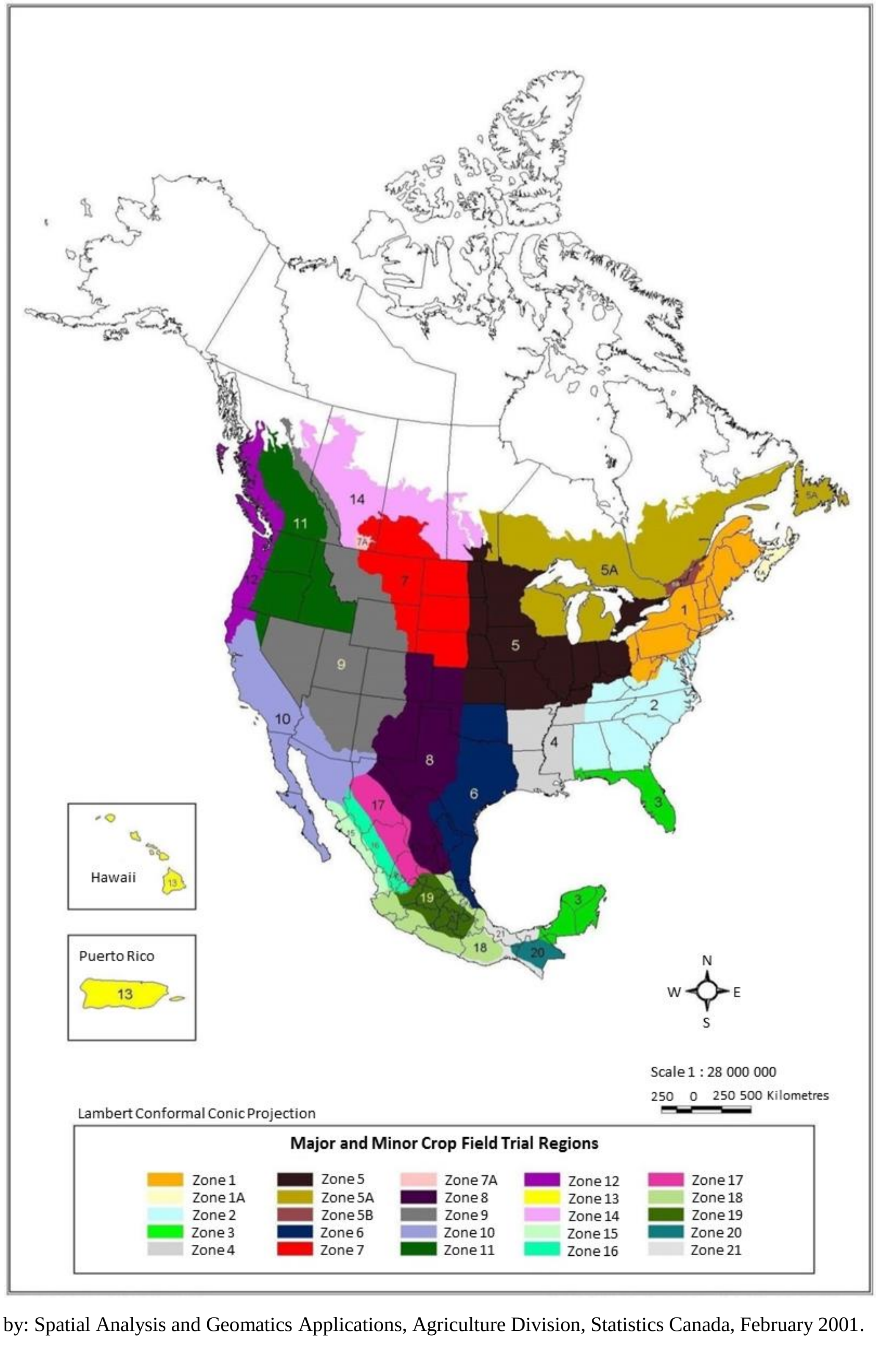
Table 2. Distribution of grape production in Canada, 2016

Production Regions	Cultivated area[1] (hectares) and percentage ( )	Marketed production[1] (metric tonnes) and percentage ( )	Farm gate value[1] ($)
British Columbia	3,918[r] ha (31%)	29,540[r] m. t. (28%)	$57.1[r] million
Ontario	7,540[r] ha (60%)	72,449[r] m. t. (70%)	$96.3[r] million
Quebec	755[r] ha (6%)	2,106[r] m.t. (2%)	$5,0[r] million
Nova Scotia	341[r] ha (3%)	x	x
Canada	12,627[r] ha	105,802[r] m. t.	$161.9[r] million

North American Major and Minor Field Trial Regions

Major and minor crop field trial regions (Figure1) were developed following stakeholder consultation and 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]



[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 processing grapes that is those 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.

Growers are advised to use certified virus-free nursery stock 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 and 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 and Nova Scotia. Several vineyards in Quebec installed irrigation systems in 2016.

Table 3. Grape production and pest management schedule in Canada

Time of Year	Activity	Action
November to March (plants are dormant)	Plant care	Check vines for winter damage. Prune vines and tie to desired training system. Hilling of vines for winter protection of graft union in colder climates.
	Insect and mite control	Monitor overwintering European red mite populations.
April (woody bud stage)	Plant care	Finish tying vines. Continue pruning vines (Quebec).
	Soil Care	Plough under fall planted green manure crop; apply lime as needed.
	Disease control	Prepare sprayer for early season fungicide applications for phomopsis diseases or anthracnose; spray as needed.
April (bud burst)	Plant care	Irrigate as needed. Remove winter protection, if used.
	Soil care	Cultivation for and/or planting of new cover 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 and tying (Quebec).
	Soil care	Apply fertilizers to the soil as needed, including first split application of nitrogen. Remove hill from around the base of vines.
	Disease control	Apply control for early season disease management.
	Insect and mite control	Apply mating disruption products for grape berry moth; monitor for grape flea beetles and early phylloxera.
	Weed control	Apply weed controls if needed.
June (shoot growth)	Soil care	Plant cover crop. Apply first split application of nitrogen (Quebec).
	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, anthracnose 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 diseases as necessary
	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; continued shoot positioning as required
	Disease control	Apply controls for disease as required.
	Insect and mite control	Monitor for leafhoppers and Japanese beetles (Ontario) and apply controls if needed; conventional insecticides timed for egg hatch 2nd generation 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 fordiseases if needed.
late July (post-bunch closure)	Plant care	Further hedging if needed; further leaf removal around bunches. Foliar fertilization if deficiency indicated by leaf analysis.
	Soil care	Manage and mow mid-rows / cover crops to maintain airflow across vineyard floor.
	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. Install bird netting as required.
	Disease control	Apply controls for diseases 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, MALB and wasps if needed.
September to November (post-harvest)	Plant care	Visually inspect vineyard wood quality. Irrigate as needed.
	Soil care	Take soil samples; apply lime following leaf drop if indicated.
	Disease control	Apply 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 -8°C.

Abiotic Factors Limiting Production

Millerandage

Adverse weather conditions during flowering can result in poor pollination of grape flowers, resulting in millerandage (shotberries), 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

- There is significant concern over the development of resistance to available fungicides within pathogen populations, particularly in the case of powdery mildew, botrytis, black rot, anthracnose 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, leaf spot, powdery mildew, and anthracnose.
- 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, crown gall and phytoplasma diseases pathogens. A nursery stock certification system is needed to ensure the production and distribution of disease/virus-free stock.
- 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. With many older fungicides being re-evaluated, there is a need to ensure access to efficacious, sustainable, and multi-site pest management products that are economical and can be used as resistance management tools. In particular, there is concern that some multiple sites 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 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.

…continued

Key Issues (continued)

- Further research is required to investigate the presence of Black Foot Disease (*Campylocarpon* spp.) in eastern Canada vineyards. Resistant rootstocks, clean nursery stock and the use of mycorrhizal fungus are all areas that require further examination.
- There is a need for funding a comprehensive virus survey to establish industry baselines regarding the number of vineyards with grapevine leafroll virus (GLRaV) and red blotch virus (GRBaV) present. Also, additional research is required to determine if there are any possible insect vectors of GRBaV.
- 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, black rot, botrytis and anthracnose.
- Given the lack of products available for management of bacterial diseases, there is a need to investigate the use of antagonistic bacteria, antibiotic materials and mycorrhizae for controlling crown gall.

