5.1 Integrated Pest Management

Integrated Pest Management (IPM) is a systematic decision-making process that supports a balanced approach to managing crop and livestock production systems for the effective, economical and environmentally-sound suppression of pests (insects, mites, plant diseases, weeds, and problem wildlife).

The elements of IPM include:

1. Planning and managing agricultural production systems to prevent insects, plant diseases and weeds from becoming pests
2. Identifying pests, their natural enemies and damage
3. Monitoring populations of pests and beneficial organisms, pest damage, and environmental conditions
4. Making control decisions based on potential damage, cost of control methods, value of production, impact on other pests, beneficial organisms and the environment
5. Using strategies that may include a combination of behavioural, biological, chemical, cultural and physical methods to reduce pest populations to acceptable levels
6. Evaluating the effects and efficacy of management decisions

The IPM concept has evolved in response to problems caused by an over-reliance on chemical pesticides. Some of these problems are development of pesticide resistance, adverse impacts on natural enemies of pests and other non-target species, outbreaks of formerly suppressed pests, and risks to environmental, human and food safety.

IPM requires knowledge of how to identify pests and evaluate their damage, how to identify natural control agents, and how to select effective control methods that minimize undesirable side effects.

Select control options for individual pests with the entire vineyard management system in mind. Many pest prevention and cultural control methods are part of normal crop production operations.

Pest Prevention

Pest prevention is the first step in avoiding pest problems in your vineyard. The objectives are to prevent the plants from becoming susceptible to pest attack, to preserve natural enemies (biological control agents), and to avoid attracting or introducing pests into the vineyard. Best management practices to achieve these objectives include:

- Selecting a vineyard site that is suitable for the grape varieties to be grown, or select grape varieties suited to the site
- Optimize plant health to avoid predisposing plants to attack and to reduce the impact of pest attack on plant production through proper irrigation and nutrition programs
- Encourage the establishment of natural enemies through use of compatible pesticides and flowering plants that supply nectar and pollen for these biocontrol agents
- Use recommended crop waste management practices to avoid attracting or maintaining pests such as proper disposal of prunings, diseased/ infested plants/plant parts
- Manage movement of soil, plants, equipment and vehicles to avoid introduction of pests

Identification of Damage, Pests and Natural Enemies

An essential step in applying IPM is to correctly identify pest damage or a specimen that might be a pest or a biological control agent (natural enemy). The text under individual insects, mites and diseases in this Guide tells when and where to look, describes symptoms of disease and pest injury and the life cycle of pests and natural enemies. Correct identification ensures that the correct control product or management practice is used. If you do not recognize the pest, plant or disease/ disorder, submit samples to your nearest BCMAL or Canadian Food Inspection Agency office for identification. Early detection of invasive alien species will allow earlier application of management practices to eliminate the new problem or slow its spread.

Monitoring

Monitoring is another essential component of all IPM programs. Monitoring involves timely sampling of the crop or site using prescribed methods to quantify the abundance and distribution of pests and their damage. Also monitor natural enemies where methods are available. Use the information to decide if and when control action is required. For example, examine leaves for the presence and abundance of mites and leafhoppers. As well, inspect green berries to determine the degree of powdery mildew infection.

Undertake to monitor regularly and consistently as required to get valid information. Monitoring is not only important for deciding if control is necessary, but is also useful for evaluating the effectiveness of a control treatment or practice.

Monitoring techniques are available for some vineyard pests and diseases. These techniques are used at a particular time in the life cycle of a pest or disease (such as larval stage or spore release) or in vine development (such as dormant, bud growth or cap fall). These techniques also involve the use of specific sampling units (such as number of leaves or vines, one hour) and equipment (thermometer, trap, beating tray, sweep net). Failure to follow the instructions as described can result in incorrect information and poor control decisions.

The presence of damage alone is not a clear indication that treatment is necessary as the pest may be gone or not in a stage susceptible to control.

Use a 10 to 20x hand lens to inspect plants and a notebook to record observations and numbers for later evaluation. Beating trays, sweep nets and insect traps are useful for capturing insect pests and their natural enemies.

You can make a beating tray using white or pale green preshrunk fabric stretched over a 45 cm x 45 cm piece of plywood or wooden or PVC pipe frame, to form a smooth, taut surface. Light coloured insects are easier to spot on darker cloth. Attach a handle to one side or to the underside to make handling easier. Cover the impact end of the beating stick with rubber or other soft padding to prevent injury to vines. The beating tray is held under a limb which is then rapped sharply three times (= one limb tap) to dislodge any insects onto the tray for counting. Make sure to clear the board of all insects and debris between each limb tap. Insect traps can collect insect pests either by visual attraction (e.g. yellow sticky boards) or by traps (e.g. earwigs). Proper placement and maintenance of these traps is essential if they are to be effective. Sweep nets are useful for collecting insects from vines and from vegetation within rows and around the vineyard.

Some monitoring and sampling equipment is available through local grower supplies retailers.

Where pest forecast models are available, monitoring daily temperatures and rainfall is necessary for these computer-generated models to indicate the presence of a specific development stage of an insect (egg, larva, nymph, etc) and to indicate an infection period of a plant disease.

