Crop Profile for Grape in Canada

Prepared by:

Pesticide Risk Reduction Program

Pest Management Centre

Agriculture and Agri-Food Canada

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The authors recognize the efforts of the Pest Management Regulatory Agency, provincial pest management representatives, industry specialists and growers in the gathering of information that was required, and the review and validation of the content of this publication.

Product trade names may be included and are meant as an aid for the reader, to facilitate the identification of products in general use. The use of these trade names does not imply endorsement of a particular product by the authors or any of the organizations represented in this publication.

Information on pesticides and pest control techniques are provided for information purposes only. No endorsement of any of the pesticides or pest control techniques discussed is implied.

Information contained in this publication is not intended to be used by growers as a production guide. Provincial publications should be consulted by growers for this information.

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Information for many of the tables in this crop profile is incomplete. It has been collected and will be published in an updated version of the crop profile on this website in the near future.

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Crop Profile for Grape in Canada

The genus *Vitis* belongs to the botanical famility *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 the insect, phylloxera. *Vitis vinifera* is often referred to 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.

Grapes (*Vitis* spp.) are long-lived woody perennial vines. Grapes grow in bunches or clusters on the vine and can be green, red, pink or purple. Grapes are eaten fresh, dried into raisins, preserved as jelly and are used for wine and juice. Grapes are a good source of vitamin C. Grapes grown in Canada are primarily used for the making of wine, juice and for sale on the fresh market. A very small amount is used to make jelly. Worldwide, the primary use of grapes is in the production of wine. Grapes destined for use in wines are judged based on their level of brix (sugar), titrateable acids and anthocyanin content.

Canadian Production (2005)	42,127 metric tonnes 10,564 hectares
Farm gate value (2005)	$51.3 million
Domestic consumption (2004)	3.4 kg/person (fresh)
Export (2005)	$1.5 million (fresh)
	$252,000 (dry)
Imports (2005)	$365.4 million (fresh)
	$63.0 million (dry)
Source(s): Statistics Canada	

Production Regions

Grapes are produced in Ontario (7,325 ha or 69% of national acreage), British Columbia (2,902 ha or 27% of the national acreage), Quebec (227 ha or 2% of the national acreage) and Nova Scotia (111 ha or 1% the of national acreage). (Source: Statistics Canada (2005). There is interest in New Brunswick and Prince Edward Island for a commercial industry, but the climate may not be suitable in these areas.

In Ontario, the majority of production (90%) occurs within the Niagara Peninsula along the southern shore of Lake Ontario. The remainder is mostly along the northern shore of Lake Erie. There is interest and some planting taking place in Prince Edward County, on the north-east shore of Lake Ontario. In British Columbia, the majority of the production (90%) occurs within the southern interior, with Vancouver Island making up 8% and the lower mainland producing 2% of the commercial grapes.

In Ontario some of the first grape plantings (1800's) and 1st wineries were located on the most southerly tip of Pelee Island. Production also has a considerable history in the Niagara Peninsula. In the late 1980's, there was a federal sponsored program for growers to pull out American hybrids that were no longer desirable in the market place to produce wine. Ontario went through an accelerated re-tooling in the 1990's with a significant planting of *V. vinifera* varieties which have superior wine making quality. *V. lubrusca* varieties 'Concord' and 'Niagara' have remained relatively stagnant in acreage because of the low yields and poor returns to growers.

In British Columbia, 96% of grapes are sold for processing, primarily wine making. The remaining 4% are sold fresh wholesale or directly by the farmer (Source: Annual BC Horticultural Statistics, 2003).

In Ontario, about 6 % of the acreage is devoted to fresh market grapes (Source: Ontario Agriculture, Food and Rural Statistics). The fresh market acreage is growing with the introduction of new semi-seedless varieties (eg. 'Sovereign' and 'Coronation') that have become well received in the market place. Based on the number of vines in the ground, the production is expected to more than double in the next few years. The market window is from late August to late September.

Cultural Practices

There are significant production differences in terms of pruning, training, fertilization and irrigation for fresh market and processing grapes. The focus of this profile will be on grapes used for the production of wine and juice, since nearly 95% of the grapes produced 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. 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. In Ontario, the bulk of the acreage is cultivated on clay loam soil types. New plantings are tile drained every 8 to 9 feet in order to improve productivity and winter hardiness.

Areas with extreme winter cold (less than -24°C) should be avoided. Grapes require a minimum of 165 days of consecutive frost free conditions, with sunshine exceeding 1250 hours per season. Low areas and frost pockets are not suitable for production. An ideal site has a slope of 3-4%, rows running north-south and full southern exposure. West facing slopes are preferable to 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.

Planting of dormant varieties should be done in early spring (March in British Columbia, April-June in Ontario and Quebec). Certified virus-free nursery stock should be planted so that the bottom roots are at least 30 cm below ground level. Newly planted vines should be watered with a starter solution high in phosphorus to help overcome transplant shock and initiate root growth. Irrigation is done to completely soak the soil around the fine roots, remove air pockets and bring the roots in contact with the soil. Protection from stresses and weed competition is important for new plantings. Milk containers, plastic tubes, or other coverings are used to protect the young vines from wind, herbicides and mechanical weeders. Soil moisture can be preserved using a thick hay mulch, which helps to encourage early growth. Black plastic mulches can be used that have the advantage of increasing soil temperature and helping to control weeds. There are currently no herbicides registered for use during the year of planting in grape.

Grapevines take about 3 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 out on a trellis to allow for movement of equipment throughout the vineyard, are spaced to avoid competition and are arranged so that fruit is produced in a position that facilitates harvest, increases light exposure, promotes air circulation and allows for good spray coverage with pesticides. 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. Over-pruning reduces yields, causes excessive vegetative growth, increases shading of fruit and makes the plant prone to cold injury. Under pruning produces poorer quality fruit in large numbers and makes the plant prone to winter injury. The amount of pruning needed depends on the level of vegetative growth and fruit production in the previous year. Pruning can begin any time after the first hard frost (-5°C or below) when the vines are certain to be dormant and should be finished before vines start to “bleed” in the spring.

Commercial grape varieties are self-fruitful, 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 sprayed with pesticides, sprinkled with water or extreme temperatures over 30°C are experienced during bloom. It may be more important to apply fungicides during bloom in order to adequately control disease rather than being focused on poor pollination, however care should be taken to try and avoid spraying water on open flower clusters, particularly on warm, sunny days when pollination is at its peak.

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. Trickle irrigation systems can be installed above or below ground and sprinkler systems can be installed overhead. Trickle systems are more efficient, delivering water directly to the root zone, while overhead sprinklers use more water, but are simple to maintain and can be used for frost protection and cover crop establishment. Irrigation is important in British Columbia. and is being given more consideration in Ontario, Quebec and Nova Scotia.

Production Issues

In Ontario and Nova Scotia, there are five main fungal and one bacterial disease that cause severe losses in this humid, continental growing environment. Seven viral diseases have also been identified. In contrast, British Columbia has less fungal disease pressure than Ontario but does have a great number of viruses transmitted by nematodes and aphids.

Climate is the most important abiotic factor affecting sustainable, quality production. Extreme winter temperatures and erratic temperatures, that result in spring frosts when growth of buds has begun, can cause lack of fruitfulness by damaging shoots and reducing the number of healthy fruitful buds and can cause vine and trunk damage. The length of the growing season as determined by the number of frost free days and the number of hours of sunshine can also limit yield and quality of grapes. Other abiotic factors include sun scalding in hot, early growing seasons, heat injury, drying of grape vines and “sick vines”. If grapes are grown on flat, heavy, shallow soil, it may result in severe root suffocation damage and/or winter injury in years of excess moisture.

Over the last 10 years, there have been significant new plantings of grapes in many parts of the world including Eastern Europe, California, South America, South Africa and Australia. Increased production and over supply of wine is already being encountered in certain segments of the market. Quality and price will become even more important in this competitive global market.

There is interest in both British Columbia and Ontario in developing organic vineyards. Limiting the development of organic production is the lack of alternative pest control products for leafhopper and fungal disease control.

Table 1. Canadian grape production and pest management schedule[1,2]

Time of Year	Activity	Action
Feb-Mar (plants are dormant)	Plant Care	Prune and tie canes; check vines for winter damage.
	Insect & Mite Control	Monitor overwintering European red mite populations.
April (woody bud stage)	Plant Care	Finish tying vines.
	Soil Care	Plough under fall planted green manure crop.
	Disease Control	Get sprayer ready in case early season phomopsis; spray as needed.
April (bud burst)	Plant Care	Irrigate as needed.
	Soil Care	Plant new green manure crop.
	Disease Control	First fungicide spray may be needed.
	Weed Control	Apply early burn off controls if needed.
May (bud growth)	Soil Care	Apply fertilizers to the soil as needed.
	Disease Control	Apply control for early powdery mildew and other diseases.
	Insect & Mite Control	Apply mating disruption products for grape berry moth; monitor for grape flea beetles.
	Weed Control	Apply controls if needed.
June (shoot growth)	Soil Care	First split application of nitrogen.
	Plant Care	Thin clusters, especially French hybrid wine grapes. Apply foliar nutrients as needed according to leaf analysis.
	Disease Control	Apply fungicides at regular intervals to cover need growing tissue every 7-14 days depending on growth.
	Insect & Mite Control	Begin monitoring for leafhoppers and spring feeding caterpillars. Apply controls if needed.
	Weed Control	Apply controls if needed – 2nd burn off and residual.
mid-June (pre-bloom, less than 5% cap fall)	Plant Care	Irrigate as needed if dry, hot spring; shoot postioning.
	Disease Control	Apply controls for black rot, powdery mildew etc. and bunch rot if wet over bloom.
	Insect Control	Continue monitoring for leafhoppers and first generation grape berry moth. Apply controls if needed.

Time of Year	Activity	Action
late June (80% cap fall, berry set)	Soil Care	Apply second split application of nitrogen fertilizer.
	Plant Care	Shoot positioning.
	Disease Control	Apply controls for black rot and powdery mildew etc.
	Insect & Mite Control	Begin monitoring for leafhopper species.
	Weed Control	Usually not necessary at this time unless problem perennials need further control (e.g. bindweed).
July (berry set and pea size growth)	Plant Care	Irrigate as needed.
	Disease Control	Apply controls for bunch rot, powdery mildew, black rot, etc.
	Insect & Mite Control	Monitor for leafhoppers, apply controls if needed; conventional insecticides timed for egg hatch of grape berry moth.
July (pre-bunch closure)	Plant Care	Final shoot positioning and early hedging if growth is vigourous.
	Disease Control	Apply controls for bunch rot and powdery mildew if needed.
late July (post-bunch closure)	Plant Care	Further hedging if needed; leaf removal around bunches.
	Soil Care	Plant green manure crop.
	Disease Control	Apply control for powdery mildew if needed to protect leaves.
mid-Aug (change of berry colour)	Plant care	Estimate yield; reduce yield by removing a number of clusters per vine.
	Disease Control	Apply controls for bunch rot and powdery mildew if needed.
mid-Aug to Sept/Oct (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.
Sept to Nov (post harvest)	Plant Care	Visually inspect vineyard wood quality. Irrigate as needed.
	Soil Care	Take soil samples.
	Disease Control	Apply control for powdery mildew; copper sprays if needed.
	Weed Control	Mowing of green manure crop to combat weeds and discourage rodents from wintering in vineyard.
Dec to Feb	Ice wine harvest	Hand and machine picking when temperatures reach 10°C.

Format adapted from BCMAFF Crop Profile

Note: This table depicts the growth activity cycle in Ontario. BC is about 2-3 weeks earlier than this table for bud break, bloom and early fruit development, while Quebec and Nova Scotia are 10-14 days later.

Abiotic Factors Limiting Production

Key Issues

- There is a need for improved vineyard management systems in order to minimize vine stress and maximize productivity, quality and environmental sustainability. This would include training, irrigation and the use of precision agriculture.
- There is a need for the development and evaluation of varieties, clones and rootstocks for improved winter hardiness.
- There is a need for the evaluation of varieties, clones and rootstocks for their performance, when grown on different soil types and their quality.
- There is a need for the development of nutrient management guidelines.
- There is a need for a better understanding of fruit quality and the factors affecting wine and fresh market quality and acceptance.
- There is a need for the development of a non-destructive technique to measure brix and acid level in grapes.
- There is concern of the lack of quantifiable standards to determine what makes a good grape.

Growing Season

To be successful, grapes must be produced in an area in which the frost free period is at least 165 days. The length of the growing season required varies with the variety grown and can be anywhere between 70 and 140 days.

Hours of Sunshine

Grape production requires a minimum of 1250 hours of sunshine per season in order to ripen grapes. More hours of sunshine may be required by some varieties.

Water Limitations and Excesses

Roots can suffocate if rainfall is in excess. This leads to poor vine performance, poor brix and poor fruit. If suffocation occurs in the fall, it can decrease winter hardiness. Hotter and drier summers have raised concerns as the lack of water can result in poor fruit quality at harvest (low brix and low acids) as well as poor winter hardiness. During vineyard establishment and the early years of production, irrigation is very important to ensure adequate water for the plants.

Extreme Winter Temperatures

In general, areas that experience temperatures colder than -24°C are not successful for grape production due to bud and vine/trunk kill during the winter. Wide temperature swings can also lead to severe winter damage.