Table 4. Occurrence of diseases in grape production in Canada[1,2]

Disease	British Columbia	Ontario	Quebec	Nova Scotia
Angular leaf scorch	[Grey]	[Black]	[Orange]	[Black]
Anthracnose	[Grey]	[Light blue]	[Red]	[White]
Black rot	[Grey]	[Red]	[Red]	[White]
Botrytis bunch rot	[Red]	[Red]	[Red]	[Red]
Downy mildew	[Black]	[Red]	[Orange]	[Orange]
Phomopsis cane and leaf spot	[White]	[Yellow]	[Orange]	[Yellow]
Powdery mildew	[Red]	[Red]	[Red]	[White]
Crown gall	[White]	[Yellow]	[Orange]	[Red]
Vine decline (esca)	[Orange]	[Grey]	[White]	[White]
Sour rot (yeast)	[Yellow]	[Red]	[White]	[White]
Virus diseases	[Orange]	[Orange]	[Light blue]	[Light blue]
Grapevine Leafroll Virus	[Orange]	[Orange]	[Grey]	[Light blue]
Grapevine red blotch-associated virus	[White]	[Orange]	[Grey]	[Grey]

[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 pest 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.
[Light blue]	Pest is present and of concern, however little is known of its distribution, frequency and importance.
[Black]	Pest not present.
[Grey]	Data not reported.

[1]Source: Grape stakeholders in reporting provinces (British Columbia, Ontario, Quebec and Nova Scotia). The data reflect the 2016, 2015 and 2014 production years.

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

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

	Practice / Pest	Botrytis bunch rot	Downy mildew	Phomopsis cane and leaf spot	Powdery mildew	Virus diseases
Avoidance	Varietal selection / use of resistant varieties					
	Planting / harvest date adjustment					
	Rotation with non-host crops					
	Choice of planting site					
	Optimizing fertilization for balanced growth and to minimize stress					
	Minimizing wounding and insect damage to limit infection sites					
	Use of disease-free propagative materials (seed, cuttings or transplants)					
Prevention	Equipment sanitation					
	Canopy management (thinning, pruning, row or plant spacing, etc.)					
	Manipulating seeding / planting depth					
	Irrigation management (timing, duration, amount) to minimize disease infection periods and manage plant growth					
	Management of soil moisture (improvements in drainage, use of raised beds, hilling, mounds, etc.)					
	End of season or pre-planting crop residue removal / management					
	Pruning out / removal of infected material throughout the growing season					
	Removal of other hosts (weeds / volunteers / wild plants) in field and vicinity					

…continued

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

Practice / Pest		Botrytis bunch rot	Downy mildew	Phomopsis cane and leaf spot	Powdery mildew	Virus diseases
Monitoring	Scouting / spore trapping					
	Maintaining records to track diseases					
	Soil analysis for the presence of pathogens					
	Weather monitoring for disease forecasting					
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of diseases					
Decision making tools	Economic threshold					
	Use of predictive model for management decisions					
	Crop specialist recommendation or advisory bulletin					
	Decision to treat based on observed disease symptoms					
	Use of portable electronic devices in the field to access pathogen / disease identification / management information					
Suppression	Use of diverse product modes of action for resistance management					
	Soil amendments and green manuring involving soil incorporation as biofumigants, to reduce pathogen populations					
	Biopesticides (microbial and non-conventional pesticides)					
	Controlled atmosphere storage					
	Targeted pesticide applications (banding, spot treatments, use of variable rate sprayers, etc.)					
	Selection of pesticides that are soft on beneficial insects, pollinators and other non-target organisms					

…continued

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

New practices (by province)	Using the trellis system 'Vertical shoot positioning (VSP)' (British Columbia)					
This practice is used to manage this pest by at least some growers in the province.						
This practice is not used by growers in the province to manage this pest.						
This practice is not applicable for the management of this pest						
Information regarding the practice for this pest is unknown.						

[1]Source: Grape stakeholders in reporting provinces (British Columbia and Ontario). The data reflect the 2016, 2015 and 2014 production years.

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.

Issues for Angular Leaf Scorch

1. There are no fungicides currently registered for angular leaf scorch. This disease is present in Quebec and there is a need to register effective products for both organic and conventional production systems.

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.

Issues for Anthracnose

1. There is a need for the registration of protectant products that can be used early during the season when infection from Anthracnose typically occurs and that are safe to use (i.e. do not cause foliar burning) on susceptible hybrid cultivars. This disease is more prevalent in eastern Canada (Quebec & Nova Scotia) where susceptible hybrid cultivars are being grown.

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. Infections need a minimal 6-hour period of wetness with temperatures between 10 and 21°C. Berries and leaves are very susceptible to infection for the first two to three weeks after bloom and become less susceptible 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: V. vinifera cultivars are very susceptible to this disease.

Issues for Black Rot

1. The development of a predictive model is required for growers to more accurately time fungicide applications for Black Rot. Cultivar susceptibility must be considered as more susceptible hybrid cultivars (e.g. Frontenac) are being planted in eastern Canada.
2. With many of the older products being re-evaluated, 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.

3. Currently there are no organic materials registered with efficacy on black rot. There is a need for organically suitable materials which is acceptable under all organic certification programs.

Botrytis Bunch Rot (*Botrytis cinerea*)

Pest Information

Damage: Botrytis causes blight on 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.

Issues for Botrytis Bunch Rot

1. 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. Further studies on the effect of calcium to strengthen berry skins, reduce berry split and subsequent botrytis infections 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 calcium sprays and gibberellic acid on botrytis bunch rot development.
4. There are anecdotal reports of botrytis control and reduced infection of up to 50% with the timely removal of the old flowers by blowing or shaking the canopy immediately post-bloom. There is a need to further investigate this practice and conduct side-by-side comparisons in susceptible cultivars.

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.

Issues for Downy Mildew

1. Fungicides with broad spectrum, multi-site activity are important management tools for downy mildew. There is concern that many older multi-site fungicides are currently under review and additional usage restrictions may be imposed or the material phased out

completely. 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 (e.g. DMCast, Dmodel, RIMpro) have been developed. There is a need to evaluate these models and to validate the most suitable for use in Canada.
3. There is grower interest in investigating more compounds with post-infection or anti-sporulant properties. This will provide more management options if an infection event takes place.

Phomopsis Cane and Leaf Spot *(Phomopsis viticola)*

Pest Information

Damage: Petioles, rachises (central fruit stems), shoots and fruit can be affected by phomopsis which causes small dark spots, with yellow margins on the 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, combined with cooler temperature (23°C). Spores are released only in early 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 cultivars. Some cultivars, such as DeChaunac, Ste-Croix and Elvira are more susceptible, whilst Baco Noir, Maréchal Foch, Seyval Blanc and Vandal Cliche are somewhat less susceptible.

Issues for Phomopsis Cane and Leaf Spot

1. The potential loss of products in the multi-site inhibitors (group M) , as a result of re-evaluation is of concern as they are effective products available for phomopsis control and are important in a resistance management program. The registration of new products is required.
2. With more hybrid grape cultivars being grown across Canada, there is interest in validating available American phomopsis predictive models for the cultivars and growing conditions associated with each production area. Cultivar susceptibilities would be an important consideration in the validation of these models.

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

Pest Information

Damage: Powdery mildew symptoms can be seen on foliage, fruit, flower parts and canes. Mildew usually appears first as whitish or greenish-white powdery patches on the undersides of basal leaves. It may cause mottling or distortion of severely infected leaves, as well as leaf curling and withering. Lateral shoots are very susceptible. Infected blossoms may fail to set fruit. Berries are most susceptible to infection during the first three to four weeks after bloom, but shoots, petioles and other cluster parts are susceptible all season. Infected berries may develop a netlike pattern of russet and may crack open and dry up or never ripen at all. Old infections appear as reddish-brown areas on dormant canes. Early powdery mildew infections can cause reduced berry size and reduced sugar content. Scarring and cracking of berries may be so severe as to make fruit unsuitable for any purpose. Winemakers have a very low tolerance for powdery mildew on grapes. Research has shown that infection levels as low as 3% can taint the wine and give off-flavours.

Life Cycle: Powdery mildew fungus overwinters as chasmothecia (tiny, round, black fruiting bodies), in bark, canes, left-over fruits, and on leaves left on the ground. Spores (ascospores) from the overwintering chasmothecia are released in the spring after a rainfall of at least 2.5 mm. For primary infection to occur the spores require at least 12-15 hours of continuous wetness at 10-15°C to infect developing plant tissue. Once primary infection has occurred the disease switches to its secondary phase. Patches of white powdery mildew develop in 7 to 10 days. Millions of spores (conidia) are spread by wind causing more infections. Disease spreads quickly in early summer when temperatures are moderate. The time between infection and the production of spores can be as short as 5 to 6 days under optimal temperatures. High temperature and sunlight inhibit powdery mildew. Extended periods of hot weather (>32°C) will slow the reproductive rate of grape powdery mildew, as well as reduce spore germination and infection.

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 powdery mildew development. Irrigation and fertilization must be managed to avoid excessive vegetative growth which also favours disease development. Disease prediction models have been developed in California which have been modified and validated in different American states, and also in Germany and Australia. In Quebec, the CIPRA Disease prediction model has been linked to a high risk index for powdery mildew when grapes have reached 600-700 degree-days.