Control Decisions

The objective of IPM is not to control 100% of the pests in a vineyard. This is neither possible nor desirable. The potential impact of a particular level of pests varies greatly depending on vine vigour and variety, crop value, weather conditions and abundance of natural enemies. For example, little leafhopper damage may result to leaves early in the season if the weather is cold and rainy. Cool weather delays egg laying and hatching which would postpone spray applications. A block of very vigorous vines with a light crop may be able to tolerate much higher numbers of mites than another block suffering from inadequate nutrition. Severity of powdery mildew varies according to temperature, moisture conditions and the degree of infection the previous year. Because of these influencing factors, the control action thresholds recommended in this Guide are only guidelines.

Once you have reviewed the monitoring and other relevant information, you or your advisor can then determine the need for a pesticide application. This task is easier if there is an economic threshold value to follow. Otherwise you must weigh the economic benefit expected from the treatment against the direct and indirect costs of control. Never protect a crop simply for 'cosmetic' purposes. To estimate the benefit of control, compare the expected loss from the pest(s) if you do not apply a pesticide to the cost of applying the pesticide. Direct costs of pesticide application include purchase and transport of pesticide, application and clean-up time, protective clothing and training and licensing requirements. Indirect costs are difficult to measure and include hazard to the applicator, workers, pollinators and other non-target species and risk of pesticide resistance development. This Guide includes information on bee poisoning, minimum days to harvest and relative toxicity of pesticides to help in selecting a suitable pesticide.

Spray effectiveness varies depending on quality of application equipment and technique, weather conditions, timing with respect to presence of susceptible stage of pest or disease and the status of pest resistance to the pesticide.

IPM Control Methods

As previously stated, IPM involves the combined use of chemical, biological, cultural and other control methods supported by accurate pest identification, monitoring, and economic thresholds to minimize crop losses and undesirable side effects on people and the environment. The IPM programs used in grape production differ in the use of control options; however, they all involve some form of pest or pest damage monitoring.

IPM of mites begins with avoiding use of chemicals harmful to predatory mites. Mite IPM also involves monitoring pest and predatory mite abundance and noting evidence of damage (yellowed leaves) and vigour of vines. If a miticide treatment is necessary, select a product that will reduce plant-feeding mites without killing predaceous mites.

IPM of leafhoppers involves monitoring (for egg hatching or for foliage damage), application of an insecticide as needed, monitoring of parasitized leafhopper eggs, and proper irrigation and nutrition to ensure healthy vines. IPM of cutworms involves monitoring developing buds in the spring for signs of feeding (buds hollowed out), inspecting the subsoil at the base of vines and the foliage for cutworms, and applying a recommended insecticide if required.

Vineyard floor vegetation management should apply a balanced approach to minimizing rodent damage and nutrient and water competition to vines and preserving suitable habitat for some natural enemies of vine pests. Also, destruction of floor vegetation may create a pest problem.

For example, do not destroy flowering plants from about one week prior to one week after full bloom of grapes to minimize western flower thrips movement up into the vines and fruit clusters and subsequent damage (pansy spot).

IPM Record Keeping and Evaluation

A very important but often neglected component of IPM is evaluating the results of pest and crop management programs at the end of the season. Did the management decisions result in the expected outcomes? If not, why? Such evaluation is only possible by keeping accurate records of pest and crop management activities. Growers should record results and observations of pest, damage and beneficial species monitoring, and also record irrigation, fertilizer and pesticide applications. Keep separate records for each block to form a permanent record for future reference. Such information is useful to identify changes in pest and natural enemy prevalence. Use these records to identify weaknesses and plan adjustments in the programs for the next growing season by consulting available technical publications and advisory services. Accurate record keeping is an essential component of IPM and these records may be required as part of any production certification programs developed for the commodity.

For various pest and disease monitoring activities, record the date, block/variety, pest/disease name, number found, sample size or unit, and any observations that could useful when the pest management programs are evaluated.

Record all pesticide and fertilizer application activities performed by you, an employee or consultant. Information to record includes the application date, block ID, vine growth stage, pest controlled, product used (trade name) and amount per tank, rate used/ha, spray volume/ha, pre-harvest interval and re-entry interval (as stated on the label), and notes on weather conditions.

5.2 Grape Diseases

Disease Diagnosis

The BC Ministry of Agriculture and Lands (BCMAL) Plant Diagnostic Lab in Abbotsford provides identification of pathogenic and non-pathogenic disorders affecting commercial crops in B.C. Instructions for submitting samples, including fees and submission forms, are located on the ministry website at: www.al.gov.bc.ca/cropprot/lab.htm.

Accurate diagnosis of pests and diseases is an important component of integrated pest management. Selection and implementation of effective disease control strategies requires knowledge about the identity of a disease and an understanding of its life cycle. Any pest or disease problems that you are not familiar with should be submitted for identification. There is no fee charged for specimens submitted as suspected invasive alien species.

Prior to using a pesticide for disease control:

- **Always read the label first!** Follow label instructions and precautions, and note the pre-harvest interval;
- Check that the chosen fungicide is acceptable to your buyers;
- Ensure that all the cultural alternatives for the disease in question have been considered.