Diseases

Key Issues

- The development of populations of pathogenic fungi with resistance to fungicides is a concern. There is a need for the registration of new products with different modes of action in order to prevent resistance to fungicides.
- Competitiveness in the global marketplace is a concern, with Canadian growers needing access to efficient new disease control products and the elimination of non-tariff barriers, such as pesticide residue limits.
- There is a concern over the registered label rate of new fungicides, as registration of low rates may lead to rapid development of resistance by powdery mildew.
- There is a need for the improved diagnostics of crown gall and virus diseases so that they can be identified in rootstocks.
- Regulations, to ensure that certification of stock as free from crown gall and virus diseases, are needed.
- There is concern over the impact of crown gall and virus diseases on grape quality.
- There is a need to develop the infrastructure to produce plants locally. Until the industry has this ability, viruses and crown gall will continue to be a problem.
- Research on virus epidemiology and the impact of leafroll and other viruses on productivity, ripening and fruit quality, is needed.
- There is concern that viruses on imports, that are not on the CFIA verification list, are causing problems. There is a need to ensure that nurseries supplying the plants are certified for all problematic viruses. Education is required to ensure that growers are aware that certified plants are only free of viruses on the verification list.
- A list of products that are exempt from registration requirements needs to be established. Exemption of future low risk products and of low risk products that are already registered in other countries is needed.
- Education on how to use new products under different growing conditions and in different regions is needed.
- Revised production guides and factsheets to inform growers of the best time to apply fungicides are needed.

Table 2. Degree of occurrence of disease pests in Canadian grape production

	Degree of occurrence			
Major Diseases	**BC**	**ON**	**QC**	**NS**
Powdery Mildew	E	E	E	E
Botrytis Bunch Rot	E	E	E	E
Downy Mildew	DNR	E	E	E
Phomopsis Leaf and Cane Spot	DNR	E	DNR	DNR
Black Rot	DNR	E	DNR	E
Crown Gall	E	E	E	E
Minor Diseases	**BC**	**ON**	**QC**	**NS**
Grape Decline	E	DNR	DNR	DNR
Eutypa Die-back	DNR	DNR	DNR	DNR
Grapevine fanleaf virus	E	DNR	DNR	DNR
Arabis mosaic virus	E	DNR	DNR	DNR
Grapevine leafroll virus	DNR	DNR	DNR	DNR
Tomato black ring virus	E	DNR	DNR	DNR
Tomato ringspot virus	E	DNR	DNR	DNR
Rugose Wood Complex	DNR	DNR	DNR	DNR
Grape vine anthracnose	DNR	DNR	E	DNR
Peach rosette mosaic virus	E	DNR	DNR	DNR

Widespread yearly occurrence with high pest pressure
Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure
Widespread yearly occurrence with low to moderate pest pressure
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure
Pest not present
DNR - Data not reported
E – established
D – invasion expected or dispersing
Source(s): Crop Profile focus groups for Ontario, Quebec and Nova Scotia, (2004); Crop Profile for Grapes in British Columbia (January 2004).

Major Diseases

Powdery Mildew *(Uncinula necator)*

Pest Information

Damage: The disease infects leaf, fruit and stem. Infections are visible as fine white powdery growth on the underside of leaves of mycelium and conidia. Infection does not kill the foliage. On shoots, infections result in dark feathery patches without sporulation. On fruit, grey-white powder grows on the surface, giving the appearance of the fruit being covered by talcum powder. Severe foliar infection can significantly reduce sugar accumulation in the fruit during veraison and also stress the vine, resulting in reduced vine vigour and possible desiccation of shoots and buds, leading to winter injury. Infected fruit can split in two during periods of rapid water uptake. The disease can stop berry growth and reduce fruit set if fruit infection occurs early in fruit development. Rachis infections can result in fruit falling from the cluster before harvest. Mid-summer infections are usually sparse and inconspicuous but can be especially important as entry points for botrytis and sour rot organisms apparent at harvest.

Life Cycle: The pathogen is found in all grape growing areas of Canada and is only able to infect cultivated and wild grape species. Wet and humid conditions during bloom and 3-4 weeks thereafter result in significant primary and secondary infections. In the late summer and early fall, the disease cycle begins with the fungus producing cleistothecia, which are small brown overwintering structures that wash off the leaves and lodge in crevices of the bark of the vine. Ascospores are released from the cleistothecia in the spring after a certain amount of rain has fallen. Infection of leaves from these spores occurs when temperatures are above 10°C from bud break until shortly after bloom. Lesions develop in 7-10 days and are covered with powdery conidia. The conidia are dispersed by wind and infect susceptible tissue at a wide range of humidity and temperature levels. Fruit are most susceptible to infection from immediate pre-bloom until about 2 weeks after fruit set.

Pest Management

Chemical Controls: Powdery mildew is controlled primarily by the well-timed application of fungicides. The present arsenal of products provide adequate control, but the development of resistant strains could alter level of control. Sulphur can provide excellent control of powdery mildew and is accepted by organic certification. Sulphur is easily removed from the vine and must be re-applied frequently during rainy weather. Myclobutanil and kresoxim-methyl also provide excellent control of powdery mildew. Azoxystrobin and folpet are also registered for powdery mildew control. In other grape growing areas of the world, where a number of the fungicides belonging to the demethylation inhibiting family of fungicides have been used since the early 1980's, lower label rates no longer provide good control of powdery mildew; however, higher label rates still provide control under low to moderate disease pressure. Rotation of chemical controls is crucial to delay shift in pathogen populations towards resistance.

Cultural Controls: Canopy management with techniques such as shoot positioning, shoot thinning, hedging and leaf removal, have modified the microclimate surrounding the bunches and reduced powdery mildew pressure. These techniques have also been helpful in promoting better fungicide coverage and penetration throughout the canopy.

Alternative Controls: The use of broad spectrum fungicides, such as sulphur, new chemistries and fungicide alternatives such as JMS Stylet oil, potassium silicate, monopotassium phosphate (Nutrol), horsetail tea (a biodynamic treatment) and the biological control agents AQ10 (*Ampelomyces quisqualis*) and Serenade (*Bacillus subtilis*) are necessary to prolong the usefulness of our fungicide arsenal. A risk model for infections by powdery mildew, based on temperature, has been developed in California (Thomas & Gubler, & Leavitt, 1994). When the risk index generated by the model is low, the interval between protectant sprays is lengthened. This model has worked well to reduce fungicide sprays in California, but has had varying levels of success in Ontario

Resistant cultivars: While there are varietal differences in terms of resistance, all grapes grown require some fungicide protection to prevent powdery mildew infection. Research is underway on genetic modification of plants in Australia in collaboration with French researchers to create resistant varieties.

Issues for Powdery Mildew

1. The most important concern is the development of populations of the pathogenic fungus that have resistance to fungicides. Newly registered pesticides belonging to the sterol inhibiting and strobiluron chemical families have single sites of action and/or possess a high risk of resistance development. In Europe, Australia and the United States, strains of powdery mildew resistant to these fungicide families have been well documented. There are documented cases of resistance to myclobutanil (Nova) in Ontario and cross resistance to strobilurans kresoxim-methyl and trifloxystrobin in New York. Broad spectrum products, such as Karathane and sulphur are key to preventing resistance development. There is a need for the registration of new products with different modes of action to continue to combat resistance.
2. To remain competitive in the global market, it is important for Canadian producers to have access to new , efficient disease control products. Sustainability of the industry depends on the elimination of non-tariff barriers, such as pesticide residues of older products.
3. There is a need to ensure the correct rate of product application is registered for new products. Registration of the lowest rate that provides control may lead to a rapid development of resistance by powdery mildew.
4. Weather conditions can sometimes prevent the application of fungicides by conventional means. There is a need for more research support for improved methods of application, including aerial applications.
5. There is concern over the lack of registration of biopesticides in Canada. These products are needed for resistance management during years when disease pressure is low. A number of products have been identified, including dormant oil, potassium bicarbonate, potassium silicate, mono potassium phosphate, *Baccillus subtilis* and *Baccillus pumilus*.
6. Predictive disease models need to be developed to better ascertain the need to apply fungicides. Models developed in other jurisdictions need to be validated to ensure their accuracy and applicability to local conditions.
7. More research is needed to determine the effect of powdery mildew infected fruit on wine quality. This research could help establish a tolerance limit and reduce the number of fungicide applications. Because most fungicides work best as protectants and powdery mildew, like most fungal diseases can increase very rapidly and cause considerable crop damage, thresholds are not applicable.

Botrytis Bunch Rot *(Botrytis cinerea)*

Pest Information

Damage: The pathogen causes rot in clusters of fruit and may also cause blight of blossoms, leaves and shoots. Bunch rot can cause severe economic loss, particularly on tight-clustered French hybrid and *Vitis vinifera* cultivars. Infections can spread rapidly through clusters, causing withered and rotted berries. Botrytis infections can also attract insect problems. Botrytis significantly impacts bunch integrity, quality and yield of ice wine, especially if the fall is wet and protracted. In addition to causing direct crop losses, the pathogen can make fruit more susceptible to infection by secondary organisms, such as *Penicillium* spp. and *Acetobacter* spp.

Life Cycle: The pathogen has a wide host range. It overwinters in debris on the vineyard floor or on the vine. Spore production occurs throughout the season, although their numbers appear to be much higher after veraison. Prolonged periods of wetness and high humidity with moderate temperatures (18-24°C) favours infection and spore production. 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

Chemical Controls: Well-timed sprays of effective fungicides can control the disease. Optimum timing of sprays has been studied, but is complex and is still not well understood. Registered products include iprodione, cyprodinil and fenhexamid. Strobilurin fungicides, although not labelled for control of botrytis, do have some activity against the pathogen and can provide some protection when used for other diseases. Table and juice grapes usually do not require special protective treatments.

Cultural Controls: Any practice that improves air circulation and reduces humidity will have a significant impact on the control of bunch rot. Canopy management by positioning shoots, thinning, hedging and removing leaves, modify the microclimate around bunches and reduce botrytis bunch rot. These practices also promote better fungicide coverage. Site selection is important. Fog pockets and heavily wooded areas should be avoided. Fertilizer should be applied in quantities that do no cause excessive vegetative growth. Loose clusters also significantly reduce the development of the pathogen. The use of clones or viticultural techniques that provide loose clusters can be beneficial.

Alternative Controls: Trichoderma harzianum is a biological control agent under development for the control of the pathogen on grapes in the United States. *Ulocladium* spp. is registered as a biological control in New Zealand.

Resistant cultivars: There are no resistant varieties, but some are less susceptible. There is research being done in Australia on genetically modified plants that have resistance to the pathogen.

Issues for Botrytis Bunch Rot

1. The development of pathogen resistance to pesticides is a significant concern. Newly registered fungicides have single sites of action and may have a high risk of resistance development. Resistance to these chemistries has been documented in Europe and has been seen for iprodione in Canada since the early 1980’s. There is a need for the registration of new products with different modes of action to continue to combat pathogen resistance development using product rotation.

2. There is a need for the development of predictive models for pesticide application.
3. There is a need for the registration of biological controls.
4. There is a need for the education of growers in the use of cultural practices (eg. Leaf removal) for the control of this disease.
5. The use of macro and micro nutrient sprays such as kelp, need to be evaluated.

Downy Mildew (*Plasmopara viticola*)

Pest Information

Damage: Infected shoot tips and fruit clusters have twisted, distorted growth covered with masses of sporangiophores. Infected fruit colour prematurely in the case of red varieties and have a mottled appearance in white varieties. Fruit does not mature properly, remaining hard as the uninfected fruit are softening. Economically, the disease can cause direct fruit loss, uneven fruit maturity, reduced sugar content when foliar infections are severe and reduced plant vigour.

Life Cycle: The pathogen overwinters as oospores on the vineyard floor. The oospores germinate, producing sporangia that are blown by wind to susceptible tissue where they cause primary infections. Primary infections require 10 mm of rain and temperatures above 10°C over a 24 hour period. Leaves develop ‘oilspots’ with sporangia within 7-14 days of infection, that are a source of secondary inoculum. Sporulation requires 4 hours of darkness with relative humidity over 98% and temperatures above 13°C. Infection occurs early in the morning, immediately following sporulation, as the sporangia are very susceptible to desiccation and UV radiation. Infection requires 2-3 hours of wetness near dawn. The disease develops quickly at temperatures between 20° and 25°C and can reach epidemic proportions in a very short period under optimum conditions. Young leaves are more susceptible than older leaves. The pathogen has a narrow host range.

Pest Management

Chemical Controls: Chemical control focuses on two separate periods: controlling primary infections in the pre-bloom and early post-bloom periods and limiting secondary spread during the summer. Sprays can be delayed if there was little infection in the previous year. Registered products include captan, folpet, metalaxyl, kresoxim-methyl, azoxystrobin, mancozeb, zoxamide, metiram and copper.

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.

Alternative Controls: None available.

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

Issues for Downy Mildew

1. There is concern that products, such as copper, captan and EBDC’s, may have their registration removed. Growers are in need of a broad spectrum, inexpensive product for the control of downy mildew. Metalaxyl is registered but is expensive and is susceptible to resistance development. New products are required for both conventional IPM and organic production systems.

2. There is a need for the development of predictive models to better time fungicide sprays. Models have been developed for other regions (DMCast, Dmodel) but are not currently validated for Canada.
3. Ridomil Gold (metalaxyl + mancozeb) is registered for the control of downy mildew but has an application time restriction to pre-bloom only on the Canadian label. In the USA this product has a 66 day pre-harvest interval with no time of application restriction. Industry is pursuing an URMULE to extend interval of use.