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

Issues for Powdery Mildew

1. Resistance management in Powdery Mildew is of great concern. Strains of Powdery Mildew resistant to sterol inhibiting (DMI) and strobilurin fungicides have been well documented. There is a continual 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 California needs to be validated and potentially modified for their applicability to Canadian conditions (west and east coast).

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. The gall formation on the aerial part of the vines is the most common symptom associated with crown gall. Galls on roots of grape are not typical but the bacteria can induce a localized necrosis of roots. The surface becomes open and the texture becomes moderately hard and very rough. Young galls are soft, creamy to greenish in colour, with no bark or covering, as they age, the tissue darkens to brown. Galled canes produce inferior shoot growth and surface tissue of the galls turns black as it dies, but the bacterium remains alive in the vine. 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. Most grape cultivars are susceptible to crown gall. The occurrence of crown gall from year to year appears to be related to the severity of the preceding winter and the maturity of the vines.

Pest Management

Cultural Controls: Avoiding replanting in old vineyards where crown gall was present for at least 2 years following grape vine removal will minimise the risk of crown gall becoming established in the new vineyard. This is important because crown gall bacteria can survive in the remnants of the old grape plants until the debris decomposes. Hot water treatment of vines is effective in reducing crown gall infection levels in planting materials and it is required for vines imported from France and Germany for the prevention of phytoplasma diseases. There is little that can be done to control this disease once it is established in the vineyard. However, suckers can be removed when shoots are small (3 to 6 cm) to reduce trunk damage and promote rapid healing. Removing larger shoots before they harden will also result in clean and small scars. Hilling young vines with 30 cm or more of soil or other material can protect them from cold temperatures. Galls can be removed by pruning below the affected tissue. Management practices that minimize the risk of cold injury are currently the only practical technique for managing the disease. 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. Certain rootstocks such as Courderc 3309, 101-14 Mgt, and Riparia Gloire are resistant, whereas Teleki 5C and 110 Richter are susceptible.

Issues for Crown Gall

1. The development of management practices that reduce physical damages to vine trunks and contribute to increased winter hardiness of vines, thereby minimizing the risk of Crown gall injury is required. It is important that information on best management practices be made available to growers to minimize problems due to crown gall.
2. The development of more resistant rootstocks is needed for managing crown gall.
3. A nursery stock certification system is essential to ensure the production and distribution of disease-free stock.
4. Need to maintain strict regulations on heat treatments at the nursery level as to not weaken vines, making them more susceptible to crown gall infections.

Sour Rots (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.

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 an effective management approach including the registration of control materials (possibly potassium

metabisulphate and biocarbonate products) with potential to slow down or provide 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 and wasps (e.g. yellow jackets) as disease vectors

Grapevine Leaf Roll Virus (GLRaV, genus *Closterovirus*) & Grapevine Red Blotch Virus (GRBaV, genus *Geminiviridae*)

Pest Information

Damage: Leaves of grapes cultivars susceptible to grapevine leafroll (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. Both red blotch (GRBaV) and leafroll (GLRaV) cause basal leaves in red varieties to turn red in late August through September. Leafroll symptoms show leaf veins stay green while the rest of the leaf turns red and roll downward. Red blotch does not cause leaves to roll, the red discolouration is blotchy and irregular and the smaller veins turn red rather than staying green. Fruit maturity is delayed and sugar content of fruit is reduced in virus infected plants. Infected vines are known to give grapes with low Brix accumulation, but the impact in cooler climates is not known at this time. 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 GLRaV and GRBaV virus are spread primarily through the movement of infected propagation material. GLRaV can be also transmitted locally from plant to plant by mealybugs and soft scale insects.

Pest Management

Cultural Controls: Removal of an infected vineyard is an economic decision - if the virus is present and significantly reducing Brix. To minimize contamination, the removed vines should be burned on the site of the vineyard rather than being moved elsewhere. 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 grapevine leafroll virus is most effective in the late summer when foliar symptoms are present. Suspect plants can be confirmed as infected through laboratory testing, and are then removed to prevent further spread of the disease. Control of insect vectors, including soft scales insects and mealybugs, will help limit virus spread.

Resistant cultivars: None available.

Issues for Grapevine Leaf Roll Virus & Grapevine Red Blotch Virus

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 a need to do a comprehensive virus survey in all major production areas to establish industry baselines regarding the presence of virus in vineyards.

4. Threshold levels and Best Management Practices (BMP) must be developed and communicated in a timely fashion to help growers properly make proper management decisions in virus infected blocks.
5. Proper testing is required at the nursery level in order to mitigate the spread of viruses through propagation. There is a need for a national certification standard for all grapevine propagation material (scion and rootstock) to prevent further spread of viral diseases.
6. There is a need to determine the potential insect vectors of GRBaV.

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.

Issues for Nematodes

1. The impact of nematodes is not well understood by growers. There are concerns as vineyards expand into areas with different soil textures and slopes. There is a need to investigate the impact of nematodes on early vine development and on long term productivity of the vines as well as have fumigation products available if required.

Fungicides, bactericides and biofungicides registered for disease management in grape production in Canada

Active ingredients registered for the management of **diseases** in grape are listed below in Table 6 *Fungicides, bactericides and biofungicides registered for disease management in grape production in Canada*. This table also provides registration numbers for products registered on grape containing these active ingredients in addition to information about chemical family and regulatory status. For guidance about active ingredients registered for specific **diseases**, the reader is referred to individual product labels on the PMRA label database https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management.html and to provincial crop production guides.

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

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
Agrobacterium radiobacter strain K84	21106	biological	N/A	unknown	unknown	R
ametoctradin	30322	triazolo-pyrimidylamine	45	C8: respiration	complex III: cytochrome bc1 (ubiquinone reductase) at Qo site, stigmatellin binding sub-site	R
ametoctradin + dimethomorph	30321	triazolo-pyrimidylamine + cinnamic acid amide	45 + 40	C8: respiration + H5: cell wall biosynthesis	complex III: cytochrome bc1 (ubiquinone reductase) at Qo site, stigmatellin binding sub-site + cellulose synthase	R + RE
Aureobasidium pullulans DSM 14940 and DSM 14941	31248	biological	N/A	unknown	unknown	R
Bacillus amyloliquefaciens strain D747 (synonym to *B.subtilis*)	31887, 31888	microbial: *Bacillus* spp. and the fungicidal lipopeptides they produce	44	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	R
Bacillus amyloliquefaciens strain MBI 600)	31887, 31888	microbial: *Bacillus* spp. and the fungicidal lipopeptides they produce	44	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	R

…continued

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

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
Bacillus subtilis strain QST 713	28549, 31666, 33035	microbial: *Bacillus* spp. and the fungicidal lipopeptides they produce	44	F6: lipid synthesis and membrane integrity	microbial disrupters of pathogen cell membranes	R
benzovindiflupyr	31522, 31981	pyrazole-4-carboxamide	7	C2: respiration	complex II: succinate dehydrogenase	R
benzovindiflupyr + difenoconazole	31526	pyrazole-4-carboxamide + triazole	7 + 3	C2: respiration + G1: sterol biosynthesis in membranes	complex II: succinate dehydrogenase + C14-demethylase in sterol biosynthesis (erg11/cyp51)	R + RE
BLAD polypeptide	31782, 32139	polypeptide (lectin)	BM01	BM: biologicals with multiple modes of action	BM: multiple effects on cell wall, ion membrane transporters; chelating effects	R
boscalid	30141	pyridine-carboxamide	7	C2: respiration	complex II: succinate-dehydrogenase	R
boscalid + pyraclostrobin	27985	pyridine-carboxamide + methoxy-carbamate	7 + 11	C2: respiration + C3: respiration	complex II: succinate-dehydrogenase + complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	R + R

…continued

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

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
canola oil	32408, 32819	not classified	N/A	unknown	unknown	R
captan	4559, 9582, 9922, 14823, 23691, 24613, 26408, 31949, 32300	phthalimide (electrophile)	M04	multi-site contact activity	multi-site contact activity	R (RVD2018-12)
citric acid + lactic acid	30110, 30468	not classified	N/A	unknown	unknown	R
copper (present as copper oxychloride)	13245, 19146	inorganic (electrophile)	M01	multi-site contact activity	multi-site contact activity	R
copper octanoate	31825	inorganic (electrophile)	M01	multi-site contact activity	multi-site contact activity	R
copper sulfate	9934	inorganic (electrophile)	M01	multi-site contact activity	multi-site contact activity	R
cyazofamid	27984, 30392	cyano-imidazole	21	C4: respiration	complex III: cytochrome bc1 (ubiquinone reductase) at Qi site	R
cyprodinil	25509	anilino-pyrimidine	9	D1: amino acids and protein synthesis	methionine biosynthesis (proposed) (cgs gene)	RE
cyprodinil + difenoconazole	30827	anilino-pyrimidine + triazole	9 + 3	D1: amino acids and protein synthesis + G1:sterol biosynthesis in membranes	methionine biosynthesis (proposed) (cgs gene) + C14-demethylase in sterol biosynthesis (erg11/cyp51)	RE + RE