Be cautious and accurate when pesticides are used for pest control. Use proper equipment, maintained in good condition and calibrated accurately. Consult the section on Pesticide Application Equipment in this publication for instructions on sprayer calibration and the section on Pesticide Safety.

Grape Powdery Mildew

Powdery mildew, also known as oidium, is caused by the fungus *Uncinula necator*. This fungus has a narrow host range attacking only grape plants and a few related species. It is the most common and widespread disease of grapevines in the Okanagan/Similkameen area. Popular wine grape varieties vary in susceptibility to powdery mildew (Table 5.1).

Table 5.1 - Level of resistance of grape cultivars to powdery mildew

Susceptible	Intermediate	Least Susceptible
Bacchus	Chelois	Auxerrois
Cabernet Franc	Chenin Blanc	Malvoisie
Cabernet Sauvignon	Concord	Melon
Chancellor	Foch	Pinot Gris
Chardonnay	Pinot blanc	Semillon
Chasselas	Malbec	
Gamay	Merlot	
Gewurztraminer	Ortega	
Grenache	Pinot Noir	
Himrod	Perlett	
Madeleine Angevine	Sheridan	
Madeleine Sylvaner	Vidal Blanc	
Malbec	Weissburgunder	
Muller Thurgau		
Pearl of Csaba		
Petit Verdot		
Rkatzeteli		
Riesling		
Sauvignon blanc		
Schonburger		
Siegerebe		
Syrah		
Viognier		

Symptoms

Powdery mildew symptoms can be seen on foliage, fruit, flower parts and canes. Mildew usually appears first as whitish or greenish-white powdery patches on the undersides of basal leaves. It may cause mottling or distortion of severely infected leaves, as well as leaf curling and withering. Lateral shoots are very susceptible. Infected blossoms may fail to set fruit. Berries are most susceptible to infection during the first three to four weeks after bloom, but shoots, petioles and other cluster parts are susceptible all season. Infected berries may develop a netlike pattern of russet, and may crack open and dry up or never ripen at all. Old infections appear as reddish brown areas on dormant canes.

Early powdery mildew infections can cause reduced berry size and reduced sugar content. Scarring and cracking of berries may be so severe as to make fruit unsuitable for any purpose. Be aware that many winemakers have a very low tolerance for powdery mildew on grapes. Research has shown that infection levels as low as 3% can taint the wine and give off-flavours.

Life Cycle

The powdery mildew fungus overwinters as cleistothecia (tiny, round, black fruiting bodies), in bark, on canes, left-over fruit, and on leaves on the ground. Spores (ascospores) from the overwintering cleistothecia are released in the spring after a rainfall of at least 2.5 mm. For primary infection to occur the spores require at least 12-15 hours of continuous wetness at 10-15°C to infect developing plant tissue.

Once primary infection has occurred the disease switches to its secondary phase. Secondary colonies (white mildew patches) form in 7 to 10 days, although the disease is not noticeable early in the season. The white patches of powdery mildew produce millions of spores (conidia) which are spread by wind to cause more infections. Free moisture is not needed for secondary infection; temperature is the most important environmental factor (Table 5.2). The disease spreads quickly in early summer when temperatures are moderate. The incubation time (the time between infection and the production of spores) can be as short as 5 to 6 days under optimal temperatures. Shaded and sheltered locations favour mildew development. High temperatures and sunlight are inhibitory to powdery mildew. Extended periods of hot weather (>32°C) will slow the reproductive rate of grape powdery mildew, as well as reduce spore germination and infection.

Table 5.2 - Effect of temperature on the development of grape powdery mildew

Temperature of leaf* (ºC)	Days for spores to develop, infect vine parts and produce new spores
6	32
9	25
12	18
15	11
17	7
23	6
26	5
30	6
33 (for at least 3 days)	0 (but 10% can recover in 5 days)
40.5 (for at least 6 hrs)	0 (kills the fungus)

*** Note:** Leaf temperature can be slightly higher or lower than air temperature.

Control

Cultural Control:

1. Manage canopies to increase air drainage and light penetration by removing lateral shoots in dense canopies. If necessary remove leaves in the fruiting zone. Dense canopies provide low light intensity, which favours powdery mildew development;
2. Use an under-vine irrigation system (drip or micro-jet);
3. Manage irrigation carefully. Excessive irrigation leads to excessive vigour and higher disease potential;
4. Select varieties that are less susceptible to mildew (Table 5.1)

Fungicides and Disease Forecasting:

Start mildew programs before the overwintering fungus can infect new growth. General recommendations are to begin spray coverage between budbreak and early shoot growth. The most important fungicide timings in this area are the blossom spray (generally just before or just after blossom) and the spray immediately following the blossom spray. Protective fungicide treatments prevent infection of grape tissue by fungal spores. Good coverage is important.