Phomopsis Cane and Leaf Spot *(Phomopsis viticola)*

Pest Information

Damage: The pathogen causes the development of small necrotic flecks on leaves surrounded by chlorotic tissue in the form of a circle. Infection can occur on petioles, rachises, shoots and fruit. On fruit, pycnidia develop as the fruit matures. Rachis and berry infection are both economically important. Rachis infection results in withered clusters as the rachis collapses, cutting off the movement of water and nutrients to developing berries. Fruit infection is sporadic, but can result in serious losses. Infected canes may be more susceptible to winter kil. 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 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 infection 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.

Pest Management

Chemical Controls: The need for fungicide applications is dependant on the level of inoculum present in the vineyard and the intensity of rainfall. Registered products include captan and folpet.

Cultural Controls: Infected shoots should be selectively removed and destroyed by pruning.

Alternative Controls: None available.

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

Issues for Phomopsis Cane and Leaf Spot

1. There is concern over the potential for the loss of the registration for captan and folpet as they are the two most effective products available. Transition strategies need to be developed.
2. Research is required to develop predictive models for this disease.

Black Rot (*Guignardia bidwellii*)

Pest Information

Damage: Infected berries initially turn brown and become covered with black pycnidia. Eventually they become mummified and remain attached to the rachis in the trellis, if not removed.

Life Cycle: The pathogen has a limited host range. It overwinters as pycnidia and pseudothecia on infected canes and mummified berries. Spores within cane lesions are available for infection starting at bud break. However the vast majority of overwintering spores (those within mummified fruit on the ground) first become available 2-3 weeks after bud break and reach peak levels 1-2 weeks before bloom. Mummified fruit in the trellis release both rain-splashed conidia and airborne ascospores throughout the summer. Only a few mummified berries on the vine, can result in much more damage than when many are found on the ground. Young leaves are most susceptible. The importance of foliar infections as a source of secondary inoculum has not been well demonstrated. Berries are very susceptible to infection for the first 2-3 weeks after bloom and become more resistant over time.

Pest Management

Chemical Controls: Registered products include azoxystrobin, captan, folpet, metiram, myclobutanil, kresoxim-methyl, mancozeb, ferbam, tri-basic copper sulfate and trifloxystrobin. Myclobutanil and kresoxim-methyl provide the best control.

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

Alternative Controls: None available.

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

Issues for Black Rot

1. There is a need for the development of predictive models to properly time fungicide applications.

Crown Gall (*Agrobacterium vitis*)

Pest Information

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

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

Pest Management

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

Cultural Controls: The use of clean planting stock is important, as infected plants can remain symptomless until winter occurs. Hot water treatment of vegetative and propagation tissue has been tested, but results are inconsistent and treatment sometimes results in poor vineyard establishment due to weakened planting stock. The method is no longer practiced by nursery suppliers in Ontario. Galls can be removed by pruning below the affected tissue and renewing the vine by means of a shoot from the base. Management practices that minimize the risk of cold injury are currently the only practical technique for managing the disease (site selection, hilling above the union graft). The use of multiple trunk vines and the yearly replacement of dead trunks with renewals helps to keep the disease at tolerable levels.

Alternative Controls: Although biological controls have been successful at controlling crown gall in some host plants, the commercially available biocontrol, *A. radiobacter* is not effective against crown gall of grape. Promising research is being done on a non-pathogenic strain of *A. vitis* that is active against the pathogenic strain.

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

Issues for Crown Gall

1. There is concern over this pathogen due to the Canadian climate and the likelihood of cold injury during the winter months. There is a need to improve the winter hardiness of vines.
2. There is concern over the difficulty in controlling bacterial diseases and the fact that there are few products registered for use against them. The registration of effective pesticides, with new modes of action, is needed.
3. The development of resistant varieties is needed for managing crown gall.
4. The use of antagonistic bacteria and mycorrhizae needs to be investigated for the management of crown gall.

Minor Diseases

Grape Decline *(Pythium ultimum)*

Pest Information

Damage: The pathogen causes symptoms resembling collar rot and winter injury, with plants dying suddenly. Vines show delayed and weak growth, sparse yellowish, undersized foliage and little, if any, berry production. Death of the vines usually occurs within two years from the time symptoms first appear.

Life Cycle: The fungus is found in most B.C. soils.

Pest Management

Chemical Controls: None available.

Cultural Controls: The restriction of free soil water can help prevent the disease. Soil can be removed from around the trunk and surface roots to allow them to dry and replaced with dry soil around the trunk and vines when weather is warmer.

Alternative Controls: None available.

Resistant cultivars: None available.

Issues for Grape Decline

None identified.

Eutypa Die-Back (*Eutypa lata*)

Pest Information

Damage: Shoots have shortened internodes and leaves are smaller, chlorotic and cupped with small necrotic spots and tattered margins. Healthy growth normally overgrows and obscures infected shoots by mid-summer. Each season, symptoms become worse until the tissue above the canker dies. Vine vigour and winter hardiness are both reduced. Affected shoots produce berry clusters that have mixed size berries.

Life Cycle: The pathogen is often found in wood cankers associated with pruning wounds. It has a wide host range that include 80 species from 27 botanical families. The majority of hosts are tree species that are common in natural forests. The fungus overwinters as perithecia that develop in cankers in the wood. Ascospores are shot out of the perithecia in late winter to early spring with as little as one mm of rain. The spores enter fresh pruning wounds and start to colonize the trunk. Symptoms are not evident until two to four years after infection, with deterioration of the vine continuing until the trunk or arm is killed.

Pest Management

Chemical Controls: Tri-basic copper sulfate and captan are registered for control of this disease..

Cultural Controls: Infected arms and trunks should be removed in late spring when foliar symptoms are noticed and wounds are less susceptible. Pruning should be far enough below the canker so that healthy wood is evident. Infected wood or stumps should be removed from the vineyard and burned. Training of multiple trunks will reduce the likelihood of complete vine loss. Trunk renewal should be done every 10-15 years.

Alternative Controls: None available.

Resistant cultivars: None available.

Issues for Eutypa Die-Back

None identified.

Grapevine Fanleaf Virus (GFLV)

Pest Information

Damage: Infected leaves are distorted, asymmetrical and puckered with exaggerated teeth. Shoots have shortened internodes and exhibit a zig-zag pattern of growth. Clusters are small with small or aborted berries. Crop losses in California and France range from 5-90% depending on the virulence of the strain and varietal susceptibility. Fruit quality is affected by a decrease in sugar content and titratable acidity.

Life Cycle: The nematode, *Xiphineman index*, is a vector for the virus. The nematode feeds on an infected root and transfers the virus when it feeds on healthy roots, resulting in short distance spread. The nematode can retain and transmit the virus for up to 8 months. Long distance spread occurs with the transport of infected scions and rootstocks.

Pest Management

Chemical Controls: Once the virus is found to be present in a vineyard, plants must be uprooted, the soil fumigated and replanting must not be done until the following year.

Cultural Controls: The use of certified, virus-free nursery material is the most effective management tool.

Alternative Controls: V. rotundifolia is immune to the disease and is used as a genetic source for resistance. *V. labruscana* can be infected, but symptoms are not serious. Almost all *V. vinifera* cultivars are susceptible to the virus.
Resistant cultivars: A genetically engineered Chardonnay grapevine has been created with resistance in France, but it will be another 10 years before the plant reaches the commercialization stage.

Issues for GFLV

None identified.

Arabis Mosaic Virus (ArMV)

Pest Information

Damage: Symptoms are similar to those observed with GFLV.
Life Cycle: The virus infects seed of many plants and has a wide, natural host range, including grape, *Prunus* spp., hops, sugar beet, celery, lettuce, cucumber, strawberry and raspberry. The virus is transmitted by several nematode species, with *Xiphinema diversicaudatum* being the most common. The disease is widespread in grape, with cases reported in Europe, Israel, Japan and Canada. The disease was introduced into Canada through infected vines imported from Europe.

Pest Management

Chemical Controls: None available.
Cultural Controls: None available.
Alternative Controls: None available.
Resistant cultivars: None available.

Issues for ArMV

None identified.

Grapevine Leafroll Virus (GLRV) (strains I and III)

Pest Information

Damage: Disease severity depends on the variety. Leaves of susceptible varieties turn red or purple (red grape varieties) or light-green to yellow (green grape varieties) in the late summer, with the discolouration often accompanied by a downward rolling of the leaf margins. All or only some leaves on a shoot may show symptoms. Once symptoms show up, they recur every year. Vines are weakened, fruit maturity is delayed and sugar content is reduced. Eventually, vines are weakened to the point that they are no longer economical for production. Some varieties can be infected, yet show no negative symptoms, but when grafted to a susceptible rootstock, eventually die.
Life Cycle: The virus is associated with several related viruses of the closterovirus type. The virus is spread primarily though propagation practices, but may also be transmitted by mealybugs.

Pest Management

Chemical Controls: None available.
Cultural Controls: None available.
Alternative Controls: None available.
Resistant cultivars: None available.

Issues for GLRV

None identified.

Tomato Black Ring Virus (TBRV)

Pest Information

Damage: Newly infected vines have leaves showing chlorotic spots, rings and lines. Older leaves are mottled in appearance. Graft failure is more common when vines are infected with the virus. Berries on infected vines are commonly of different sizes and maturities. Grapevine growth and yield are reduced.

Life Cycle: The virus is found in Germany, Greece, Israel and France. The nematode *Longidorus attenatus* is responsible for transmission. Infected weed seed and nursery material allows for introduction of the virus to vineyards. Although the virus was imported into the Niagara region of Ontario in the 1980's, it has since been eradicated.

Pest Management

Chemical Controls: None available.
Cultural Controls: None available.
Alternative Controls: None available.
Resistant cultivars: None available.

Issues for TBRV

None identified.

Tomato Ringspot Virus (TRSV)

Pest Information

Damage: Growth of shoots is stunted with irregular clusters and reduced winter hardiness. Many buds are killed after infection. Suckers on infected vines are weak and stunted. Severe leaf symptoms are seen only on a few hybrid varieties, but many varieties suffer from reduced vigour. When a hypersensitive scion is grafted to a susceptible rootstock the virus moves upward to the graft union, and the hypersensitivity causes the death of reactive scion tissue. The result is graft union necrosis and vine death.

Life Cycle: The virus is commonly found in many native weed plant species and is vectored by the nematode *Xiphinema americanum*.

Pest Management

Chemical Controls: None available.
Cultural Controls: None available.
Alternative Controls: None available.

Resistant cultivars: Susceptible cultivars include ‘Baco Noir’, ‘Vidal’, ‘Seyval’ and ‘M. Foch’. Resistant rootstocks have a hypersensitive response to the virus, with the tissue into which the virus is injected dying, preventing infection of the rest of the plant. Most varieties of *V. vinifera* and *V. labruscana* have similar reactions.

Issues for TRSV

None identified.

Rugose Wood Complex

Pest Information

Damage: Infected vines experience reduced vigour and delayed bud opening. Some infected vines will decline and die within a few years of planting. Infected, grafted vines produce swelling above the graft union and have marked differences in the diameters of the scion and rootstock. The different syndromes of the complex are difficult to distinguish in the field. Vines infected with corky bark virus exhibit grooving and pitting in all parts of the new vines. The stem pitting virus causes distinct basipetal pitting limited to a band extending downward from the point of inoculation. The stem grooving virus causes marked grooving on the stem. The effect of the various types of rugose wood virus varies according to both scion and rootstock cultivars being used. Some combinations may appear almost normal, except for symptoms on wood and bark. In other cases, a significant number of vines may have reduced yield and die prematurely. Severe losses are possible, as symptoms are delayed and whole vineyards that were planted with clones can be affected.

Life Cycle: The appearance of symptoms is often delayed. There are four disorders that are recognized as part of the complex: corky bark virus (GVB), Rupestris stem pitting virus (RSP), Kober stem grooving (GVA) and LN33 stem grooving (LNSG). The different strains of the complex are differentiated by graft transmission to indicator plants of *V. rupestris*. The virus is primarily transmitted by propagation of infected rootstocks and scions. In other parts of the world, GVA and GVB are also spread by mealybugs and scale insects.

Pest Management

Chemical Controls: None available.
Cultural Controls: None available.
Alternative Controls: None available.
Resistant cultivars: None available.

Issues for Rugose Wood Complex

None identified.