…continued

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

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
cyprodinil + fludioxonil	28189, 30185	anilino-pyrimidine + phenylpyrrole	9 + 12	D1: amino acids and protein synthesis + E2: signal transduction	methionine biosynthesis (proposed) (cgs gene) + MAP/histidine-kinase in osmotic signal transduction (os-2, HoG1)	RE + RE
difenoconazole	30004	triazole	3	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	RE
dimethomorph	27700, 32026	cinnamic acid amide	40	H5: cell wall biosynthesis	cellulose synthase	RE
fenhexamid	25900	hydroxyanilide	17	G3: sterol biosynthsis in membranes	3-keto reductase, C4-demethylation (erg27)	RE
ferbam	20136, 20536	dithiocarbamate and relatives (electrophile)	M03	multi-site contact activity	multi-site contact activity	RE
fludioxonil + pydiflumetofen	33021	phenylpyrrole + N-methoxy-(phenyl-ethyl)-pyrazole-carboxamide	12 + 7	E2: signal transduction + C2:respiration	MAP/histidine-kinase in osmotic signal transduction (os-2, HOG1) + complexe II: succinate dehydrogenase	R (RVD2018-04) + R

…continued

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

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
fluopicolide	30050	pyridinylmethyl-benzamide	43	B5: cytoskeleton and motor proteins	delocalisation of spectrin-like proteins	RES
fluopyram	30509	pyridinyl-ethyl-benzamide	7	C2: respiration	complex II: succinate-dehydrogenase	R
fluopyram + pyrimethanil	30510	pyridinyl-ethyl-benzamide + anilino-pyrimidine	7 + 9	C2: respiration + D1: amino acid and protein synthesis	complex II: succinate-dehydrogenase + methionine biosynthesis (proposed) (cgs gene)	R + R
flutriafol	31679	triazole	3	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	R
fluxapyroxad	30565, 31697	pyrazole-4-carboxamide	7	C2: respiration	complex II: succinate-dehydrogenase	R
folpet	15654, 27733	phthalimide (electrophile)	M04	multi-site contact activity	multi-site contact activity	RE
fosetyl-Al	24458, 27688	ethyl phosphonate	P07	P7: host plant defence induction	phosphonate	RE
garlic powder	30601	biological	N/A	unknown	unknown	R

…continued

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

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
hydrogen peroxide	27432	inorganic	N/A	unknown	unknown	R (RVD2018-09)
hydrogen peroxide + peroxyacetic acid	32907	inorganic	N/A	unknown	unknown	R (RVD2018-09)
iprodione	15213, 24709	dicarboximide	2	E3: signal transduction	MAP/ histidine-kinase in osmotic signal transduction (os-1, Daf1)	R (RVD2018-16)
isofetamid	31555, 31758	phenyl-oxo-ethyl thiophene amide	7	C2: respiration	complex II: succinate-dehydrogenase	R
kresoxim-methyl	26257	oximino-acetate	11	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	RE
lime sulphur (calcium polysulphide)	16465	inorganic	M02	multi-site contact activity	multi-site contact activity	R
mancozeb	8556, 10526, 20553, 23655, 25396, 28217, 30241, 31267	dithiocarbamate and relatives (electrophile)	M03	multi-site contact activity	multi-site contact activity	RE (RVD2018-21)
mancozeb + zoxamide	26842	dithiocarbamate and relatives (electrophile)+ toluamide	M03 + 22	multi-site contact activity + B3: cytoskeleton and motor proteins	multi-site contact activity + ß-tubulin assembly in mitosis	RE + R

…continued

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

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
mandestrobin	32286 32288	methoxy-acetamide	11	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	R
mandipropamid	29074	mandelic acid amide	40	H5: cell wall biosynthesis	cellulose synthase	R
metalaxyl-M and S-isomer + mancozeb	25379, 25419, 28893	acylalanine + dithiocarbamate and relatives (electrophile)	4 + M03	A1: nucleic acids synthesis + multi-site contact activity	RNA polymerase I + multi-site contact activity	R + RE
methyl bromide	9564, 19498	alky halide[4]	8A[4]	miscellaneous non-specific (multi-site) inhibitor[4]	miscellaneous non-specific (multi-site) inhibitor[4]	PO[5]
metiram	20087	dithiocarbamate and relatives (electrophile)	M03	multi-site contact activity	multi-site contact activity	R (RVD2018-20)
metrafenone	29765	benzophenone	U8	unknown	actin disruption (proposed)	R
mineral oil	27666, 33099		not classified	N/A	unknown	R
myclobutanil	22399	triazole	3	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	R

…continued

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

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
oriental mustard seed	30263	not classified	N/A	unknown	unknown	R
phosphites (mono and dibasic sodium, potassium and ammonium phosphite	30449	not classified	N/A	unknown	unknown	R
polyoxin D zinc salt	32688, 32918	polyoxin	19	H4: cell wall biosynthesis	H4: chitin synthase	R
potassium bicarbonate	28095, 31091	diverse	N/A	not classified	unknown	R
pyraclostrobin + boscalid	27985	methoxy-carbamate + pyridine-carboxamide	11 + 7	C3: respiration + C2: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene) + complex II: succinate-dehydrogenase	R + R
pyriofenone	32376, 32534	benzoylpyridine	50	B6: cytoskeleton and motor protein	B6: actin / myosin/ fimbrin function	R
pyrimethanil	28011	anilino-pyrimidine	9	D1: amino acids and protein synthesis	methionine biosynthesis (proposed) (cgs gene)	R

…continued

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

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
quinoxyfen	29755	aryloxyquinoline	13	E1: signal transduction	signal transduction (mechanism unknown)	R
Reynoutria sachalinensis (extract)	30199	complex mixture, ethanol extract (anthraquinones resveratrol)	P05	P5: host plant defence induction	anthraquinone elicitors	R
spiroxamine	31959	spiroketal-amine	5	G2: sterol biosynthesis in membranes	reductase and isomerase in sterol biosynthesis (erg24, erg2)	R
Streptomyces lydicus strain WYEC 108	28672	biological	N/A	unknown	unknown	R
sulphur	873, 14653, 16465, 18836, 29487, 31869, 32475	inorganic (electophiles)	M02	multi-site contact activity	multi-site contact activity	R
tea tree oil (*Melaleuca alternifolia*)	30910	terpene hydrocarbons and terpene alcohols	46	F7: lipid synthesis and membrane integrity	cell membrane disruption (proposed)	R
tetraconazole	30673, 32042, 32200	triazole	3	G1: sterol biosynthesis in membranes	C14-demethylase in sterol biosynthesis (erg11/cyp51)	R

…continued

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

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Target Site[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
trifloxystrobin	27529, 30619, 30427	oximino-acetate	11	C3: respiration	complex III: cytochrome bc1 (ubiquinol oxidase) at Qo site (cyt b gene)	R
zoxamide	26840	toluamide	22	B3: cytoskeleton and motor proteins	ß-tubulin assembly in mitosis	RE

[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 September 27, 2018.** While every effort has been made to ensure all fungicides, bactericides and biofungicides registered in Canada on grape have been included in this list, some active ingredients or products may have been inadvertently omitted. 'Numerous products' is entered where there are more than ten products for an active ingredient. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The product label is the final authority on pesticide use and should be consulted for application information. 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 2018: Fungicides sorted by mode of action (including FRAC code numbering).* February 2018. (www.frac.info/) (accessed August 20, 2018).

[3]PMRA re-evaluation status as published in Re-evaluation Note REV2018-06, Pest Management Regulatory Agency Re-evaluation and Special Review Work Plan 2018-2023 and other re-evaluation documents: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review. Other codes include: DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

[4] Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (Version 8.4; May 2018)* (www.irac-online.org) (accessed August 23, 2018).

[5]As published by Government of Canada: *Notice to anyone engaged in the use of methyl bromide: June 2017 https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/notice-use-methyl-bromide-june-2017.html*

Insects and Mites

Key issues

- 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 spotted wing drosophila (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 also attract and kill approaches.
- With many of the older products being re-evaluated, there is a need to ensure access to efficacious, sustainable, and multiple sites of pest management products that are economical and can be used as resistance management tools.
- With concerns about resistance development and the potential de-registration of uses due to concerns about toxicity to bees, there is a continued need to register new chemical products. In particular, products compatible with pollinators, and with efficacy against spotted wing drosophila (SWD), grape mealybug, mite, rose chafer, Japanese beetle and grape phylloxera, 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 (MALB). Most commercial wineries have taken a conservative, zero tolerance approach to MALB presence in harvested grapes.
- There is a need for the registration of more pest control options compatible with organic production systems for the management of pests including leafhopper, cutworm, grape phylloxera, Japanese beetle and rose chafer.
- Colonies of the brown marmorated stinkbug (BMSB) have been identified within proximity to major grape production areas. There continues to be elevated levels of 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 required.