A mildew risk model can be used to forecast disease severity of secondary infections. The UC model developed at the University of California, Davis is the one most widely available and is sold with weather instrument software. The UC model requires a data logger for leaf wetness and temperature. Initially the model predicts primary infection based on hours of leaf wetness and temperature and then switches to the risk phase based only on temperature. The risk indices can be used to help time fungicide applications. When the risk is high the model recommends that fungicides be applied more often. In trials in California, the model has reduced the amount of fungicides applied to grapes. In tests in the Okanagan, the primary phase of the model has not been accurate and more research is required to adapt the model to local conditions. However the risk phase of the model could be valuable for assessing the risk of secondary infection during the growing season. Daily analysis of the model allows the grower to visualize what the conidial population will be approximately one week later and what the potential disease severity will be two weeks later, allowing them to plan their fungicide program in terms of product and application interval. Several years of data from many different sites around the Okanagan and Similkameen indicate that the risk mode consistently predicts severe powdery mildew and the shortest interval between fungicide sprays in July and August. Typical Okanagan temperatures during the summer months are optimum for powdery mildew.

For more information on powdery mildew forecasting models, refer to the University of California website at: www.ipm.ucdavis.edu/DISEASE/DATABASE/grapepowderymildew.html. If not using a disease forecasting model, apply powdery mildew control materials as frequently as necessary when severe mildew conditions exist, keeping in mind the leaf temperature and the number of days needed for spores to infect grape parts and produce new spores (Table 5.2).

Spray Schedule

Protect grape foliage from primary infection by application of fungicides from early shoot growth until after bloom. Good control early in the season to prevent establishment of the disease is the key to preventing a powdery mildew epidemic later in the summer.

Apply fungicides such as Kumulus (sulphur), Nova, Lance, Sovran, Flint, Milstop or Serenade at the following growth stages (also see "Fungicide Notes" below for more information).

1. When new growth is 5 to 10 cm long
2. Just before or immediately after bloom.
3. Every 10 to 14 days until grapes begin to soften and red varieties begin development of colour and white varieties change from green to white or yellow. If Kumulus (sulphur) is used, shorten the spray interval to 7-10 days.

Contact your winery at the beginning of the season to determine the acceptable pre-harvest intervals for any pesticides or sulphur products that may be used in the growing season. Some products contribute to the development of off odours and off flavours and may interfere with the fermentation process.

Dormant spray: Lime Sulphur is effective at suppressing the overwintering population of powdery mildew. It should be applied in early spring before bud break to dormant vines to kill powdery mildew cleistothecia (initial inoculum). Good spray coverage of dormant vines is important.

Post-harvest powdery mildew spray: Post-harvest sprays to control powdery mildew are beneficial. Harvest date will determine the need to keep foliage and canes protected. Severe powdery mildew conditions are generally a result of poor control of this organism during the growing season. Additional sprays for powdery mildew under such conditions after harvest will not protect canes.

Table 5.3 - Fungicides registered for control of powdery mildew on grape

Fungicide	Active Ingredients	Chemical Group[1]	Rate/ha	Rate/acre	PHI[2] (days)	Notes
Quintec	quinoxyfen	13	300-480 ml/ha	122-194 ml/acre	14	Excellent mildew fungicide. Apply on a 14 day interval. Do not exceed 5 applications/season. Use higher rate for severe disease conditions. Alternate with other fungicides. See *Fungicide notes*.
Flint	trifloxystrobin 50% WG	11	105-140g/ha	43-57 g/acre	14	Excellent mildew fungicide. Apply preventively using a 14-21 day interval. Do not use Flint or other group 11 fungicides more than 2 times per season. Alternate with fungicides from other groups. See *Fungicide notes*.
Sovran	kresoxim-methyl 50% WG	11	240-300 g/ha	100-122 g/acre	14	Excellent mildew fungicide. Apply at 14-21-day intervals. Do not use Sovran or other group 11 fungicides more than 2 times per season. Alternate with fungicides from other groups. See *Fungicide notes*.
Pristine	pyraclostrobin + boscalid	11 + 7	420-735 g/ha	170-300 g/acre	14	Excellent mildew fungicide; also provides suppression of botrytis. See label for details on rates and spray intervals. Do not use Pristine or other group 11 fungicides more than 2 times per season.
Lance	boscalid 70% WDG	7	315 g/ha	128 g/acre	14	May also provide some suppression of botrytis bunch rot. Alternate with fungicides from other groups.
Nova	myclobutanil 40%	3	200 g/ha	81 g/acre	14	Excellent mildew fungicide. Apply at 21-day intervals. Do not use more than 2 times per season. Alternate with fungicides from other groups.
Kumulus DF	sulphur 80%	M	4.2 kg/ha	1.7 kg/acre	21/1[3]	Good mildew fungicide. Apply at 10-day intervals.
wettable sulphur	sulphur 92%	M	2.25 kg/ha pre-bloom 4.5-6.0 kg/ha post-bloom	910 g/acre pre-bloom 1.8-2.4 kg/acre post-bloom	21/1[3]	Use the higher rate when vines are in full leaf. Apply at 10-day intervals. Re-apply after rain.
Milstop	potassium bicarbonate	NC	2.8-5.6 kg/ha	1.1-2.3 kg/acre	0	Apply at 7-14 day intervals
Serenade MAX	*Bacillus subtilis*	NC	3.0-6.0 kg/ha	1.2-2.4 g/acre	0	Biofungicide. Disease suppression only.
Lime sulphur	sulphide sulphur	M	100 L lime sulphur in 1000 L of water		120 (apply dormant)	Apply 500L of spray mixture per hectare once per season during dormant stage prior to bud swell (early March to early April). Spray to point of runoff, cover completely.