Table 3. Disease control products, classification and performance for Canadian grape production

Regulatory Status as of May 18, 2006					Stakeholder Comments[6]	
Active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action – resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**	**Performance of product according to recommended use[5]**	**Notes**
azoxystrobin (Abound 80WG)	Oximino acetate fungicide	11	R	Powdery mildew		
				Downy mildew		
				Black rot		
boscalid (Lance)	Carboxamide fungicide	7	RR	Powdery mildew		Newly registered product with limited field use to date.
captan (Supra Captan 80WDG)	Phthalimide fungicide	M4	R	Downy mildew	A	Has a desirable, short pre-harvest interval.
				Black rot	A	Good IPM fit. Broad spectrum product so is essential to maintain product registration. Good protectant. Good retention on foliage. Used for resistance management. Low cost. Less hard on benficials than mancozeb.
				Phomopsis cane and leaf spot		
				Eutypa dieback		
copper oxychloride (Guardsman Copper Oxychloride)	Inorganic fungicide	M1	R	Powdery mildew		
				Downy mildew		

Regulatory Status as of May 18, 2006					Stakeholder Comments[6]	
Active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action – resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**	**Performance of product according to recommended use[5]**	**Notes**
cyprodinil (Vangard)	Anilino-pyrimidine fungicide	9	R	Botrytis bunch rot	A	Vulnerable to resistance. Need at least two other chemical families in rotation to prevent resistance development. Good IPM fit. Broad spectrum.
fenhexamid (Elevate 50 WDG)	Hydroxyanilide fungicide	17	RR	Botrytis bunch rot	A	Good IPM fit.
ferbam (Ferbam76WDG)	Dithiocarbamate fungicide	M3	R	Black rot		Juice processors do not allow use of this product.
folpet (Folpan WDG)	Phthalimide fungicide	M4	R	Downy mildew	A[P]	In Ontario is allowed on juice grapes only by special permission of processor when disease pressure is high. Not vulnerable to resistance. Expensive. Broad spectrum. Not a good IPM fit.
				Powdery mildew		
				Black rot		
				Phomopsis cane and leaf spot		
				Eutypa		
iprodione (Rovral)	Dicarboximide fungicide	2	R	Botrytis bunch rot	I - A	Documented resistance, but manageable with rotation of products and rapid reversion. Good foliar retention.
kresoxim-methyl (Sovran)	Oximino acetate fungicide	11	R	Powdery mildew	A	Excellent IPM fit. Curative treatment. Safe for the environment as treatments are more targeted. Also provides control of black rot and downy mildew. Rotation with other chemical families is essential to prevent resistance. A limitation is the high cost.
				Downy mildew	I	
				Black rot		

Regulatory Status as of May 18, 2006					Stakeholder Comments[6]	
Active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action – resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**	**Performance of product according to recommended use[5]**	**Notes**
mancozeb (Dithane WSP 80% WP)	Dithiocarbamate fungicide	M3	R	Downy mildew	A	Pre-bloom restrictions for juice grapes by juice processors. Good broad spectrum product to control downy mildew and manage resistance. Does not control other diseases that require controls at the same time. Good retention on foliage.
				Black rot		Used in a tank mix with Nova 40W
mancozeb + dinocap (Dikar)	Dithiocarbamate + dinitrophenol crotonate fungicides	M3, 29	R	Downy mildew	A	Pre-bloom restrictions for juice grapes by juice processors. Broad spectrum.
				Powdery mildew	A	
mancozeb + zoxamide (Gavel 75DF)	Dithiocarbamate + benzamide fungicides	M3, 22	R	Downy mildew	A	Mancozeb component limits this on juice grapes to pre-bloom only. Restrictions by juice processors. Good resistance management tool. Zoxamide is in a unique chemical family. Product especially good for use under high disease pressure.
metalaxyl + mancozeb (Ridomil Gold MZ 68WP)	Acylalanine fungicides + Dithiocarbamate fungicides	4, M3	RE	Downy mildew		Is a systemic, curative treatment. Product is expensive and has a narrow disease spectrum. Product would be more useful to wine grape growers if use pattern could be extended to veraison. Hard on beneficial insects.
metiram (Polyram DF)	Dithiocarbamate fungicide	M3	R	Downy mildew	A	Has pre-bloom restrictions for juice grapes by juice processors. Controls downy mildew only. Slightly toxic to beneficials.
				Black rot		

Regulatory Status as of May 18, 2006					Stakeholder Comments[6]	
Active ingredient / organism (product)[1]	Classification[2]	Mode of action – resistance group[2]	PMRA status of active ingredient[3]	Pests or group of pests targeted[4]	Performance of product according to recommended use[5]	Notes
myclobutanil (Nova)	Triazole fungicide	3	R	Powdery mildew	A -A[P]	Good product where there is no resistance and it is used in rotation with other chemical families. Flint, Sovran and Lance are now superior. Some documented cross resistance with Sovran and Flint with Nova resistant isolates in New York state. Expensive product. IPM friendly. Systemic - provides a beneficial eradicant effect. Environmentally friendly.
				Black rot		
sulphur (Basf Kumulus DF fungicide water dispersable granular)	Inorganic fungicide	M2	R	Powdery mildew	A	Excessive amounts of sulfur are detrimental to wine grapes and applications must be made not later than 30 days before harvest. Eradicates active lesions and is a good resistance management tool. Product washes off easily and may perform worse under wet conditions and when intervals are stretched because of poor wet weather and field conditions. Sulphur may take out beneficial mites. Low cost.
tri-basic copper sulfate (Basicop, Copper 53W)	Inorganic fungicide	M1	R	Eutypa dieback		
				Black rot		Copper formulations not recommended on most fresh and juice grapes because they may cause severe spray burn on leaves and fruit.
				Downy mildew	A	Works as an eradicant and also has protectant ability. Good product in rotation. Rusts equipment. Accumulates in soil.

Regulatory Status as of May 18, 2006					Stakeholder Comments[6]	
Active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action – resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**	**Performance of product according to recommended use[5]**	**Notes**
trifloxystrobin (Flint 50WG)	Oximino acetate fungicide	11	RR	Powdery mildew	A	Newly registered product with limited field use to date. Is well priced and usage is expected to dramatically increase. Not to be used on Concord grapes as there are phytotoxicity concerns. Vulnerable to resistance development. Good IPM fit.
				Black rot		

[1] Common trade name(s), if provided in brackets, are for the purpose of product identification only. No endorsement of any product in particular is implied.
[2]The classification and the mode of action group are based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action. The document is under revision and up-to-date information can be found on the following web sites: herbicides:http://www.plantprotection.org/HRAC/Bindex.cfm?doc=moa2002.htm ; insecticides:http://www.irac-online.org/documents/moa/MoAv5_1.pdf ; fungicides:http://www.frac.info/frac/index.htm

[3] R-full registration (non-reduced risk), RE-under re-evaluation (yellow), DI (red) -discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA, BI-biological, RR-reduced risk (green), OP-organophosphate replacement, NR-not registered. Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Individual product labels should be consulted for up to date accurate information concerning specific registration details. The information in these tables should not be relied upon for pesticide application decisions. Consult individual product labels for specific registration details. The following website can be consulted for more information on pesticide registrations: http://www.eddenet.pmra-arla.gc.ca/4.0/4.0.asp

[4] Please consult the product label on the PMRA web site (http://www.eddenet.pmra-arla.gc.ca/4.0/4.0.asp) for specific listing of pests controlled by each active ingredient.
[5] A – Adequate (green) (the pest control product (PCP), according to recommended use, maintains disease below economic threshold OR provides acceptable control), Ap – Provisionally Adequate (yellow) (the PCP, while having the ability to provide acceptable control, possesses qualities which may make it unsustainable for some or all uses), I – Inadequate (red) (the PCP, according to recommended use, does not maintain disease below economic threshold OR provides unacceptable control)
[6]Sources: Crop profile focus groups for Ontario, Quebec and Nova Scotia (2004).

Table 4. Availability and use of disease pest management approaches for Canadian grape production

	Practice \ Pest	Powdery Mildew	Botrytis Bunch Rot	Downy Mildew	Phomopsis Leaf and Cane Spot	Black Rot	Crown Gall
Prevention	tillage			available/not used	available/used	available/used	
	residue removal / management	available/not used		available/not used	available/used	available/used	available/used
	water management	available/used	available/used	available/used		available/used	
	equipment sanitation						available/used
	row spacing / seeding depth	available/used	available/used				
	removal of alternative hosts (weeds/volunteers)	available/used	available/used	available/used		available/used	
	mowing / mulching / flaming	available/used	available/used	available/used	available/used	available/used	
Avoidance	resistant varieties	not available	available/used	not available	not available	not available	not available
	planting / harvest date adjustment		available/not used				
	crop rotation						available/used
	trap crops - perimeter spraying	available/not used					
	use of disease-free seed						available/used
	optimizing fertilization	available/used	available/used	available/used		available/used	available/used
	reducing mechanical damage / insect damage		available/used				available/used
	thinning / pruning	available/used	available/used	available/used		available/used	available/used
Monitoring	scouting - trapping						
	records to track pests	available/used	available/used	available/used	available/used	available/used	available/used
	field mapping of weeds	available/used	available/used				
	soil analysis						
	weather monitoring for disease forecasting	available/used	available/used	available/not used	available/used	available/used	
	grading out infected produce	available/used	available/used				
Suppression	use of thresholds for application decisions						
	biological pesticides	available/used	available/used	available/used	not available	not available	available/used
	pheromones						
	sterile mating technique						
	beneficial organisms & habitat management						
	pesticide rotation for resistance management	available/used	available/used	available/used		available/used	
	ground cover / physical barriers						
	controlled atmosphere storage						
	forecasting for applications	available/not used	available/not used	not available	not available	not available	

no indication that the practice is available/used
available/used
available/not used
not available
Source(s): Crop profile focus groups for Ontario, Quebec and Nova Scotia, 2004.

Insects and Mites

Key Issues

- Research is needed on the economics of early season leaf removal for the control of leafhopper.
- The enhancement of biological control with altered vegetation management, such as the impact of mulches on cutworm populations, needs to be investigated.
- The assessment of the role of vine fertility in the control of grape pests is needed.
- The registration of effective insecticides that allow a short pre-harvest interval, in order to eliminate insects such as the Asian lady beetle (Ontario), fruit fly (B.C. wine grapes) and earwig (B.C. table grapes) to prevent wine – taint and re-infestation, is needed. Material that is suited to organic production is preferable. The development of economic thresholds for these pests is also needed.
- Continued work to quickly identify new, emerging pests is needed.
- A list of products that are exempt from registration requirements needs to be established. Exemption of future low risk products that are already registered in other countries is needed.
- The assessment of wasp damage and the effectiveness of early season trapping and control is needed.
- The registration of a late season use insecticide is needed for wasps.
- Research into the relationship between wasps and sour rot is needed.
- *Vertebrate Control* – There is a need for better control systems for bear, bird and raccoon such as electric fences and netting.

Table 5. Degree of occurrence of insect pests in Canadian grape production.

	Degree of occurrence			
Major pests	**BC**	**ON**	**QC**	**NS**
Grape Berry Moth	DNR	E	E	DNR
Potato Leafhopper	DNR	E	E	DNR
Western Grape Leafhopper	E	DNR	DNR	DNR
Virginia Creeper Leafhopper	E	DNR	DNR	DNR
Multi-coloured Asian Beetle	DNR	E	DNR	DNR
Lesser Pests	**BC**	**ON**	**QC**	**NS**
Grape Phylloxera	E	E		E
European red mite	DNR	E	DNR	DNR
Grape Erineum Mite	DNR	E	DNR	DNR
McDaniel Spider Mite	DNR	DNR	DNR	DNR
Grape Cane Gallmaker	DNR	DNR	E	DNR
Grape Cane Girdler	DNR	DNR	DNR	DNR
Grape Flea Beetle	DNR	DNR	DNR	DNR
Grape Tumid Gallmaker	DNR	E	E	DNR
Wireworms	E	DNR	DNR	DNR
Climbing Cutworms	E	DNR	E	DNR
Western Flower Thrips	DNR	DNR	DNR	DNR
Lecanium Scale	E	DNR	DNR	E
Snailcase Bagworm	E	DNR	DNR	DNR
Three-banded leafhopper	DNR	E	E	DNR
Grape leafhopper	DNR	E	E	DNR
Grapevine leafhopper	DNR	DNR	E	DNR
Redbanded Leafroller	DNR	DNR	E	DNR
Grape Mealy Bug	E	DNR	DNR	DNR
Tarnished plant bug	DNR	DNR	E	DNR
Eight spotted forester	DNR	DNR	E	DNR
Redheaded flea beetle	DNR	DNR	E	DNR
Lesser grapevine flea-beetle	DNR	DNR	E	DNR
Japanese Beetle	DNR	DNR	E	DNR
European earwig	E	DNR	DNR	E
Yellowjacket Wasps	E	DNR	DNR	E
Other mites	E	E	E	E

Widespread yearly occurrence with high pest pressure

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

Widespread yearly occurrence with low to moderate pest pressure

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

Pest not present

DNR - Data not reported

E – established

D – invasion expected or dispersing

Source(s): Crop profile focus groups for Ontario, Quebec and Nova Scotia, 2004; Crop Profile for Grapes in British Columbia (January 2004).

Major Insects and Mites

Grape Berry Moth (*Endopiza viteana*)

Pest Information

Damage: During pre-bloom, larvae consume individual florets and form a small protective webbing between berries. Webbing can be dense, encasing blossoms, stems and entire sections of fruit clusters. Many damaged berries will wither or drop to the ground before they reach pea size. For summer and fall generations, larvae enter where berries touch one another. 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 such as *Botrytis cinerea*. Late season infestations are often the most serious as they lead to botrytis infection, resulting in serious losses. Sporadic outbreaks cause serious losses.

Life Cycle: The pest is native to North America where it feeds exclusively on wild grape (*Vitis riparia*), cultivated wine grape (*Vitis vinifera*) and juice grape (*Vitis lubrusca*). There are up to 3 generations of active, feeding larvae each year in Ontario. Seasonal movement of the pest between nearby woodlots harbouring wild grape and vineyards is not entirely understood, but it has been observed that greater damage is frequently observed around the periphery of vineyards that are adjacent to wooded or weed infested areas. High infestations early in the season are often localized in low areas of the vineyard where drifting snow can cover leaves and protect overwintering pupae. 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.