Table 7. Occurrence of insect and mite pests in grape production in Canada[1,2]

Insect	British Columbia	Ontario	Quebec	Nova Scotia
Grape berry moth	Black	Red	Orange	Black
Spotted wing drosophila	Yellow	Light blue	White	White
Western flower thrips	Yellow	Grey	Grey	White
Brown marmorated stinkbug	Light blue	Light blue	Black	Black
Grape mealybugs	White	Orange	White	White
Leafhoppers	Black	Grey	Orange	White
Potato leafhopper	Black	Red	Orange	White
Grape leafhopper	Black	Red	White	Light blue
Threebanded leafhopper	Black	Red	White	Light blue
Virginia creeper leafhopper	Orange	White	White	Black
Tarnished plant bug	Black	White	Yellow	Yellow
Lady beetle complex	White	Grey	Orange	Yellow
Multicoloured Asian lady beetle	White	Red	Orange	White
Sevenspotted lady beetle	White	Orange	White	White
Mites	Orange	Grey	White	Orange
European red mite	Orange	Yellow	Grey	White
Two-spotted spider mite	Orange	Yellow	White	White
Grape erineum mite	White	Orange	White	Orange
Grape phylloxera	White	Orange	Orange	White
Flea beetles	Black	White	Orange	White
Grape flea beetle	Black	White	Orange	White
Japanese beetle	Black	Orange	White	White
Cutworms	Orange	Grey	White	White
European earwig	Yellow	White	White	White
European fruit lecanium	White	Black	White	Orange
Wasps	Yellow	Orange	Orange	Yellow

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 pest 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.
Light blue	Pest is present and of concern, however little is known of its distribution, frequency and importance.
Black	Pest not present.
Grey	Data not reported.

[1]Source: Grape stakeholders in reporting provinces (British Columbia, Ontario, Quebec and Nova Scotia). The data reflect the 2016, 2015 and 2014 production years.

[2]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	Leafhoppers	Lady beetle complex	Flea beetles	Mites
Avoidance	Varietal selection / use of resistant or tolerant varieties					
	Planting / harvest date adjustment					
	Rotation with non-host crops					
	Choice of planting site					
	Optimizing fertilization for balanced growth					
	Minimizing wounding to reduce attractiveness to pests					
	Reducing pest populations at field perimeters					
	Use of physical barriers (e.g. mulches, netting, floating row covers)					
	Use of pest-free propagative materials (seeds, cuttings and transplants)					
Prevention	Equipment sanitation					
	Canopy management (thinning, pruning, row or plant spacing, etc.)					
	Manipulating seeding / planting depth					
	Irrigation management (timing, duration, amount) to manage plant growth					
	Management of soil moisture (improvements in drainage, use of raised beds, hilling, mounds)					
	End of season or pre-planting crop residue removal / management					
	Pruning out / removal of infested material throughout the growing season					
	Tillage / cultivation to expose soil insect pests					
	Removal of other hosts (weeds / volunteers / wild plants) in field and vicinity					

…continued

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

	Practice / Pest	Grape berry moth	Leafhoppers	Lady beetle complex	Flea beetles	Mites
Monitoring	Scouting / trapping					
	Maintaining records to track pests					
	Soil analysis for pests					
	Weather monitoring for degree day modelling					
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of pests					
Decision making tools	Economic threshold					
	Use of predictive model for management decisions					
	Crop specialist recommendation or advisory bulletin					
	Decision to treat based on observed presence of pest at susceptible stage of life cycle					
	Use of portable electronic devices in the field to access pest identification / management information					

…continued

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

Practice / Pest		Grape berry moth	Leafhoppers	Lady beetle complex	Flea beetles	Mites
Suppression	Use of diverse pesticide modes of action for resistance management	green	green	red	red	green
	Soil amendments and green manuring involving soil incorporation as biofumigants, to reduce pest populations	red	red	red	red	red
	Biopesticides (microbial and non-conventional pesticides)	green	green	red	red	red
	Release of arthropod biological control agents	red	green	red	red	green
	Preservation or development of habitat to conserve or augment natural controls (e.g. preserve natural areas and hedgerows, adjust crop swathing height, etc.)	white	green	grey	white	green
	Mating disruption through the use of pheromones	green	red	red	red	red
	Mating disruption through the release of sterile insects	red	red	red	red	red
	Trapping	red	red	red	red	red
	Targeted pesticide applications (banding, variable rate sprayers, spot treatments, etc.)	green	green	green	white	green
	Selection of pesticides that are soft on beneficial insects, pollinators and other non-target organisms	green	green	green	green	green

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

[1]Source: Grape stakeholders in reporting provinces (British Columbia and Ontario). The data reflect the 2016, 2015 and 2014 production years.

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, 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.

Issues for Grape Berry Moth

1. There is a need to re-examine the effectiveness of pheromones in trapping grape berry moth (GBM) under growing conditions in Quebec. There is some concern that the pheromones do not effectively attract this insect.
2. With the rising costs of pesticides, mating disruption (MD) technology has become more cost effective and more growers in Ontario are adopting it as a suitable control measure in low pressure areas. There continues to be concerns of reduced efficacy of MD products in high pressure areas where MD is not employed at neighbouring vineyards.
3. Additional research is needed on the environmental factors required to have a partial 4^{th} generation GBM develop late season. In hot growing seasons, Ontario has observed a small amount of late season (mid-late September) GBM larval activity.
4. GBM developmental models developed at Michigan State University need to be validated under Ontario and Quebec conditions.

Spotted Wing Drosophila (*Drosophila suzukii*)

Pest Information

Damage: Spotted wing drosophila (SWD) has become a chronic pest in berry and tender fruit crops in Ontario. Early detection and management are required to limit economic damage. 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 fruit flies serve also as entry points for disease.

Life Cycle: The insect overwinters as an adult fly. In the spring, 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: Regular monitoring can be used to assess the severity of SWD infestation, and can allow growers to make informed decisions about pesticide applications. While traps baited with apple cider vinegar can be used to monitor adult SWD populations, monitoring larvae in fruit is also desirable. If SWD larvae are present, you will need to take action to control the population to reduce further damage to the crop. The frequent harvest of all ripe fruits and removal of unmarketable fruit culls help to reduce the chances of the fly infesting the fruit and reduces sources of continued infestations.

Resistant Cultivars: None identified.

Issues for Spotted Wing Drosophila

1. There is a need to establish the over wintering habitats of SWD and formulate action strategies for both table and wine grapes. This is of particular importance where the pest can cross over to grapes from other commodities. Currently no yield losses have been reported in grapes from SWD.
2. An effective management strategy that includes best management practices, effective chemicals and chemical rotations, must be developed before this pest becomes a problem.
3. It is important to fully register both conventional and organic materials that have short pre-harvest intervals since damage from this insect typically corresponds to peak fruit maturity.
4. The development of pesticide resistance must be monitored closely given the short reproductive cycle of SWD and the frequency of insecticide applications required.

Brown Marmorated Stinkbug (*Halymorpha halys*)

Pest Information

Damage: Brown marmorated stinkbug (BMSB) 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. The presence of only a few adults at crushing time can taint wine.

Life Cycle: The insect spreads through natural means and also as a "hitchhiker" in cargo and vehicles. In the spring, adults mate and lay eggs on host plants. Both nymphs and adults feed on host plants. Each female can lay up to 400 eggs throughout the summer on host plants, resulting in overlapping nymph stages. Eggs hatch in 4–5 days; nymphs mature in about 5 weeks depending on temperature. 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.

Issues for Brown Marmorated Stinkbug

1. The presence of BMSB has been confirmed in Ontario, British Columbia and Quebec. This insect remains as one of the greatest potential threats to fruit production and monitoring BMSB movement into grape production areas needs to be of high importance.
2. Currently, there are only two products registered for use on BMSB. The registration of additional non-neonicotinoid materials with low pre-harvest intervals (PHI's) from different chemical groups would be of benefit to ensure this pest can be responsibly managed if it becomes a problem in grape. Organically suitable products need to be investigated as well.
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 Seven-spotted 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 (e.g. soybean aphids), ornamental plants, grasses and other crops. The beetles overwinter as adults in protected areas. They 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 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.

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.

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.

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, organophosphates).

2. This insect is the major vector of grapevine leafroll virus (GLRV). There is a need to establish economic thresholds and better monitoring techniques to identify presence of grape mealybug early in the season to enable growers to apply timely treatments and minimize feeding damage and virus spread.
3. There is a need to register additional, fully systemic materials effective on this pest to target nymphs feeding under bark as well as adults closer to harvest. Further investigation into soft chemicals, such as phosphate-free cold water detergents (e.g. Artic Power®) at high water volumes targeting migrating nymphs is required as an organically acceptable alternative.

Leafhopper Complex: 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.

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, 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 grape cultivars.
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.