[1] Chemical Group: Products with the same number belong to the same class of compounds. Alternate products with different chemical groups to help delay or prevent the development of resistance

[2] PHI = Pre-harvest Interval, or minimum number of days between last spray and harvest.

[3] Sulphur can be used on table grapes up to the day of harvest (1 day PHI), but the pre-harvest interval for wine grapes is 21 days. Excessive amounts of sulphur are detrimental to winery yeasts. It is suggested that the last application to wine grapes be made not later than 30 days before harvest. Check with the winery before application of any fungicides within the last month.

Fungicide Notes

Resistance Management

Grape powdery mildew has developed resistance or reduced sensitivity to sterol-inhibiting fungicides (Nova) and to strobilurin fungicides (Flint, Sovran, Pristine) in other areas such as Eastern North America. Avoid overusing these products to prolong effectiveness in this area.

To help prevent resistance from developing:

- Alternate between different fungicide groups. Do not use more than 2 back-to-back sprays of fungicides with the same group number (see table 3 for group numbers).
- Limit the number of sprays of products with a high risk of resistance (Nova, Sovran, Flint, Pristine) to 2 per season per chemical group. Mildew fungicides with a low risk of resistance include Kumulus, sulphur, lime sulphur, Milstop and Serenade. Lance has a moderate risk of resistance.
- Use only recommended dose rates.
- Ensure sprayer is properly calibrated to deliver accurate and thorough coverage.
- Integrate with non-chemical control methods.
- Discontinue use of a product if resistance is suspected and consult your crop advisor.

Sulphur is currently the most common fungicide used for powdery mildew control in the BC Interior in both conventional and organic vineyards. Kumulus DF is a dry flowable formulation of sulphur. The addition of a wetting agent will help to improve the distribution of wettable sulphur over the plant surfaces. However, the use of these agents may cause more *Botrytis* infection. Too much wetting agent will cause excessive foaming in the sprayer. Fruit and leaf "burning" may occur if sulphur is applied during slow drying conditions or when temperatures are above 27°C. Do not apply sulphur to Concord, Sheridan or Foch.

Sovran and Flint are strobilurin fungicides which provide good control of powdery mildews. These products are in the same class of compounds (group 11) and are at high risk of resistance. Use the higher rate under heavy disease pressure. Use 14-day intervals under moderate to heavy pressure, and 21-day intervals under low disease pressure. To help prevent the development of resistance, limit the use of group 11 fungicides to a maximum of 2 times per season, and never make more than 2 applications in a row. Alternate with at least 2 applications of fungicides in different chemical groups (see table 3). Caution: Sovran drift may cause severe injury to certain cherry and Asian pear varieties.

Pristine contains 2 fungicides; one is in the same class as **Flint** and **Sovran** and at high risk of resistance. Begin applications prior to the onset of disease. Use a 10-14 day interval if using the low rate, or a 21 day interval if using the high rate. To help prevent the development of resistance, limit the use of Pristine (and other group 11 fungicides including Sovran and Flint) to a maximum of 2 times per season. Alternate with fungicides from different groups (see table 3). Pristine also suppresses botrytis bunch rot.

Nova is a strong fungicide for control of powdery mildew, however powdery mildew has developed a reduced sensitivity to Nova in some areas of the world. To prevent the development of resistance, alternate Nova with other fungicides and do not use more than 2 times per season. Nova is locally systemic. Once absorbed by the plant, it can not be washed off by rain. Do not apply Nova with copper fungicides such as fixed copper, copper oxychloride, copper sulphate or other copper containing products because this combination reduces the effectiveness of Nova.

Lance provides some suppression of bunch rot, in addition to control of powdery mildew. Apply on a 10-14 day schedule. Use the shorter interval when disease pressure is high. Rotate with other fungicides for resistance management.

Quintec was registered June 2010 for control of powdery mildew in grape. It is a protectant fungicide, best used before visible mildew is present. Use the higher rate during high mildew pressure conditions. Rotate with fungicides from other chemical groups for resistance management. Quintec does not provide control of botrytis bunch rot.

Milstop is a contact fungicide that controls powdery mildew. It does not provide control of botrytis. It is considered a weaker product than sulphur, but provides a good alternative for use on sulphur-sensitive cultivars and is another rotational product for resistance management. Apply using a sufficient volume of water to insure complete coverage of all stems and foliage. Use the high rate and short application interval (7 days) when conditions favour the development of powdery mildew. OMRI approved for organic production.

Serenade Max is a biofungicide derived from the beneficial bacterium *Bacillus subtilis*. It is registered for "suppression" of powdery mildew, and will also provide some suppression of bunch rot and sour rot. OMRI approved for organic production.