Pest Management

Chemical Controls: Azinphos-methyl is the most commonly used registered product for control. Field experience has shown that other organophosphate insecticides do not provide adequate control in medium to high pressure situations. Carbaryl, cypermethrin, diazinon, permethrin, phosalone and phosmet are also registered. Carbaryl has not proven effective in medium to high pressure situations and resistant populations exist in western New York and north-eastern Pennsylvannia.

Cultural Controls: The removal of alternate hosts near a vineyard can reduce the pest’s migration into vineyards. Cultivating in early spring buries the previous season's leaves and prevents moths from emerging, reducing the number of spring emerging moths resident in the vineyard. Record keeping of injury levels in specific areas of a vineyard or on specific cultivars can assist in determining control measures in subsequent years. Low temperatures in winter help reduce spring populations, especially in the absence of snow.

Alternative Controls: The first generation of the pest does not cause economically important damage at most sites, with only a small number of clusters being infested. Broad-spectrum insecticides may not need to be used on the first generation. Mating disruption technology is available and although it may have higher material or labour costs, the economic benefits of resistance management should be considered. Mating disruption technology is available as both fixed-point and sprayable formulations. Sprayable formulations are used when a threshold of five moths have been caught on five traps during two consecutive inspections done at three to four day intervals. Pheromone traps are effective tools for timing conventional chemical insecticides and provide early warning of the failure of mating disruption technology. For the third generation, border sprays are usually sufficient unless cluster assessments indicate complete block sprays are needed. Beneficial organisms include earthworms, ground beetles, *Trichogramma minutum, Elachertus coxalus, Apantales polychrosidae,* and *Enytus obliteratus*.

Resistant cultivars: Varieties with tighter bunches may have more severe infestations and experience serious botrytis infections.

Issues for Grape Berry Moth

1. There is a need to register alternatives to azinphos-methyl for the control of this pest.
2. Research needs to be done to determine the effectiveness of potential replacement products under high insect pressure situations.
3. There is concern over the re-entry interval restrictions of azinphos-methyl, as they make other summer vineyard tasks difficult to schedule.
4. There is concern over the fact that mating disruption technology is not economical, since other pests, such as leafhopppers and multicoloured Asian lady beetle, still need to be controlled using insecticides.
5. There is a need for new, reduced risk insecticides to allow for the rotation of pesticides, support pheromone disruption based programs and to replace the loss of organophosphate insecticides.

Leafhopper Complex: Potato Leafhopper (*Empoasca fabae*)

Pest Information

Damage: The pest feeds by sucking plant juices from the leaves and young stems of grape plants. While feeding, the insect injects a toxin that blocks the vascular system. Feeding reduces vigour and plugs the vascular system, affecting nutrient transport, halting photosynthesis and stopping the production of sugars needed for growth. Symptoms can be confused with those of lack of water or manganese deficiency and appear when the plants are under stress. Leaves turn yellow and curl upwards, with severe infections causing leaves to turn brown and die. The effects of the pest are most severe in newly planted vineyards, but leaf symptoms do occur in plantings older than five years when they are under moisture stress, leading 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.

Pest Management

Chemical Controls: Registered insecticides include azinphos-methyl, diazinon, carbaryl, endosulfan, malathion, permethrin, phosalone and acetamiprid. Diazinon and carbaryl are harsh on predatory mites. Permethrin and cypermethrin, registered for control of the grape leafhopper, have also been observed to give control of the potato leafhopper.

Cultural Controls: None available.

Alternative Controls: For established vineyards, monitoring should be done once a week beginning at petal fall and continuing until the end of August. For newly established vineyards, monitoring should begin when sufficient growth has occurred, about two to three weeks after planting and/or end of June for unfruitful plantings in their second or third leaf (if not yet fruiting).

Resistant cultivars: Indications are that the pest does have a preference for certain varieties.

Issues for Leafhopper Complex

1. There is a need for the establishment of standard thresholds to determine when control action is required.
2. There is concern that thresholds need to take into account other pests that are present, such as grape leafhopper and the European red mite.
3. There is a need for the registration of new insecticides to replace the organophosphate insecticides to be lost.

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

Pest Information

Damage: The insect feeds on the underside of leaves by sucking sap. The tissue around the puncture created by the insect turns pale white and eventually dies. Feeding injury is first seen along veins, but spreads to the entire leaf. Initial feeding is limited to the lower leaves. Heavy feeding can result in premature leaf drop, lowered sugar content, increased acid and poor colouring of the fruit. Ripening fruit is often smutted or stained by the sticky excrement of the hoppers, which affects appearance and supports the growth of sooty molds. Vines may be unable to produce sufficient wood the following season. Damage to the vine can be serious if infestations are allowed to persist unchecked for two or more years. The threebanded leafhopper causes similar damage, but is considered a minor pest. Vines can tolerate up to 15 hoppers per leaf with little or no economic damage.

Life Cycle: Overwintering adults emerge from hibernation in mid-spring and begin feeding on various plants, such as strawberry, various berry bushes, catnip, Virginia creeper, burdock, beech, and sugar maple. They mate, but don't reproduce on these plants, remaining there until new growth develops in the vineyard. In Ontario, migration to the grape vines begins in late May and continues through mid-July. High populations and damage to vines can be favoured by warm early springs and hot, dry summers. The pest is found in the vineyard into the fall, with migration to overwintering sites beginning during the latter part of October and continuing into December.

Pest Management

Chemical Controls: Complete spray coverage of the underside of leaves is important, with coverage of the fruit clusters of secondary importance. Registered products include azinphos-methyl, diazinon, carbaryl, cypermethrin, endosulfan, malathion, permethrin, phosalone and acetamiprid.

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.

Alternative Controls: The pest does have some natural enemies. Monitoring for the pest and environmental stress should be done.

Resistant cultivars: None available.

Issues for Grape Leafhopper

1. There is a need to define thresholds for wine grapes and grapes under environmental stress.
2. There is a need for the registration of replacements to organophosphates to help avoid resistance to acetamiprid.
3. Research is needed on the economics of early season leaf removal for the control of leafhopper.

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

Pest Information

Damage: Adults and nymphs feed by piercing leaves and sucking sap. Light infestations cause leaves to appear stippled, while heavier feeding results in brown, dried leaves that fall prematurely. Excessive feeding can cause decreased photosynthetic activity, resulting in delayed maturity, yield losses and reduced fruit quality. Table grapes, particularly light-coloured varieties, can become spotted and unsightly with excrement and adult leafhoppers can be a nuisance during harvest.

Life Cycle: The biology and life cycles of the two species are very similar, both having two generations per year and overwintering in the adult stage in plant debris in and around the vineyard. First generation nymphs are present from mid-May to the end of July and second generation nymphs appear in August.

Pest Management

Chemical Controls: Chemical sprays should be targeted against the nymphs, as the adults are more tolerant of insecticides. The first generation nymphs are easier to control and the threshold for control of first generation nymphs should be lowered for vineyards with a history of heavy damage. If insecticides are required to control first generation nymphs, it is often sufficient to spot spray or treat only the perimeter of the vineyard. Spraying in this fashion is more economical and helps preserve beneficial insects. Spot spraying and edge treatments may not be as effective against the second generation. Some populations of western grape leafhopper are resistant to certain insecticides. Registered products include azinphos-methyl, diazinon, carbaryl, cypermethrin, endosulfan, malathion, permethrin, phosalone and acetamiprid.

Cultural Controls: Fall or spring discing 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.

Alternative Controls: Estimates of the numbers of overwintering adults can be obtained from monitoring with yellow sticky traps in the spring, but these numbers do not correlate well with subsequent nymph abundance. Although accurate thresholds have not been developed for leafhoppers, it is known that vines (except for fresh market grapes) can tolerate fairly large populations without suffering any economic damage. Based on a limited amount of monitoring conducted in B.C. and information from neighbouring American states, chemical control of the first or second brood is likely required only when populations exceed about 20 to 25 nymphs per leaf in the more infested areas of the vineyard. 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%. More research is being done on *Anagrus erythroneurae*, a newly discovered parasitic wasp that attacks the western grape leafhopper.

Resistant cultivars: None available.

Issues for Virginia Creeper Leafhopper and Western Grape Leafhopper

1. There is a need for the registration of softer products to be used in rotation with acetamiprid to help avoid resistance and provide less disruption to beneficials.
2. The establishment of economic thresholds, taking into consideration the presence of other pests, such as grape leafhopper, European red mite and grape berry moth, is needed.
3. Defined thresholds for wine grapes and grapes under environmental stress are needed.
4. Predictive models need to be developed.
5. Research on the use of anti-feedants and repellents for the control of these pests is needed.
6. The efficacy of sticky traps needs to be evaluated in the field.
7. The feasibility of leaf stripping needs to be investigated as a control option.
8. Biological controls for the control of western grape leafhopper are needed.

Multicoloured Asian Lady Beetle (MALB) (*Harmonia axyridis*)

Pest Information

Damage: The beetles migrate into the vineyard during the ripening and harvesting period. 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 the harvest and wine making process can lead to the release of methoxypyrazine which imparts a serious, sensory taint to wine, making it unmarketable. There is zero tolerance for this pest in juice and wine grapes.

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

Pest Management

Chemical Controls: Applications of insecticides provide quick knock down, but re-infestation under high population pressure may require frequent applications resulting in pre-harvest application interval issues. Cypermethrin and malathion are registered for MALB control.

Cultural Controls: Bunches should be kept healthy and intact and free of injury from other insects, birds and disease.

Alternative Controls: Research using special fine bird netting to protect bunches against both birds and the beetle is being done. Harvesting by hand and mechanically separating beetles from harvested grapes can be done.

Cultivar Susceptibility: Some varieties tend to be more attractive to the beetle than others, possibly due to susceptibility to botrytis bunch rot and the production of volatiles during the ripening process.

Issues for Multicoloured Asian Lady Beetle

1. There is concern over this new and emerging problem in Ontario. It is not expected to become a problem in British Columbia because of insufficient alternate food hosts.
2. There is a need for the development of economic thresholds for the beetle.
3. There are no insecticides registered for control of this pest. Currently, producers rely on temporary emergency registrations for control.
4. There is a need for the registration of effective insecticides that allow a short interval between application and harvest in order to avoid re-infestation.

Minor Insects and Mites

Nematodes

Pest Information

Damage: Nematodes feed on the inside of vine roots. Feeding damage increases the susceptibility of the vine to root rotting pathogens. Some nematode species transmit viruses that affect grapevines. Severely affected plants are stunted and have reduced yields. Above ground symptoms usually appear in patches, although entire blocks of vines can be uniformly affected. When populations are high, root systems are sparse, with only fine roots that are reddish, brown or black in colour present.

Life Cycle: Plant protection measures that require treatment of imported planting stock have prevented the most damaging nematode of grapevines, *Xiphinema index*, from being introduced into BC. Several other potentially damaging species exist in the grape-growing regions of BC and include dagger nematode, (*X. americanum* and several closely related species of *Xiphinema*), northern root-knot nematode (*Meloidogyne hapla*), and root-lesion nematode (*Pratylenchus penetrans*). While these nematodes are potentially damaging, little research has been conducted to quantify their effects on vine health under field conditions, and economic damage thresholds are not known. Dagger nematodes are present in heavier soil types and can be a vector of various viral diseases attacking grape. Root-lesion nematode has not been a serious problem in Ontario, as most of the grapes have been planted on heavier soil types. Root-lesion may become more of a issue if there is an increasing acreage on lighter sandy soils.

Pest Management

Chemical Controls: Fumigation of the soil before planting can reduce nematode populations in the soil.

Cultural Controls: None available.

Alternative Controls: None available.

Resistant cultivars: Nematode resistant rootstocks are available.

Issues for Nematodes

1. There is a need for research to identify rootstocks that have resistance to nematodes.

Grape Phylloxera (*Daktulosphaira vitifoliae*)

Pest Information

Damage: During feeding, the pest secretes a chemical that causes plant tissue to grow near the feeding site, resulting in characteristic galls. Damage is done to vines from feeding on sap from leaves, stems and tendrils, but no damage is directly caused to the fruit. The galls result in decreased leaf surface area leading to leaves that contain up to 90% less chlorophyll than healthy ones and less photosynthesis. Fruit may have reduced sugar levels at harvest and winter hardiness is reduced. Severe infestations cause defoliation, retarded shoot growth and delayed fruit ripening. Very susceptible varieties can have as many as 200 galls per leaf with 50-80% of leaves being affected. The pest is also known to attack roots. On cultivars susceptible to root infestation (mainly ungrafted *V. vinifera*) infestations may be lethal to the vine. Infested roots swell to form root galls while the phylloxera continue to feed on the outer surface of the swollen area. Large galls on older roots are often attacked by root rot diseases, which usually results first in decline and then the death of the vine three or four years following an infestation. In the major grape-growing regions, phylloxera-tolerant American rootstocks are used to cultivate *V. vivifera*. In Ontario, the pest inhabits most root systems, but has no lethal effects due to low winter temperatures, preventing excessive population buildup.

Life Cycle: Grape phylloxera has a complex life cycle. Phylloxera can overwinter as nymphs on large roots. At maturity, the insects lay eggs on the roots which hatch and continue the cycle.. Populations of the root feeding phylloxera tend to be low (in Ontario). In the fall, winged adults may be produced that migrate to stems where they lay eggs that give rise to males and females. Following mating, an overwintering egg is laid on the stem, which gives rise to the leaf infesting phylloxera.