Eastern Grape Leafhopper (*Erthroneura comes*) and Three-banded Leafhopper (*E. tricincta*)

Pest Information

Damage: The eastern grape and three-banded 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 leafhoppers, 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 plant susceptibility to leafhopper feeding damage. The presence of natural enemies can result in higher treatment thresholds. Leafhoppers have several natural enemies, including birds, spiders, insect predators, parasites and diseases.

Resistant cultivars: None available.

Issues for Grape Leafhopper and Three-banded 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, biological controls 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 cultivars.

Virginia Creeper Leafhopper *(Erythroneura ziczac)*

Pest Information

Damage: Adults and nymphs feed by piercing leaves and sucking sap. Light feeding results in stippling of the leaves. While 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 excreta. Adult leafhoppers can be a nuisance during harvest. This *Erythroneura* species is mainly a mesophyll feeder but may also feed in other tissues such as xylem.

Life Cycle: The biology and life cycle of this species has 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. 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.

Issues for Virginia Creeper Leafhopper

1. This leafhopper species is becoming more prevalent in British Columbia, especially during warm and wet growing seasons. Research is urgently needed into the effects of climate change on this insect and the impact on economic thresholds. The effects of canopy damage can be variable depending on overall vigor and plant health. Under heavy feeding pressure,

low vigor and late ripening red vinifera cultivars are most at risk from the damaging effects of leafhopper feeding.

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, biological controls, sticky traps and companion planting require investigation.
3. The registration of additional, non-neonicotinoid, control materials is required for conventional and organically managed vineyards.

Tarnished Plant Bug (*Lygus lineolaris*)

Pest Information

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

Issues for Tarnished Plant Bug

None identified.

Grape Phylloxera *(Daktulosphaira vitifoliae)*

Pest Information

Damage: Grape 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 on the roots. There may be as many as nine generations per season of the root form. In early summer, some adult root-form 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 eggs of the leaf-form phylloxera.

Pest Management

Cultural Controls: The best lines 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 cultivars have a large proportion of *V. vinifera* in their genetic composition which could increase their vulnerability to 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.

Issues for Grape Phylloxera

1. The greatest control of grape phylloxera is achieved using truly systemic materials at critical timings during pre-bloom, targeting the first generation. Additional fully systemic pest control products that can provide a quick knockdown of this pest and that are safe for pollinators are required.
2. A predictive model for grape phylloxera developed at the University of Arkansas need to be validated for use under Canadian conditions to help time treatment decisions for this insect.
3. With more phylloxera sensitive cultivars are being planted (e.g. Marquette and Frontenac), there is a need to develop an improved management strategy for highly susceptible cultivars. These cultivars typically require at least one additional control spray each season compared to moderately susceptible cultivars.

European Red Mite (*Panonychus ulmi*), Two-Spotted Spider Mite (*Tetranychus urticae*) and Grape Erineum Mite (*Colomerus vitis*)

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 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 overwinters as eggs, two- spotted spider mite, as fertilized females, and the erineum mites as adults under the bud scales. 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 all mites. The careful selection and use of pesticides is important to minimize their impact on natural enemies. 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.

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

1. The impact of fungicides and insecticide products on beneficial 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. There is a need for effective control options for grape erineum mites. Sulphur is currently being used and will suppress activity and slow down foliar damage however, more efficacious materials are required for better control in situations of high pest pressure.

Soft Scale Insects (Coccidae):
European Fruit Lecanium (*Parthenolecanium corni*)

Pest Information

Damage: Coccidae 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 soft scale insects. The honeydew supports the growth of black sooty moulds and together can render the fruit unmarketable. Feeding by scale insects weakens shoots and vines.

Life Cycle: Scale insects 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 to the current year’s canes and secrete the hardened shell covering to overwinter.

Pest Management

Cultural Controls: As healthy vines are less attractive to scale insects, 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.

Issues for Soft Scales

None identified.

Grape Flea Beetle (*Altica chalybea*) and Redheaded Flea Beetle (*Systena frontalis*)

Pest Information

Damage: In the spring, adult grape 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 causes the more serious damage, 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. Little information is available on redheaded flea beetle damage in grapes, however it is assumed to be similar to grape flea beetle damage.
Life Cycle: Grape flea beetles overwinter as adults in protected locations in 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 grape flea beetle damage. Disking to control weeds between grape rows can expose pupae to desiccation.
Resistant cultivars: None identified.

Issues for Grape Flea Beetle and Redheaded Flea Beetle

1. Effective insecticides already registered on grapes should be investigated as potential candidates for flea beetle control in vineyards, including grape flea beetle, redheaded flea beetle, and the corn flea beetle, (*Chaetochnema pulicaria*), a pest which is increasing in prevalence in SW Ontario.
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. However, no occurrence information was collected for this pest.

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 hatching 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.

Issues for Rose Chafer

1. The rose chafer is a pest of concern in Quebec vineyards. There is a need for the development of a rose chafer management strategy that includes chemical (conventional as well as organically acceptable) 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: 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 Japanese beetles and damage can be done by visual inspection of plants from late June through August, and also with the use of traps baited with attractants. There are concerns that this approach may attract more beetles into the area that may need to be subsequently controlled.

Resistant Cultivars: None available.

Issues for Japanese Beetle

1. The use of biological/ organically acceptable 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.
3. Validation of alternative methods of control should also be investigated (e.g. repellents, nets, mass trapping, etc.)
4. Additional research is needed to determine economic thresholds and cultivar specificity for Japanese beetle feeding.
5. This pest is not present in western Canada (British Columbia) however, it is potentially a threat and strict quarantine and surveillance must be maintained.

Climbing Cutworms: Noctuidae (*Peridroma saucia* & *Xestia c-nigrum*)

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: Climbing cutworms overwinter as eggs or young larvae. In the spring, these cutworms feed on weeds and other vegetation. If weeds are destroyed from mid-May to mid-June, climbing 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 climbing cutworms of food hosts. However, destroying weeds during the period from mid-May to mid-June can result in cutworms feeding on the vines as the only available source of food. Weed control in the fall, before new vineyards are planted, will help to minimize problems due to these cutworms the following spring.

Resistant cultivars: None available.

Issues for Climbing Cutworm

1. Approaches to determining the need for treatment for climbing cutworms, including economic thresholds, require further development.
2. The evaluation and registration of reduced risk materials including biopesticides, as groundcover and grape foliage sprays and as bait is needed for climbing cutworm control.
3. There is a need for continued work on vegetation management focusing on the use of different ground cover crops for climbing cutworm management.

European Earwig (*Forficula auricularia*)

Pest Information

Damage: European earwig can cause damage to soft fruits such as grapes, peaches and apricots by chewing into ripening and overripe fruit. It has been reported in Australia, as causing problems in vineyards where its presence in harvested berries results in the tainting of wine.

Life Cycle: This insect overwinters as an adult and has one generation per year. Females lay eggs in the spring and care for the nymphs for 1-2 weeks. The duration of the egg and nymphal stages is influenced by temperature. Development times for the different stages under field conditions in British Columbia were recorded as 18-24 days (2nd instar), 14-21 days (3rd instar), 15-20 days (4th instar), and 21 days (5th instar). The four nymphal stages are completed in about 68 days or more. Adult are brownish black, about 14 mm long, have short feathery front wings and a pair of forceps at rear. It is sensitive to low humidity and at 25-30% relative humidity earwigs survive only 3-6 days.

Pest Management

Cultural Controls: There are no prevention measures in place specifically targeting the accidental introduction of *F. auricularia*. These earwigs are nocturnal, feed at night and hide during the day. Traps made from crumpled paper in tubes or cans, rolled cardboard can be used to detect their presence and to collect individuals. Fumigation of shipments undoubtedly helps to reduce the frequency of accidental introduction. Growers can minimise the risk of introduction by ensuring that all machinery, vehicles and equipment arriving on their property have been cleaned. Earwigs can be found in large numbers under boards, tree holes, decaying bark or wherever it is moist and dark. The first step to controlling them is to eliminate these and other breeding and nesting places. IPM practices seem to be well suited to control damage caused by earwigs while still benefiting from their capacity as biological control agents for other insect pests.

Resistant cultivars: None available.

Issues for European Earwig

None identified.

Wasps (*Vespula* spp.)

Pest Information

Damage: Wasps produce slits about 0.2 mm long in the berry skin with their mouthparts, then sap leaks from the berry. Prolonged feeding results in multiple wounds and eventually mining of a cavity can extend into the grape. Wasps feed on ripe and damaged berries and are occasionally present in such large numbers can seriously affect yield. In other cases they are just a nuisance when mechanically harvesting. However, for hand harvesting, wasps can be a dangerous and disruptive pest for workers.