Bordeaux Mixture is a broad-spectrum fungicide and bactericide that is not easily washed off by rain. Experience in Ontario indicates post harvest Bordeaux sprays using copper sulphate as a copper source to control late powdery mildew infections also appear to be an aid to increased bud hardiness and improved wood maturity in older vines. Sprays of fixed copper to young vines one month before the first fall frost appear to help "induce" some level of bud hardiness and wood maturity.

Copper sulphate (Bordeaux) is registered for several grape diseases including downy mildew, black rot and dead arm. It is not a strong powdery mildew fungicide, but may be useful for post-harvest control of light mildew problems, or as part of a mildew program on sulphur-sensitive varieties. **Do not mix copper with other fungicides or insecticides**. Copper applied under cool, slow drying conditions may cause injury, even to so called tolerant varieties. Copper oxychloride is less injurious to plant tissue than copper sulphate. Addition of the lime helps to minimize, but may not prevent injury.

The label rate for copper sulphate on grape is 3 kg copper sulphate + 6 kg hydrated lime in 1,000 L water/ha. Also used is copper oxychloride (50% copper) at 3 kg + 6 kg hydrated lime in 1,000 litres of water.

Making Tank-Mix Bordeaux

1. Start water flowing into spray tank.

2. When tank is about one-third full and the mechanical agitator is in operation, start washing the powdered copper sulphate into the tank through a screen with water from the supply hose. A wooden spoon is often helpful in working powdered copper sulphate through the screen. Pre-soaking the copper sulphate in a plastic bucket of hot water will speed up the process.

3. By the time the tank is two-thirds full, all of the powdered copper sulphate should be in the tank. Then wash the lime (hydrated or builders') through the screen, using the water supply hose, into the copper sulphate tank. The lime should be as dilute as possible before it meets the copper sulphate solution in the tank, so use lots of water to wash lime through the screen. Pre-soaking the lime before adding to the tank may be preferred to washing powdered lime directly through the screen into the tank.

4. Keep the agitator running continuously and apply the Bordeaux mixture immediately.

Botrytis Bunch Rot of Grape

Botrytis bunch rot, caused by the fungus *Botrytis cinerea*, is a common problem wherever grapes are grown. The disease can cause serious losses in both yield and quality when weather conditions favour the disease.

Symptoms

Ripening grapes are affected by a rot which may progress to infect whole clusters. With sufficient rain and humidity, berries split open and develop a greyish mold on the surface. Affected berries may shrivel in the dry Okanagan climate.

Botrytis may cause girdling lesions on the pedicel or rachis, leading to drying of clusters or portions of clusters, and premature cluster drop.

Infection and Spread

Botrytis infects grape shoots, flowers, leaves and fruit under a range of temperature and humidity conditions (Table 5.4). Infection is optimal at 15-20 °C with free water or over 90% humidity. Grape cultivars with dense canopies, thin skins and/or tight clusters are more susceptible to botrytis bunch rot (Table 5.5).

Botrytis overwinters as mycelium or sclerotia on bark and as mycelium in dormant buds. It may also overwinter in mummified fruit. In the spring, conidia (spores) are produced which can infect leaves and young clusters before bloom. The fungus may infect blossoms leading to fruit infection, but the fungus becomes inactive (latent) in the fruit possibly due to low sugar and high acid contents. It becomes active again when the berries begin to soften. Fruit infection usually begins in berries with 5 to 8 percent sugar (at veraison), with berries remaining susceptible up to harvest and also post-harvest.

Abundant conidia are produced on infected fruit, leading to secondary spread to adjacent berries in a cluster and to nearby clusters. Spread of the spores is aided by summer rains, overhead irrigation, heavy dew and juice from split berries. Spores are also carried by the wind. Mechanical damage caused by birds or insects creates entry points for the fungus and can greatly increase losses due to bunch rot.

Table 5.4 Time/temperature relationships for botrytis bunch rot infection

Temperature	Amount of Time
10 °C	30 hours or more
15.5 °C	18 hours or more
22.5 °C	15 hours or more
26.5 °C	22 hours or more
39 °C	35 hours or more

Slow drying conditions together with high humidity (90% or better) favour the development of botrytis. Table 1 indicates the temperature required plus the corresponding period that slow drying conditions must exist for bunch rot infection to occur.

Cultural Control

<u>*During the growing season*</u>

- Avoid overhead irrigation and keep irrigation periods as short as possible.
- Prevent excessive vine growth by judicious use of water and fertilizer.
- Canopy management and leaf removal before fruit set will reduce botrytis bunch rot. Remove leaves and lateral shoots located opposite, one node above, and one node below each fruit cluster.
- Prevent berry damage by effective control of powdery mildew early in the growing season.
- Minimize berry damage by birds and insects.

<u>*During the dormant season*</u>

- Knock mummified fruit and infected prunings to the ground and cover with soil, or alternatively burn.

Chemical Control

Fungicides registered for the control of botrytis include Rovral (iprodione), Vangard (cyprodinil), Elevate (fenhexamid) and Scala (pyrimethanil) (See Table 5.6). These fungicides represent 3 different chemical classes. Note that Scala and Vangard belong to the same class, with the same mode of action. Alternate fungicides from different classes to help prevent the development of resistance. Note that none of these fungicides provides any significant control of powdery mildew.