Pest Management

Chemical Controls: Endosulfan and malathion are the only chemical controls registered. Early season chemical control may be more effective than mid- to late-season control in problem vineyards. Chemical control is only recommended in vineyard blocks that have a history of serious infestations.

Cultural Controls: Dormant, well-matured grape cuttings and grape plants may be treated against the pest and nematodes by washing all soil from the cuttings and/or roots and treating them with hot water.

Alternative Controls: Monitoring the leaf feeding cycle of the pest depends on timely visual observations. During the crawling and early gall development phase the pest is most vulnerable to insecticides. Common predators, including lacewing nymphs, minute pirate bugs and predatory fly larvae, will help control populations.

Resistant cultivars: Varieties highly susceptible to leaf feeding forms include: ‘DeChaunac’, ‘Foch’, ‘Ventura’, ‘Baco Noir’, ‘Villard Noir’, ‘Le Commandant’ and ‘Chelois’. All vinifera grape varieties are grown on tolerant / resistant rootstocks (ON).

Issues for Grape Phylloxera

1. Alternative control products to use in rotation with currently registered products or to replace products which may be discontinued, are needed.

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

Pest Information

Damage: Feeding by mites causes bronzing of the leaves of the plant when vines are under stress. The grape erineum mite causes major stress to young vines by injuring young leaves and causing early drop of heavily infested, mature leaves. Galls can form on the upper surface of leaves where the mites have been feeding.

Life Cycle: Hot and dry conditions and the use of broad spectrum insecticides and fungicides that are harsh on beneficial insects and mites are probably the main contributors to the increase in mite problems. The grape erineum mite has been identified in Quebec, Ontario and B.C. Increased pressure from this pest in Ontario in recent years has been attributed to changes in cultivars grown and on the reduction in the use of sulfur for the control of powdery mildew, as sulfur applied early in the season affects the mite's population.

Pest Management

Chemical Controls: Pyridaben and dicofol are registered for control of the European red mite and the two spotted mite. Sulphur is registered for use on grape erineum mite, but may cause flare-ups of other pest mite species.The use of harsh insecticides for control of grape berry moth and leafhoppers, such as carbaryl, Cymbush and other pyrethroids should be avoided. The use of harsh miticides for the control of the European red mite, such as Carzol, should be avoided.

Cultural Controls: None available.

Alternative Controls: Natural predation by other mites is a strong influence on pest mite populations. Commercial strains of predatory mite species are being evaluated for introduction into vineyards. A general threshold of 5 active mites per leaf on stressed vines and 5-10 active mites on healthy vines during the month of July is used.

Resistant cultivars: None available.

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

1. There is concern over the use of insecticides on mite populations as many are toxic or repel beneficial and predatory mites. They may cause rapid dispersal of the pest throughout the canopy and field and they may stimulate feeding and egg laying in pest mite species. Control products that are compatible with biological controls are required. Research is required to develop techniques for the selection of pesticides to mitigate the disruption of beneficial mites.
2. There is concern about the use of pyrethroids that have been linked to mite outbreaks in several crops.
3. There is concern over the effect of fungicides on mite outbreaks, since some fungicides are toxic to predatory mites. Chemicals such as dinocap and mancozeb are known to affect mite populations. The combination of mancozeb and sulfur has been shown to be very toxic, while separately they are less toxic.
4. There is concern that thresholds found in the literature are often not applicable to Canada, where light is a limiting factor for good fruit quality in the fall. There is a need for the establishment of thresholds that are applicable to Canada.

5. There is concern over the rapid development of resistance in mite populations to miticides. Additional summer miticides are required.
6. There is a need for additional research to determine the role of beneficials and ground cover management in controlling mite populations.

McDaniel Spider Mite (*Tetranychus mcdanieli*)

Pest Information

Damage: The mites suck sap from leaves and shoots, causing leaves to become bronzed, dry and brown and causing shoots to be stunted. Fruit on severely affected vines may not ripen.
Life Cycle: The pest has been identified as a problem in B.C.

Pest Management

Chemical Controls: The application of a miticide, such as dicofol or pyridaben, will reduce plant-feeding mites without killing predaceous mites.
Cultural Controls: None available.
Alternative Controls: Pest levels are not economically important if the ratio of pests to predators is 10 to 1 and chemical controls harmful to the predator are avoided. Regular assessment of pest and predaceous mite numbers is required along with noting the colour and vigour of leaves and vines before sprays are applied.
Resistant cultivars: None available.

Issues for McDaniel Spider Mite

None identified.

Grape Cane Gallmaker (*Ampeloglypter sesostris*)

Pest Information

Damage: Except in some localized areas, the grape cane gallmaker is usually a very minor problem. The gall-like swelling on the cane is caused by the oviposition injury and reaches full size after 6-8 weeks. Galls are usually twice as thick as the cane and 2.5 to 4 cm long. They are found just above the nodes and are of uniform shape except for a deep longitudinal scar on the side of the gall where the female made the egg cavity. On galls where beetles successfully completed development and emerged, a round exit hole can be found near the longitudinal scar. Galls have little effect on vigour and growth of the vine, but they can weaken the mechanical strength of the cane, resulting in breakage.
Life Cycle: The grape cane gallmaker is one of two *Ampeloglypter* species which can damage new shoot growth in the spring. This small snout beetle is found throughout eastern and midwestern North America and has caused considerable injury in some areas in recent years. It has only one generation per year. It has been occasionally found in Ontario.

Pest Management

Chemical Controls: Sprays applied against the grape flea beetle when the buds are swelling will help control this pest.
Cultural Controls: It is possible to prune out galls without affecting the crop. This reduces the overwintering population provided galls are pruned out and destroyed before the adults emerge in August.

Alternative Controls: None available.
Resistant cultivars: None available.

Issues for Grape Cane Gallmaker

None identified.

Grape Cane Girdler (*Ampeloglypter ater*)

Pest Information

Damage: The pest attacks new shoot growth in the spring. The girdling by the female causes the terminal growth of new shoots to bend over above the upper girdle and drop to the ground. The whole infested shoot dies back to the lower girdle and falls from the vine. Vines "pruned" by the grape cane girdler have a ragged appearance, suggesting serious injury to the plant, but actual damage is usually minor. Girdling of the terminal growth has little or no effect on the crop unless fruit-producing nodes are close to attacked shoot tips.

Life Cycle: The pest has been reported from throughout the midwestern and eastern United States and is only occasionally found in Ontario and Quebec. Originally this species was described as feeding primarily on Virginia creeper, *Parthenocissus quinquefolia*, but it has adapted quite well to cultivated grapes. Like the grape cane gallmaker, it has only one generation per year.

Pest Management

Chemical Controls: Sprays applied against the grape flea beetle when the buds are swelling will help control this pest. Azinphos-methyl is registered for control of this pest.

Cultural Controls: Shoots injured by the grape cane girdler are easy to identify early in the season and should be cutoff below the lower girdle before the aduIts emerge in the summer. This may also help reduce the overwintering population.

Alternative Controls: None available.

Resistant cultivars: None available.

Issues for Grape Cane Girdler

None identified.

Grape Flea Beetle (*Altica chalybea*)

Pest Information

Damage: Overwintered adults attack swelling buds by boring into them and hollowing out the inside. In contrast, the larvae and summer adults feed on the tender leaf tissues but avoid the leaf veins. Feeding on the primary buds is by far the more serious damage by this insect, causing yield loss and stunted growth from secondary or tertiary buds. No fruit develops on canes where the primary and secondary buds are destroyed. As the small shoots appear the adults and young larvae feed on the expanding leaves.

Life Cycle: The pest is native to North America and has been found occasionally in Ontario and Quebec. The amount of injury varies from year to year, being more serious in years when bud development is prolonged by unfavourable climatic conditions. Under favourable growing conditions the bud passes rapidly through the stage when it is susceptible to attack.

Pest Management

Chemical Controls: To prevent bud feeding, treatment with a broad-spectrum insecticide is effective against adults migrating to grapevines from their hibernation sites, but timing is very critical. At the time larvae and beetles are feeding on the upper surface of grape leaves, they are easily controlled by spraying. Insecticide treatments applied post bloom against the grape berry moth will also help reduce grape flea beetle populations. Azinphos-methyl is the only insecticide registered for this pest.

Cultural Controls: When possible, wasteland and woodland located near cultivated vineyards should be cleaned up, eliminating hibernation sites. Frequent discing to control weeds between grape rows can also break the pupal cells in the soil and expose them to desiccation.

Alternative Controls: None identified.

Resistant cultivars: None identified.

Issues for Grape Flea Beetle

None identified

Grape Tumid Gallmaker (*Janetiella brevicauda*)

Pest Information

Damage: The small fly produces galls measuring 3.2 to 6.4 mm in diameter typically located on leaves, petioles and flower clusters. In heavy infestations, the galling may reduce vine vigour and can cause shoot breakage, but in most instances, galling is of little economic importance. Galling on flower clusters can result in poorly shaped fruit clusters or their complete loss.

Life Cycle: This pest is native to the northeastern United States and southeastern Canada and is occasionally found in Ontario. It infests only wild and cultivated grapes (*Vitis* spp.). Infestations are generally spotty, both within vineyards and within infested vines. In the past, tumid galls were attributed to as many as five species of flies, but it is now thought that the single species accounts for almost all of the damage seen in northeastern vineyards.

Pest Management

Chemical Controls: There are no chemicals registered for the control of this insect on grape.

Cultural Controls: Burying pupae by mounding soil up under the vines early in the season can prevent the pest from emerging.

Alternative Controls: There are several parasitic and predatory insects that attack the larvae.

Resistant cultivars: None identified.

Issues for Grape Tumid Gallmaker

1. There is a need for the registration of control products for this pest.

Click Beetle or Wireworm (*Coleoptera*: *Elateridae*)

Pest Information

Damage: Feeding destroys the developing primary grape buds in the dormant to 3 cm growth stage. Secondary growth from damaged buds is delayed and the potential crop yield is reduced.

Life Cycle: It is not yet well understood what species of click beetle cause damage to grapes. Click beetles emerge in the spring to mate, lay eggs and feed on developing buds, flowers and leaves.

Pest Management

Chemical Controls: Prior to planting, growers should monitor soil in grassy areas to determine if a potential wireworm problem exists. If control is required, chemical products may be applied. There are no products registered for click beetles. Certain sprays applied for cutworm control in the spring will also control click beetles. There are no products specifically registered for control of wireworms in established vineyards, but control can be achieved by drilling insecticide-treated cereal seed into the soil between and around the rows.

Cultural Controls: In established vineyards, weed control, especially of grasses, is critical in the prevention and control of wireworms. Elimination of ground vegetation discourages egg-laying by female click beetles and also deprives wireworms of food. Shallow cultivation in the late spring or early summer exposes eggs to predators and drying. Maintaining healthy, vigorous plants reduces the impact of wireworm feeding damage to the roots.

Alternative Controls: Yellow sticky boards can be placed around the vineyard to attract incoming beetles and determine when they enter the vineyard.

Resistant cultivars: None available.

Issues for Click Beetle / Wireworm

None identified

Climbing Cutworms (*Peridroma saucia* and *Xestia c-nigrum*)

Pest Information

Damage: The pest feeds on buds and young leaves. Many buds on a single shoot or along a cordon may be destroyed.

Life Cycle: The variegated cutworm *(Peridroma saucia)*, the spotted cutworm *(Xestia c-nigrum)* and other cutworm species are present in BC vineyards. Female moths are attracted to tall weeds and grasses where they lay their eggs in the soil. The cutworms hatch the next spring and feed on weeds and other vegetation. If weeds are destroyed from mid-May to mid-June, cutworms will have no source of food other than the grapevines.

Pest Management

Chemical Controls: There are no chemicals registered for the control of these insects on grape.

Cultural Controls: Proper vegetation management will discourage egg-laying by the moths and deprive young cutworms of food hosts. Destroying weeds during the period from mid-May to mid-June should be avoided so the cutworms are not forced to feed on the vines. Vines should be examined daily during this period for cutworm or for signs of feeding.

Alternative Controls: None available.

Resistant cultivars: None available.

Issues for Climbing Cutworm

1. Economic thresholds need to be established.
2. Methods available to monitor cutworm need to be improved.
3. The evaluation and registration of reduced risk materials as sprays to groundcover, to grape foliage and as baits is needed.
4. Research to determine the role of diseases and biological control agents, in the control of cutworm, is needed.
5. Research and registration of microbials for the control of this pest is needed.
6. There is a need for demonstration and education on vegetation management. The use of mustard and other ground covers for cutworm management needs to be evaluated. Proper timing of spring weed control needs to be determined and communicated. The registration of control products for areas with sandy soils and heavy clay soils is needed, due to the absences of weeds.
7. Species need to be identified so that pesticide labels are accurate.
8. There is concern over the use of drip irrigation as this gives cutworms no alternative host.

Western Flower Thrips (*Frankliniella occidentalis*)

Pest Information

Damage: Adults and nymphs of the western flower thrips feed on flower and fruit tissue from bloom to the beginning of fruit set. Feeding causes berry scarring and russeting. Females cause fruit spotting as they insert their eggs into young fruit. Cracking and deformation of fruit occurs and is particularly destructive to grapes sold as fresh fruit. Flower thrips and grape thrips also cause feeding damage, but are not as economically significant.