Life Cycle: Wasps are social insects. They live in colonies consisting of a queen, female workers and males. Each colony starts out the year with a single, mated female queen, the only life stage that is able to survive the winter. In the spring, the queen emerges from a protected site and begins the process of nest building. She constructs her papery nest out of wood fibres and lays several dozen eggs. Larvae mature and become infertile females, which continue the work of expanding the nest, foraging for the colony's food, and defending the colony. The queen continues to lay eggs and expand the numbers of yellow jackets, never leaving the nest again. Once the colony reaches a size of up to a thousand of individuals or more, some of the eggs that are laid will develop into what will become future reproductive queens and males. Future queens and males leave the colony to mate late in the fall. The mated females seek out places to stay alive during the cold months. The original colony dies and the papery nest falls apart.

Pest Management

Cultural Controls: To discourage wasp feeding, grape clusters should be picked as soon as they ripen. Minimize injury to grapes caused by birds, insects or diseases. Remove any overripe or damaged fruit from the grapevines. Insecticides are not an effective management option for controlling wasps. Trapping wasps later in the season may help lower the damage on grapes but the trapping needs to be started early and maintained through harvest. Trapping will not eliminate all wasps in the area; it will only lessen the problem. Early season bait should be fresh meat or fish but later in August, sweet liquids are best. When yellow jackets are plentiful, just about any sweet liquid will attract dozens to funnel traps each hour, so traps need to be serviced daily or they will lose effectiveness when full of dead wasps.

Resistant cultivars: None available.

Issues for Wasps

None identified.

Insecticides, miticides and bioinsecticides registered for the management of insect and mite pests in grape production in Canada

Active ingredients registered for the management of **insects and mites** in grape are listed below in Table 9 *Insecticides, miticides and bioinsecticides registered for the management of insect and mite pests in grape production in Canada*. This table also provides registration numbers for products registered on grape containing these actives in addition to information about chemical family and regulatory status. For guidance about active ingredients registered for specific **insects and mites**, the reader is referred to individual product labels on the PMRA label database https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management.html and to provincial crop production guides.

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

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Re-evaluation Status (re-evaluation decision document)[3]
abamectin	24551, 31607	avermectin, milbemycin	6	glutamate-gated chloride channel (GluCl) allosteric modulator	RE
acetamiprid	27128	neonicotinoid	4A	nicotinic acetylcholine receptor (nAChR) competitive modulator	R
Bacillus thuringiensis subsp. *Aizawai*, strain ABTS-1857	31557	neonicotinoid	4A	nicotinic acetylcholine receptor (nAChR) competitive modulator	R
Bacillus thuringiensis subsp. *kurstaki* strain ABTS-351	26508	*Bacillus thuringiensis* and the insecticidal proteins they produce	11A	microbial disruptor of insect midgut membranes	R
Bacillus thuringiensis subsp. *kurstaki* strain EVB113-19	26854, 27750, 32425	*Bacillus thuringiensis* and the insecticidal proteins they produce	11A	microbial disruptor of insect midgut membranes	R
bifenazate	27925	bifenazate	20D	mitochondrial complex III electron transport inhibitor	R
canola oil	32408, 32819	not classified	N/A	unknown	R
carbaryl	22339	carbamate	1A	acetylcholinesterase (AChE) inhibitor	R

…continued

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

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Re-evaluation Status (re-evaluation decision document)[3]
chlorantraniliprole	28981	diamide	28	ryanodine receptor modulator	R
clothianidin	29382, 29384	neonicotinoid	4A	nicotinic acetylcholine receptor (nAChR) competitive modulator	RES*
cyclaniliprole	32862, 32889	diamide	28	ryanodine receptor modulator	R
cyflumetofen	31284	beta-ketonitrile derivative	25A	mitochondrial complex II electron transport inhibitor	R
cypermethrin	15738, 28795, 30316, 32563	pyrethroid, pyrethrin	3A	sodium channel modulator	R (RVD2018-22)
ferric sodium EDTA	28774	not classified	N/A	unknown	R
flupyradifurone	31452	butenolide	4D	nicotinic acetylcholine receptor (nAChR) competitive modulator	R
imidacloprid	24094	neonicotinoid	4A	nicotinic acetylcholine receptor (nAChR) competitive modulator	RES*
kaolin	27469	not classified	N/A	unknown	R
lime sulphur (or calcium polysulphide)	16465	sulphur	N/A	unknown	R

…continued

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

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Re-evaluation Status (re-evaluation decision document)[3]
malathion	4590, 8372	organophosphate	1B	acetylcholinesterase (AChE) inhibitor	R
methoxyfenozide	27786	diacylhydrazine	18	ecdysone receptor agonist	R
mineral oil	27666, 33099	not classified	N/A	unknown	R
permethrin	14882, 16688, 24071, 24175, 28877, 29886	pyrethroid, pyrethrin	3A	sodium channel modulator	RE
phosmet	23006, 29064	organophosphate	1B	acetylcholinesterase (AChE) inhibitor	RE
potassium salts of fatty acids	27886, 28146, 31433	not classified	N/A	unknown	R
pyridaben	25135	METI acaricide and insecticide	21A	mitochondrial complex I electron transport inhibitor	RE
pyrethrin	30164	pyrethroid, pyrethrin	3A	sodium channel modulator	RE
spinetoram	28777, 28778	spinosyn	5	nicotinic acetylcholine receptor (nAChR) allosteric modulator	R

…continued

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

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Re-evaluation Status (re-evaluation decision document)[3]
spinosad	26835, 27825, 30382	spinosyn	5	nicotinic acetylcholine receptor (nAChR) allosteric modulator	RE
spirodiclofen	28051	tetronic and tetramic acid derivative	23	inhibitor of acetyl CoA carboxylase	R
spirotetramat	28953, 28954	tetronic and tetramic acid derivative	23	inhibitor of acetyl CoA carboxylase	R
sulfoxaflor	30826	sulfoximine	4C	nicotinic acetylcholine receptor (nAChR) competitive modulator	R
sulphur	14653, 18836, 29487, 31869, 32475	sulphur	N/A	unknown	R
Z-9-dodecen-1-yl acetate (grape berry moth pheromone)	27525	not classified	N/A	unknown	R

…continued

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

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Group[2]	Resistance Group[2]	Mode of Action[2]	Re-evaluation Status (re-evaluation decision document)[3]
Storage Treatment					
methyl bromide	9564, 19498	alkyl halide	8A	miscellaneous non-specific (multi-site) inhibitor	PO[5]

[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 September 27, 2018.** While every effort has been made to ensure all insecticides, miticides and biopesticides registered in Canada on grape have been included in this list, some active ingredients or products may have been inadvertently omitted. 'Numerous products' is entered where there are more than ten products for an active ingredient. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The product label is the final authority on pesticide use and should be consulted for application information. 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 8.4; May 2018)* (www.irac-online.org) (accessed Aug. 23, 2018).

[3]PMRA re-evaluation status as published in Re-evaluation Note REV2018-06, Pest Management Regulatory Agency Re-evaluation and Special Review Work Plan 2018-2023 and other re-evaluation documents: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review. Other codes include: DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

[4]Source: Fungicide Resistance Action Committee. *FRAC Code List 2017: Fungicides sorted by mode of action (including FRAC code numbering)* (www.frac.info/) (accessed September 13, 2017).

[5]As published by Government of Canada: *Notice to anyone engaged in the use of methyl bromide: June 2017 https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/notice-use-methyl-bromide-june-2017.html*

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 and Thistle.
- 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. Mechanical weed control and the use of acetic acid applications are two options that require research and investigation.

Table 10. Occurrence of weeds in grape production in Canada[1,2]

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

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 pest 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 (British Columbia, Ontario, Quebec and Nova Scotia). The data reflect the 2016, 2015 and 2014 production years.

[2]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	Annual grass weeds	Perennial broadleaf weeds	Perennial grass weeds	Biennial weeds
Avoidance	Varietal selection / use of competitive varieties					
	Planting / harvest date adjustment					
	Crop rotation					
	Choice of planting site					
	Optimizing fertilization for balanced crop growth					
	Use of weed-free propagative materials (seed, cuttings or transplants)					
	No till or low disturbance seeding to minimize weed seed germination					
	Use of physical barriers (e.g. mulches)					
Prevention	Equipment sanitation					
	Canopy management (thinning, pruning, row or plant spacing, etc.)					
	Manipulating seeding / planting depth					
	Irrigation management (timing, duration, amount) to maximize crop growth					
	Management of soil moisture (improvements in drainage, use of raised beds, hilling, mounds)					
	Weed management in non-crop lands					
Monitoring	Scouting / field inspection					
	Maintaining records of weed incidence including herbicide resistant weeds					
	Use of precision agriculture technology (GPS, GIS) for data collection and mapping of weeds					

…continued

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

Practice / Pest		Annual broadleaf weeds	Annual grass weeds	Perennial broadleaf weeds	Perennial grass weeds	Biennial weeds
Decision making tools	Economic threshold					
	Crop specialist recommendation or advisory bulletin					
	Decision to treat based on observed presence of weed at susceptible stage of development					
	Decision to treat based on observed crop damage					
	Use of portable electronic devices in the field to access weed identification / management information					
Suppression	Use of diverse herbicide modes of action for resistance management					
	Soil amendments and green manuring involving soil incorporation as biofumigants to reduce weed populations					
	Biopesticides (microbial and non-conventional pesticides)					
	Release of arthropod biological control agents					
	Mechanical weed control (cultivation / tillage)					
	Manual weed control (hand pulling, hoeing, flaming)					
	Use of stale seedbed technique					
	Targeted pesticide applications (banding, spot treatments, variable rate sprayers, etc.)					
	Selection of herbicides that are soft on beneficial insects, pollinators and other non-target organisms					

…continued

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

Practice / Pest		Annual broadleaf weeds	Annual grass weeds	Perennial broadleaf weeds	Perennial grass weeds	Biennial weeds
New practices (by province)	Roll-chopping between rows (Ontario)					

This practice is used to manage this pest by at least some growers in the province.
This practice is not used by growers in the province to manage this pest.
This practice is not applicable for the management of this pest
Information regarding the practice for this pest is unknown.