Table 5.5 Susceptibility of grape varieties in British Columbia to botrytis bunch rot

Very Susceptible		Susceptible	Moderately Susceptible	Least Susceptible
Auxerrois	Optima	Barbera	Ortega	Cabernet Franc
Bacchus	Pinot Blanc	Kerner	Scheurebe	Cabernet Sauvignon
Chardonnay	Riesling	Lemberger	Schoenburger	Chancellor
Chasselas	Semillon	Malbec	Syrah	Foch
Chenin Blanc	Siegerebe	Muscat Ottonel	Vidal	Merlot
Ehrenfelser	Zinfandel	Pearl of Csaba	Viognier	Petit Verdot
Gamay Noir		Pinot Gris		
Madeleine Angevine		Pinot Meunier		
Madeleine Sylvaner		Pinot Noir		
		Sangiovese		
		Sauvignon Blanc		

Correct identification of botrytis bunch rot prior to applying fungicide sprays is important. Botrytis can be confused with other rots such as sour rot. Application of botrytis fungicides where sour rot is present may increase the level of sour rot infection.

The number of spray applications necessary to control bunch rot depends upon disease pressure in the vineyard and weather conditions, as well as other factors such as susceptibility. Fewer applications may be needed if weather is very dry and/or disease pressure is low. Use a full program in vineyards where bunch rot was a serious problem in the previous year, and where sanitation measures were not taken after harvest. The number of sprays can be reduced or eliminated in vineyards with a history of low disease levels and for all vineyards in dry years.

Key timings for botrytis fungicide applications are bloom, just before bunch closing, veraison and pre-harvest. Botrytis control becomes more difficult as the grapevine matures because heavy canopy growth and bunch closing make it difficult to place the fungicide where it is needed.

Under typical Okanagan weather patterns, high risk periods for botrytis infection are during bloom and from 1 to 2 weeks after veraison to harvest. These growth stages often coincide with rainy periods during June and September.

Be cautious about adding spreaders or stickers to fungicide sprays, as some spray adjuvants have been shown to increase the development of bunch rot on grape clusters. It is believed that spray adjuvants remove the natural wax protection on grape berries.

Table 5.6 Fungicides registered for bunch rot suppression and control

Fungicide	Active Ingredients	Chemical Group[1]	Rate/ha	Rate/acre	PHI[2]	Comments
Rovral	iprodione 50%	2	1.5kg/ha	600g/acre	7	Maximum 2 sprays/season
Elevate	fenhexamid 50%	17	1.12kg/ha	450g/acre	7	Maximum 3 sprays/season.
Pristine	pyraclostrobin 12.8% + boscalid 25.2%	7 + 11	420-735g/ha	170-300g/acre	14	Registered as suppression only for botrytis bunch rot. Maximum 2 sprays/season.
Scala	pyrimethanil 400g/L	9	2.0L/ha	810mL/acre	7	Maximum 3 sprays/season.
Vangard	cyprodinil 75%	9	750g/ha	300g/acre	7	Maximum 2 sprays/season.
Serenade MAX	*Bacillus subtilis*	NC	3.0-6.0kg/ha	1.2-2.4kg/acre	0	Biofungicide. Disease suppression only.

[1] Chemical Group: Products with the same number belong to the same class of compounds. Alternate products with different chemical groups to help delay or prevent the development of resistance.
[2] Pre-harvest Interval

Grape Sour Rot

Sour rot has not been a commonly recognized problem in the Okanagan/Similkameen, but it was a serious issue in many vineyards during the 2004 growing season. Varieties which were affected include Pinot Blanc, Pinot Gris, Riesling, Pinot Noir and Chardonnay. It is likely that sour rot has always been present, but it may have been confused with botrytis bunch rot in the past. Sour rot affects both crop yield and wine quality. Infected fruit can give an unpleasant flavour to the finished wine and push volatile acid beyond acceptable levels.

Symptoms

Symptoms include a soft watery rot with leakage of berry juice, and a distinctive vinegar smell. Large numbers of fruit flies, (also known as vinegar flies) and fruit fly larvae are generally present. The fruit flies produce ethyl acetate, a common fault in wine. There is very little tolerance of fruit contaminated with ethyl acetate. Sour rot appears similar to botrytis bunch rot. Affected berries are brick-coloured in white cultivars and purplish-brown in red cultivars.

Disease Cycle

Sour rot is caused by a number of undesirable yeasts and bacteria, often in association with other fungal rot diseases including *Botrytis*, *Penicillium* and *Rhizopus*. Causal agents of the 2004 Okanagan outbreak of sour rot are under investigation.

Sour rot pathogens gain entry into grape berries through cracks and wounds caused by wasps, hail, birds, powdery mildew, botrytis, or by berry splitting caused by excessive vigour in tight clusters. Such injuries attract fruit flies which also effectively carry and spread the disease-causing organisms. During favourable conditions (warm moist weather, sugar accumulation in berries) the fruit fly will lay hundreds of eggs and start a new generation every ten to twelve days. Under the right conditions this can lead to explosive disease outbreaks. Fruit left on the ground from post-veraison bunch thinning can also be a contributing factor to build-up of fruit fly populations.