Life Cycle: The most common and destructive thrips of grapes grown in BC's interior is the western flower thrips. In Ontario, while this pest is found in greenhouses adjacent to vineyards, it has not been identified as a pest problem. Other thrips species, including the flower thrips (*F. tritici*) and the grape thrips (*Drepanothrips reuteri*) are of secondary importance.

Pest Management

Chemical Controls: Certain pesticides applied for leafhoppers will also help control thrips.

Cultural Controls: Mowing or the destruction of ground cover in the week prior to and during bloom to fruit set should be avoided so that thrips are not forced onto vines.

Alternative Controls: The presence of thrips can be confirmed by shaking flower or fruit clusters or leaves onto a white surface.

Resistant cultivars: None available.

Issues for Western Flower Thrips

1. The registration of a new organic formulation of spinosad, known as "Entrust" has been identified as a useful product for organic growers.

Lecanium Scale (*Lecanium coryli*)

Pest Information

Damage Caused: Adults and nymphs feed by sucking plant fluids from shoots and vines. As scales feed, they excrete a sticky honeydew which drips onto the fruit, leaves and vines. A black sooty fungus grows on the honeydew, giving the grapes an unsightly appearance. Feeding by scales weakens shoots and vines.

Life Cycle: Mature lecanium scales are flat, round insects that cling to woody parts of grapevines. Each female scale can produce hundreds of nymphs (crawlers). Crawlers are the only mobile stage of the scale.

Pest Management

Chemical Controls: Malathion is registered for the control of scale crawlers.
Cultural Controls: None identified.
Alternative Controls: None available.
Resistant cultivars: None available.

Issues for Lecanium Scale

None identified.

Snailcase Bagworm (*Apterona crenulella*)

Pest Information

Damage Caused: The pest causes minimal feeding damage to leaves and young fruit.

Life Cycle: Identified only in B.C., the caterpillar lives within a snail-like case that it makes from silk and oil particles. Snailcase bagworms have been found on grape plants and posts and wires in early summer in high numbers. There is one generation per year and it is considered to be economically important only for table grapes.

Pest Management

Chemical Controls: There are no products registered to control snailcase bagworm. Insecticides applied to control other pests should provide adequate control.
Cultural Controls: None available.
Alternative Controls: None available.
Resistant cultivars: None available.

Issues for Snailcase Bagworm

1. There is a need for a control for this pest for table grapes. *Bacillus thuringiensis* has been identified as a potential minor use candidate.

Table 6. Insect control products, classification and performance for Canadian grape production

Regulatory Status as of May 18, 2006					Stakeholder Comments[6]	
Active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action – resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**	**Performance of product according to recommended use[5]**	**Notes**
9-dodecenyl Acetate, 11-Tetradecenyl (3M MEC-GBM sprayable pheromone)	Pheromone		R	Grape berry moth	A	This is a mating disruption product for grape berry moth and a good resistance management tool. There are no worker exposure problems. The number of applications and need for a monitoring service to support it while growers still need to apply insecticides for leafhopper control have made this product uneconomical and unattractive for use.
acetamiprid (Assail 70 WP)	Neonicotinoid insecticide	4A	RR/OP	Leafhoppers	A	Require other products for resistance management. Need to increase frequency of applications permissable. Product is non-disruptive to beneficials and is a good IPM product.

Regulatory Status as of May 18, 2006					Stakeholder Comments[6]	
Active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action – resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**	**Performance of product according to recommended use[5]**	**Notes**
azinphos-methyl (Guthion, Sniper)	Organophosphate insecticide	1B	PO (use accepted until Dec 31, 2007)	Grape berry moth	A	Is a broad spectrum and controls several sporadic pests. Good in rotation. Long re-entry periods make this product difficult to use. New entry restrictions have greatly reduced use of product. Growers are left with few, effective alternatives. More research is required to develop alternatives.
				Leafhoppers	I - A	Potato leafhoppers are resistant to this product. Provides good control of the three banded leafhopper.
				Grape flea beetle	A	Works well for this early season, sporadic pest. There are no other product choices available. There is no research underway to support replacements.
				Grape Cane Girdler		
carbaryl (Chipco Sevin RP2 carbaryl insecticide liquid suspension)	Carbamate insecticide	1A	RE	Grape berry moth	I - A[P]	
				Leafhoppers	A	Effective against all species of leafhoppers. Poor IPM fit. Harsh on beneficial mites and can trigger European red mite flare-ups.

Regulatory Status as of May 18, 2006					Stakeholder Comments[6]	
Active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action – resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**	**Performance of product according to recommended use[5]**	**Notes**
cypermethrin (Ripcord 400EC, Cymbush 250 EC)	Pyrethroid ester insecticide	3	R	Grape berry moth		No longer available in the market place
				Grape leafhopper		
				Multicoloured Asian lady beetle	A	Good IPM fit. Less disruptive than Pounce on beneficial mites. Time of application also minimizes impact on beneficial mites.
diazinon (Diazinon 50W, Diazinon 500 E)	Organophosphate insecticide	1B	RE	Grape berry moth	A	
				Leafhoppers	A	Expensive product.
				Grape mealy bug		
dicofol (Kelthane 50W)	Unclassified acaricide	Unclassified	R	European red mite		
				Two-spotted spider mite		
				Mc Daniel Mite		
endosulfan (Thionex 50WP endosulfan)	Cyclodiene organochlorine insecticide	2A	RE	Leafhoppers		
				Grape phylloxera (leaf form)		

Regulatory Status as of May 18, 2006					Stakeholder Comments[6]	
Active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action – resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**	**Performance of product according to recommended use[5]**	**Notes**
malathion (Malathion 500E)	Organophosphate insecticide	1B	RE	Multicoloured Asian lady beetle	A	It is essential to have this product as some grapes are shipped to the USA. There is a tolerance set by the EPA for malathion but not for cypermethrin the other product of choice for control of this pest. In a high pressure year, re-infestation may occur before 3 day PHI allows for harvest. Good IPM fit.
				Leafhoppers		
				spider mites		
				Grape phylloxera		
				Grape mealy bug		
				Scale (crawlers)		
permethrin (Pounce EC insecticide)	Pyrethroid insecticide	3	R	Grape berry moth	A[P]	Efficacy is dependent on pest pressure and temperature - with high temperatures is less effective. Disruptive to beneficial mite complex and thus is not a good IPM product. Effective against leafhoppers. Effective against Asian lady beetles but pre-harvest interval is too long for this use.
				Leafhoppers		
phosalone (Zolone Flo)	Organophosphate insecticide	1B	RE	Grape berry moth	I	Provides poor control so is used in lightly infested areas only. Is a poor IPM fit as is harsh on beneficials.
				Leafhoppers		Efficacy against leafhoppers is unknown.

Regulatory Status as of May 18, 2006					Stakeholder Comments[6]	
Active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action – resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**	**Performance of product according to recommended use[5]**	**Notes**
phosmet (Imidan 50-WP)	Organophosphate insecticide	1B	RE	Grape berry moth	A[P]	Provides poor control. Has less restrictions on re-entry, so is an alternative in sites with low grape berry moth pressure. More effective alternatives are needed.
pyridaben (Pyramite miticide/insecticide)	METI Acaricide	21	R	European red mite	A	Product prone to resistance like all miticides. Provides fairly quick knock down and gives control the remainder of the season and drastically reduces overwintering populations. Good IPM fit. Numerous new summer miticides under development would be an excellent fit and would help delay resistance development.
				Two-spotted spider mite		
				Mc Daniel Mite		
sulphur (Basf Kumulus DF fungicide water dispersable granular)	Multi-site contact activity fungicide	M2	R	Grape erineum mite	A	Only product that is registered and effective. However it is disruptive to beneficial mites and encourages outbreaks of other mites. Addition to post harvest interval requested for wine grapes by processors to avoid wine quality/fermentation problems.

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

[2]The classification and the mode of action group are based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action. The document is under revision and up-to-date information can be found on the following web sites: herbicides:http://www.plantprotection.org/HRAC/Bindex.cfm?doc=moa2002.htm ; insecticides:http://www.irac-online.org/documents/moa/MoAv5_1.pdf ; fungicides:http://www.frac.info/frac/index.htm

[3] R-full registration (non-reduced risk), RE-under re-evaluation (yellow), DI (red) -discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA, BI-biological, RR-reduced risk (green), OP-organophosphate replacement, NR-not registered. Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Individual product labels should be consulted for up to date accurate information concerning specific registration details. The information in these tables should not be relied upon for pesticide application decisions. Consult individual product labels for specific registration details. The following website can be consulted for more information on pesticide registrations: http://www.eddenet.pmra-arla.gc.ca/4.0/4.0.asp

[4] Please consult the product label on the PMRA web site (http://www.eddenet.pmra-arla.gc.ca/4.0/4.0.asp) for specific listing of pests controlled by each active ingredient.

[5] A – Adequate (green) (the pest control product (PCP), according to recommended use, maintains disease below economic threshold OR provides acceptable control), Ap – Provisionally Adequate (yellow) (the PCP, while having the ability to provide acceptable control, possesses qualities which may make it unsustainable for some or all uses), I – Inadequate (red) (the PCP, according to recommended use, does not maintain disease below economic threshold OR provides unacceptable control)

[6]Sources: Crop profile focus groups for Ontario, Quebec and Nova Scotia (2004).

Table 7. Availability and use of insect pest management approaches for Canadian grape production

	Practice \ Pest	Grape Berry Moth	Potato Leafhopper	Western Grape Leafhopper	Virginia Creeper Leafhopper	Multi-coloured Asian Beetle
Prevention	tillage	available/not used				
	residue removal / management					
	water management					
	equipment sanitation					
	row spacing / seeding depth					
	removal of alternative hosts (weeds/volunteers)	available/not used				
	mowing / mulching / flaming					
Avoidance	resistant varieties					
	planting / harvest date adjustment					
	crop rotation					
	trap crops - perimeter spraying					
	use of disease-free seed					
	optimizing fertilization					available/used
	reducing mechanical damage / insect damage					
	thinning / pruning					
Monitoring	scouting - trapping	available/used				available/not used
	records to track pests	available/used	available/used			available/not used
	field mapping of weeds					available/not used
	soil analysis					available/not used
	weather monitoring for disease forecasting					available/used
	grading out infected produce	available/not used				
Suppression	use of thresholds for application decisions	available/used	available/used			not available
	biological pesticides					
	pheromones	available/used				
	sterile mating technique					
	beneficial organisms & habitat management					
	pesticide rotation for resistance management	not available	not available			available/used
	ground cover / physical barriers					available/used
	controlled atmosphere storage					
	forecasting for applications		not available			

no indication that the practice is available/used
available/used
available/not used
not available

Source(s): Crop Profile focus groups for Ontario, Quebec and Nova Scotia, 2004.

Weeds

Key Issues

- The registration of herbicides in families with new modes of action, to be used in rotation with existing chemistries, is needed to limit the occurrence of resistance in weed populations.
- There is a need for new herbicides that are less harmful to the environment and that have less of an impact on vine health.
- Herbicide registrations are needed for new plantings.
- The reduction in the environmental impact of herbicides by reducing the rates of residual herbicides such as simazine and diuron used, is needed.
- There is a need to develop cultural methods (winter protection hilling and de-hilling), to enable the use of herbicides with shorter residual periods.
- There is concern that newly introduced weed species may not be controlled by the herbicides currently available, allowing them to quickly establish in an environment of little competition. Surveying for new weed species and screening for new herbicide controls is needed.
- Control measures for perennial weeds, such as Canada thistle and field bindweed are needed. Late season weed escapes can greatly increase harvest losses from mechanical harvesters.
- There is a need to identify key problem weeds and to communicate to growers the difference between problem weeds and plants that are beneficial.
- Research on ground cover management is needed.
- Education and demonstration projects to help growers deal with their weed problems in the proper manner are needed.
- There is a need to determine the proper timing of herbicide applications and to communicate this to growers.
- There is a concern about the use of manures, straw mulches and improperly composted organic material as they can lead to the introduction of new, invasive weed species, which are not controlled by registered herbicides.
- There is concern over the impact of weed management practices on new suckers being grown to generate a new trunk as a result of winter injury on older plants.
- Require new, innovative ways to manage weeds to support organic production of grapes.

Table 8. Degree of occurrence of weed pests in Canadian grape production

Weed	Degree of occurrence			
	BC	ON	QC	NS
Annual grass	E	DNR	DNR	DNR
Annual broadleaf	E	DNR	DNR	DNR
Perennial grass & sedge	E	DNR	DNR	DNR
Perennial broadleaf	E	DNR	DNR	DNR

Widespread yearly occurrence with high pest pressure
Localized yearly occurrence with high pest pressure OR widespread sporadic occurrence with high pest pressure
Widespread yearly occurrence with low to moderate pest pressure
Localized yearly occurrence with low to moderate pest pressure OR widespread sporadic occurrence with low to moderate pest pressure
Pest not present
E – established
D – invasion expected or dispersing

Source(s): BCMAFF; Crop Profile focus groups for Ontario, Quebec and nova Scotia, 2004.