[1]Source: Grape stakeholders in reporting provinces (British Columbia and Ontario). The data reflect the 2016, 2015 and 2014 production years.

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 to increase the weed seed bank. 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.

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, would be welcomed by growers.

3. There is concern that newly developed, 2, 4-D ready seed will result in more 2, 4-D herbicide 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. Although there are acetic acid-based herbicides now available to organic growers, there continues to be a need for the development and communication to growers of organic approaches to weed control.
5. The use of low growing, semi hardy grape varieties in Quebec 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.
6. Mechanical weed control in grapes is an option that requires more research as a viable option.
7. Growers in British Columbia need better information on how to identify and stop the spread of Puncture vine and Long spine sand bur.

Herbicides and bioherbicides registered for weed management in grape production in Canada

Active ingredients registered for the management of **weeds** in grape are listed in *Table 12 Herbicides and bioherbicides registered for weed management in grape production in Canada*. This table also provides registration numbers for products registered on grape containing these actives in addition to information about chemical family and regulatory status. For guidance about active ingredients registered for specific **weeds**, the reader is referred to individual product labels on the PMRA label database https://www.canada.ca/en/health-canada/services/consumer-product-safety/pesticides-pest-management.html and to provincial crop production guides.

Table 12. Herbicides, bioherbicides and plant growth regulators registered for the control of weeds in grape in Canada

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Family[2]	Resistance Group[2]	Site of Action[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
acetic acid	30248	not classified	N/A	unknown	R (RVD2018-13)
ammonium salt of fatty acids	30012, 30515	not classified	N/A	inconnu	R
carfentrazone-ethyl	28573, 33127	triazolinone	14	inhibition of protoporphyrinogen oxidase (Protox, PPO)	R
dichlobenil	12533, 20233	nitrile	20	inhibition of cell wall synthesis site A	R
dimethenamid-P	29194	chloroacetamide	15	inhibition of mitosis	R
diuron	21252, 28107, 28543, 30081	urea	7	inhibition of photosynthesis at photosystem II site A (different behavior from group 5)	R
flazasulfuron	32910, 33130	sulfonylurea	2	inhibition of acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS)	R
fluazifop-p-butyl	21209	aryloxyphenoxy-propionate 'FOP'	1	inhibition of acetyl CoA carboxylase (ACCase)	R

… continued

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

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Family[2]	Resistance Group[2]	Site of Action[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
flumioxazin	29231, 29235	N-phenylphthalimide	14	inhibition of protoporphyrinogen oxidase (Protox, PPO)	R
glufosinate ammonium	23180, 28532, 32860	phosphinic acid	10	inhibition of glutamine synthetase	R
glufosinate ammonium + glyphosate	25795, 26625	phosphinic acid + glycine	10 + 9	inhibition of glutamine synthetase + inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	R + R
glyphosate (present as dimethylamine salts)	28840, 28977, 29774, 29775, 30319, 30516, 31090, 32314,	glycine	9	inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	R
glyphosate (present as isopropylamine salts)	29995, 30093, 30366, 30678, 30721,31063, 31314, 32181	glycine	9	inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	R
glyphosate (present as isopropylamine and potassium salts)	29888, 31316, 32228, 32532, 33029, 33030	glycine	9	inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	R
glyphosate (present as potassium salt)	31199, 31655.01, 32209, 32504, 32817	glycine	9	inhibition of 5-enolypyruvyl-shikimate-3-phosphate synthase (EPSPS)	R

…continued

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

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Family[2]	Resistance Group[2]	Site of Action[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
indaziflam	30220, 30221, 30451	unknown	29	inhibition of cell wall synthesis site C	R
methyl bromide (fumigant, pre-plant soil application)	19498	alky halide[4]	8A[4]	miscellaneous non-specific (multi-site) inhibitor[4]	PO[5]
napropamide	25230, 25231, 25297, 31688, 31081	acetamide	15	inhibition of mitosis	R
paraquat	8661, 33125	bipyridylium	22	photosystem-I-electron diversion	R
sethoxydim	24835	cyclohexanedione 'DIM'	1	inhibition of acetyl CoA carboxylase (ACCase)	R

…continued

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

Active Ingredient[1]	Product Registration Numbers[1]	Chemical Family[2]	Resistance Group[2]	Site of Action[2]	Re-evaluation Status (Re-evaluation Decision Document)[3]
simazine and related triazines	15902, 16370 23181	triazine	5	inhibition of photosynthesis at photosystem II site A	R
sulfentrazone	29012, 32846	triazolinone	14	inhibition of protoporphyrinogen oxidase (Protox, PPO)	R

[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 September 27, 2018.** While every effort has been made to ensure all herbicides, bioherbicides and plant growth regulators registered in Canada on grape have been included in this list, some active ingredients or products may have been inadvertently omitted. 'Numerous products' is entered where there are more than ten products for an active ingredient. Not all end-use products containing a particular active ingredient may be registered for use on this crop. The product label is the final authority on pesticide use and should be consulted for application information. The information in this table should not be relied upon for pesticide application decisions and use. '

[2]Source: Weed Science Society of America (WSSA). Herbicide Site of Action Classification list (last modified August 16, 2017) http://wssa.net (accessed August 23, 2018)

[3]PMRA re-evaluation status as published in Re-evaluation Note REV2018-06, Pest Management Regulatory Agency Re-evaluation and Special Review Work Plan 2018-2023 **and other re-evaluation documents**: R - full registration, RE (yellow) - under re-evaluation, RES (yellow) - under special review and RES* (yellow) - under re-evaluation and special review. Other codes include: DI (red) - discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA.

[4] Source: Insecticide Resistance Action Committee. *IRAC MoA Classification Scheme (Version 8.4; May 2018)* (www.irac-online.org) (accessed August 23, 2018).

[5]As published by Government of Canada: *Notice to anyone engaged in the use of methyl bromide: June 2017 https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/notice-use-methyl-bromide-june-2017.html*

Resources

Integrated Pest Management / Integrated Crop Management Resources *for Production of Grape in Canada*

Agri-Réseau. *Fiches Techniques*. Centre de référence en agriculture et agroalimentaire du Québec.
www.agrireseau.qc.ca

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

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

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

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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

Perennia Agriculture and Food Inc. Nova Scotia. *Fruit Production Grape* (Factsheets, Management Guides, and Publications)
http://www.perennia.ca/portfolio-items/grapes/?portfolioCats=87

Provincial Crop Specialists and Provincial Minor Use Coordinators

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

National, Provincial, Grape Growers and Wineries Organizations

Provincial:

British Columbia

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

British Columbia Wine Institute (http://winebc.com/)

British Columbia Wine Grape Council (www.bcwgc.org/)

Ontario

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

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

Winery and Grower Alliance of Ontario (https://wgao.ca/)

Prince Edward County Winegrowers Association (www.thecountywines.com/)

VQA Ontario (www.vqaontario.ca)

Quebec

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

Quebec Wine Council (https://conseiltaq.com/association/avq/)

Nova Scotia

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

Winery Association of Nova Scotia (https://winesofnovascotia.ca/)

National:

Canadian Horticultural Council (www.hortcouncil.ca)

Canadian Vintner's Association (www.canadianvintners.com/)

Canadian Grapevine Certification Network (www.cgcn-rccv.ca)

Appendix 1

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

Information on the occurrence of disease, insect and mite and weed pests in each province is provided in Tables 4, 7 and 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>Blue</td></tr>
<tr><td>Not present</td><td colspan="4">The pest is not present in commercial crop growing areas of the province, to the best of your knowledge.</td><td>black</td></tr>
<tr><td>Data not reported</td><td colspan="4">Information on the pest in this province is unknown. No data is being reported for this pest.</td><td>grey</td></tr>
</table>

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https://www.bctfpg.ca/pest_guide/info/129/European_Earwig

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