Major Weeds

Annual Grass and Broadleaf Weeds

Common annual weeds: Velvet leaf *(Abutilon theophrasti)*

Pest Information

Damage: Crop loss can be very high if annual weeds are not controlled. Newly planted vines do not compete well with large, annual weeds. Annual weeds are highly competitive and heavy users of water and nutrients. New vines will lose a year's growth if there is a lot of annual weed competition and could be killed if water or nutrients are a limiting factor. Competition can cause crop loss on older vines, causing fruit to be smaller and allowing fewer fruit buds to set for the next season's crop. Losses can reach 50%, depending on the rootstocks and weeds involved. Indirect damage can be caused as some weed species can be hosts to insects and mites, such as tarnished plant bug, mullein leaf bug and two-spotted spider mites. Nematodes and vertebrates can use weed roots as a food source, with vertebrates also taking advantage of weeds as hiding places.

Life Cycle: Annual weeds complete their life cycle in one year, going through seed germination, growth and new seed production. Many weeds in fruit crops are winter annuals, beginning their growth in the fall, growing a rosette and producing their flower in the second year. Spring annual weeds germinate in the early spring. They grow for May and June and produce seeds during the summer. Annual weeds are very adept at disseminating through the production of huge numbers of seeds. Most arable land is infested with weed seeds at all times. Some weed seeds can remain viable in the soil for many years, germinating when conditions are right. For new plantings, the critical stage for control of annual weeds is during May and June. The critical weed-free period generally means that no yield reduction will result if the crop is kept free of weeds during this time. Weeds emerging after the critical weed-free period will not affect yield, but control efforts after this time may make for a more efficient harvest or reduce weed problems in subsequent years.

Biennial Weeds

Common Biennial weeds – buttercup *(Ranunculus* spp.), yellow rocket *(Barbarea vulgaris),* wild carrot *(Daucas carota),* burdock *(Arctium minus*) and peppergrass *(Lepidium* sp.*).*

Pest Information

Damage: See annual grass and broadleaf weeds section for damage.

Life Cycle: Biennial weeds are plants that germinate in the spring, produce a rosette of leaves and remain vegetative during the first summer. They overwinter as rosettes and then during the second summer they bolt and send up a flower stock on which seeds are produced. The original plants then die at the end of the second growing season. Biennial weeds only disseminate through the seeds produced every other year and so their dissemination potential is slightly less than that of annuals. Seeds can be banked in the soil for years waiting for the right conditions to germinate.

Perennial Grass (Quack Grass) and Perennial Broadleaf (Thistle, Dandelion, Poison Ivy, Plantain, Milkweed, Creeping Charlie, Wild Grape, Bindweed, Vetch, Perennial Nightshade)

Common perennial weeds – quackgrass (*Elytrigia repens*), thistle, dandelion (T*araxicum officinale*), poison ivy (*Rhus toxicodendron*), plantain (*Plantago* sp.), common milkweed (*Asclepias syriaca*), creeping Charlie (*Glechoma hederacea*) wild grape (*Vitis* sp.), field bindweed (*Convolvulus arvensis*.), vetch *(Vicia* sp.) and perennial nightshade (*Solanum* sp.).

Pest Information

Damage: The potential crop damage is similar to that for annuals. Perennial weeds can get very large and be very competitive especially if they have been established for several years.

Life Cycle: Perennials are plants that live for many years. They can spread by seed, but also can spread vegetatively with their root systems. The plants usually flower every year and continually expand their root systems.

Weed Pest Management

Pest Management

Chemical Controls: Registered pre-emergent herbicides include simazine, diuron, and napropamide. Registered post-emergent products include glufosinate ammonium, paraquat and glyphosate. All products are ground applied using booms with various types of hoods to avoid drift and/or the use of "Enviromist" technology (use of fine droplet size with ultra low volumes of water applied in an enclosed round hood with brushes to avoid drift and non-target contact). Spot treatments combined with hand weeding are essential to prevent the establishment of new weed species and/or resistant biotypes.

Cultural Controls: The management of surrounding fields, ditches and road areas by cultivation, fallowing or mowing will keep weeds from flowering and producing seed that could potentially be blown into the vineyard. A biodegradable plastic mulch or straw mulch can be used for weed control in the planting strip. A green manure crop planted with rye-grass or Sudan grass the year before planting, combined with fallow periods, can stimulate weed seed germination and deplete the weed seed bank in the soil. In addition, non-selective herbicides for broadleaf weed control, such as 2,4-D can be used in the green manure cropping system. Mulch and manure must be weed seed free to prevent the introduction of new weeds. Establishing sod cover the year before planting and then planting into the sod that has been chemically killed before planting to avoid competition, 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. Systemic herbicides, such as glyphosate and amitrole, can be considered in the pre-plant year when there are no crop restrictions. Repeated applications and cultivations may be needed to control certain weed species, such as quack grass.

Alternative Controls: The concept of critical control stage has helped growers determine what period the planting strip must remain weed free to avoid competition between weeds and the fruit crop. Fruit growers will often have to apply 2-3 applications of either pre-emergent and/or post emergent products to control weeds over this critical period that lasts approximately 2-3 months.

Issues for Weeds

1. There is a concern over the use of manures, straw mulches and improperly composted organic material, as they can lead to the introduction of new weed species not normally found in the area and controlled by common herbicides used.
2. .Reduced rates of herbicides would be a useful management tool for vineyard renewal after winter injury. AAFC and PMRA need to support an URMULE submission of half mixture of diuron and simazine.

Table 9. Weed control products, classification and performance for Canadian grape production

Regulatory Status as of May 18, 2006					Stakeholder Comments[6]	
Active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action – resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**	**Performance of product according to recommended use[5]**	**Notes**
Paraquat (Gramoxone)	Bipyridylium herbicide	22	R (Re-evaluation complete)	Annual broadleaf weed	A	Good in rotation. Hinders establishment of perennial weeds but does not kill established perennials. Acts as a chemical prune on vines.
				Annual grasses	A	Good in rotation. Good to supplement pre-emergent program when weeds have already germinated or became established. Product may damage green sucker growth being trained as trunk renewals. Worker exposure concerns; preference to use safer products so use is in decline.
				Perennial broadleaf weeds	A	
				Perennial grasses	A	
Glufosinate amonium (Ignite 15 SN)	Phosphinic acid herbicide	10	R	Perennial broadleaf weeds		Safer than paraquat. Product is applied once to control multiple weed species.
				Annual broadleaf weeds	A	Good in rotation. Provides good control without occupational hazard concerns. Product is increasing in use and replacing paraquat because of its lower price, ease of use and saftey on sucker/trunk renewals.
				Annual grasses	A	Product is applied once to control multiple weed species. Possible chemical prune.

Regulatory Status as of May 18, 2006					Stakeholder Comments[6]	
Active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action – resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**	**Performance of product according to recommended use[5]**	**Notes**
Glyphosate and N-glycine trimethylsulfonium salt (Touchdown IQ)	Glycine herbicides	9	R	Perennial broadleaf weeds		One application controls all four weed groups. Could get some crop injury. Tolerant weeds could move in to vineyard without chemical rotation. Glyphosate is the only herbicide used in vineyards in QC.
				Perennial grasses and sedges		
				Annual broadleaf weeds	A	Tolerant species may move into vineyard. Could get some crop injury. There is a risk of phytotoxicity following drift onto non target plants.
				Annual grasses	A	Tolerant species may move into vineyard without chemical rotation. Could get some crop injury.
Diuron (Karmex DF)	Urea herbicide	7	RE	Annual broadleaf weeds (seedlings)	**A**	Good in rotation. Long lasting control.
				Annual grasses (seedlings)		
Dichlobenil (Casoron G-4)	Nitrile herbicide	20	R (Re-evaluation complete)	Perennial broadleaf weeds	A	Very expensive. Used only as a spot treatment for weeds, less than 1% of the area is treated.
				Perennial grasses and sedges		Very expensive. Used only as a spot treatment for weeds, less than 1% of the area is treated.

Regulatory Status as of May 18, 2006					Stakeholder Comments[6]	
Active ingredient / organism (product)[1]	**Classification[2]**	**Mode of action – resistance group[2]**	**PMRA status of active ingredient[3]**	**Pests or group of pests targeted[4]**	**Performance of product according to recommended use[5]**	**Notes**
napropamide (Devrinol 10G	Acetamide	15	R	Annual grasses		
				Annual broadleaf weeds		
Simazine plus relative triazines (Princep nine-T)	Triazine herbicide	5	R	Perennial broadleaf weeds (seedlings)	A[P] - A	Provides fair to good pre-emergent control for this weed group. Simazine is not used in Quebec.
				Perennial grasses (seedlings)		Provides fair to good pre-emergent control for this weed group.
				Annual broadleaf weeds	A	Cannot be used in young plantings as it burns roots.
				Annual grasses	A	Good in rotation. Provides excellent control as a pre-emergent control of annual grasses and broadleaves. Cannot be used in young plantings as it burns roots.

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

[2]The classification and the mode of action group are based on the classification presented in the Pest Management Regulatory Agency Regulatory Directive DIR99-06, Voluntary Pesticide Resistance-Management Labelling Based on Target Site/Mode of Action. The document is under revision and up-to-date information can be found on the following web sites: herbicides:http://www.plantprotection.org/HRAC/Bindex.cfm?doc=moa2002.htm ; insecticides:http://www.irac-online.org/documents/moa/MoAv5_1.pdf ; fungicides:http://www.frac.info/frac/index.htm

[3] R-full registration (non-reduced risk), RE-under re-evaluation (yellow), DI (red) -discontinued by registrant, PO (red) - being phased out as a result of re-evaluation by the PMRA, BI-biological, RR-reduced risk (green), OP-organophosphate replacement, NR-not registered. Not all end-use products will be classed as reduced-risk. Not all end use products containing this active ingredient may be registered for use on this crop. Individual product labels should be consulted for up to date accurate information concerning specific registration details. The information in these tables should not be relied upon for pesticide application decisions. Consult individual product labels for specific registration details. The following website can be consulted for more information on pesticide registrations: http://www.eddenet.pmra-arla.gc.ca/4.0/4.0.asp

4 Please consult the product label on the PMRA web site (http://www.eddenet.pmra-arla.gc.ca/4.0/4.0.asp) for specific listing of pests controlled by each active ingredient.

[5] A – Adequate (green) (the pest control product (PCP), according to recommended use, maintains disease below economic threshold OR provides acceptable control), Ap – Provisionally Adequate (yellow) (the PCP, while having the ability to provide acceptable control, possesses qualities which may make it unsustainable for some or all uses), I – Inadequate (red) (the PCP, according to recommended use, does not maintain disease below economic threshold OR provides unacceptable control)
[6]Sources: Crop profile focus groups for Ontario, Quebec and Nova Scotia (2004).

Table 10. Availability and use of weed pest management approaches for Canadian grape production

	Practice \ Pest	annual grass	annual broadleaf	perennial grass	perennial broadleaf
Prevention	tillage				
	residue removal / management				
	water management				
	equipment sanitation				
	row spacing / seeding depth				
	removal of alternative hosts (weeds/volunteers)				
	mowing / mulching / flaming				
Avoidance	resistant varieties				
	planting / harvest date adjustment				
	crop rotation				
	trap crops - perimeter spraying				
	use of disease-free seed				
	optimizing fertilization				
	reducing mechanical damage / insect damage				
	thinning / pruning				
Monitoring	scouting - trapping				
	records to track pests				
	field mapping of weeds				
	soil analysis				
	weather monitoring for disease forecasting				
	grading out infected produce				
Suppression	use of thresholds for application decisions				
	biological pesticides				
	pheromones				
	sterile mating technique				
	beneficial organisms & habitat management				
	pesticide rotation for resistance management				
	ground cover / physical barriers				
	controlled atmosphere storage				
	forecasting for applications				

no indication that the practice is available/used

available/used

available/not used

not available

Source(s): Crop profile focus groups for Ontario, Quebec and Nova Scotia, 2004.

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Table 11. Research contacts related to pest management in Canadian grape production

Organization	Pest type	Specific pests	Type of research
AAFC - PARC	insect	wireworm, click beetles	population dynamics, monitoring techniques, biocontrols
AAFC - HRDC	insect	grape pests	dynamics, development of an organic pesticide
AAFC - Vineland	insect	grape berry moth, leafhoppers, mites, multicoloured Asian lady beetle	toxicology, resistance management, insecticide efficacy, IPM fit of new chemistries
AAFC - HRDC	insect/disease, Geomatics/plant science		disease and insect forecasting
KCMS Inc.	disease, insect	grape berry moth, leafhoppers, multicoloured Asian lady beetle	technology transfer, pheromone, mating disruption technology efficacy, monitoring methods
AAFC – Vineland	disease	virology, crown gall	preventative, new detection methods, epidemiology, new biotechnology methods
University of Guelph	insect	multicoloured Asian lady beetle	behaviour, populations dynamics, monitoring techniques
AAFC - Vineland	insect	grape berry moth, leafhoppers, mites, multicoloured Asian lady beetle.	efficacy and residue testing
AAFC - Vineland	insect	grape berry moth	mating disruption, pheromones, no longer active in grape research

Organization	Pest type	Specific pests	Type of research
AAFC - HRDC	insect	grape pests	dynamics, development of an organic pesticide
AAFC - HRDC	phytopathology	powdery mildew, botrytis	fungicide resistance, monitoring of spores and modelling risk of infection, biocontrol agents, cultural management of diseases, evaluation of chemical, botanical, and biological fungicides
AAFC - PARC	post-harvest pathology	botrytis, pennicillium	prevention
Lowery Entomological Research Ltd.; AAFC - PARC	insect	leafhoppers, aphids	monitoring, etc.
McSmith Agr Services	disease	powdery and downy mildew, crown gall	efficacy of new fungicides, alternative methods of control, disease predictive models