Cultivars with tight clusters and thin skins are generally more susceptible to sour rot. Very vigorous vines seem to be more prone to the disease due to tighter bunches with berries more likely to burst, and also due to a higher moisture environment.

The onset of hot, dry weather can lead to the drying of the infected and damaged berries, thereby slowing the spread of the disease. Cool weather will considerably slow fruit fly population growth, in turn leading to a reduction in the spread of the disease.

Some local and Californian observations indicate that the use of botrytis fungicides during periods favourable to sour rot development may increase damage caused by sour rot. Some experts speculate that the fungicide may kill the micro-flora present on the berry surface. These organisms may have some protective effect against the yeasts and bacteria responsible for sour rot. However, research done in Italy in the early eighties found that powdery mildew and botrytis control, together with fruit fly control, significantly reduced the incidence of sour rot.

Prevention and Control

- Reduce excessive vigour through the use of cover crops and/or the reduction of nitrogen fertilization and irrigation.
- Leaf removal between fruit set and veraison can lead to tougher berry skins, thereby reducing the risk of lesions.
- Control wasps through trapping and nest removal.
- Control powdery mildew to reduce grape berry lesions, which attract fruit flies.
- Prevent bird damage.
- Bunch thinning is best done before or during veraison. Berries removed during late season thinning have higher sugars which can contribute to the fruit fly population increase.
- Discard affected bunches before or during harvest to minimize the negative effects on the wine.
- No insecticides are registered for the control of fruit flies on grape. Fruit flies quickly become resistant to most chemical control

products due to their fast rate of multiplication.

- Some French sources recommend 2-3 applications of Bordeaux mixture (copper sulphate and hydrated lime) at ten to twelve day intervals around the time of veraison. Copper applied to the fruiting zone has the effect of thickening the grape berry skin, hence reducing the risk of lesions. See fungicide notes under powdery mildew for more information on copper fungicides.

Crown Gall of Grape

Crown gall is an important disease of wine grapes when they are grown in cold climates. Gall formation on the aerial part of the vines is the most common symptom associated with this disease. The bacterium which causes crown gall may be present in plants that do not show any symptoms. Most grape cultivars are susceptible to crown gall. Major outbreaks are generally restricted to the varieties that are most susceptible to winter injury. The amount of crown gall present from year to year appears to be related to the severity of the preceding winter and the maturity of the vines.

A major source of diseased vines appears to be through propagation of diseased wood. The bacterium remains inside the vine until there is an injury to the trunk and only then invades the outer part of the trunk where it causes rapid cell multiplication and distortion of tissue producing galls.

Galls are usually noticed as swellings near the base of the vine and up the trunk. Galls on roots of grape are not typical, however the bacteria can induce a localized necrosis of roots. Young galls are soft, creamy to greenish in colour, with no bark or covering. As they age, the tissue darkens to brown. The surface becomes open and the texture becomes moderately hard and very rough. The surface tissue of the galls turns black as it dies, but the bacterium remains alive in the vine.

Control

Control of crown gall can at best be referred to as an attempt to manage this disease.

Before Planting

Losses of grape plants due to crown gall may be minimized with some considerations before vineyard sites are selected and before vineyards are planted. Criteria to consider include the following:

- Select sites with good air and water drainage.
- Avoid planting in frost-prone areas.
- Select rootstocks that are resistant to crown gall. Certain rootstocks such as Courderc 3309, 101-14 Mgt, and Riparia Gloire are resistant, whereas Teleki 5C and 110 Richter are susceptible. See Table 3.2 (Characteristics of important grape rootstocks) on page 3-19 of the *Grape Management Guide* for resistance ratings. Resistant rootstocks can reduce the amount of crown gall that appears on susceptible scions.
- Select hardy varieties where possible.
- Prepare sites with nutrients and lime before planting to avoid vine stress due to poor nutrition or low pH.
- Consider pest control programs for nematodes and phylloxera before planting through the use of soil fumigation or rootstocks. Feeding damage by these pests provides sites for the entry of crown gall bacteria.
- Plant old vineyard areas where crown gall was present only after grapevines have been removed for at least 2 years. This is important because crown gall bacteria can survive in the remnants of the old grape plants until the debris decomposes. Success in reducing crown gall from the soil by leaving soil fallow or rotating to other crops may vary depending on the amount of vine debris that is left in the soil, and how fast it breaks down.
- Do not propagate wood taken from galled vines.
- Specify that plant material you purchase be propagated from crown gall free plants. Producers must promote the production of certified indexed crown gall free vines.

After Planting

There is little that can be done to control this disease once it is established in the vineyard.

Avoid injury to vines (winter, mechanical and human). Remove suckers when shoots are small

(3 to 6 cm) to reduce trunk damage and promote rapid healing of wounds. Removing larger shoots before they harden will result in clean and small scars.

- Hill young vines with 30 cm or more of soil or other material to protect them from cold temperatures. Remove this material carefully to avoid mechanical damage.
- Prune to delay budbreak (late pruning) on varieties prone to early bud break.
- In France, application of K2O instead of nitrogen fertilizers is used to improve resistance of the vines to cold.
- Biological control of grape crown gall has been effective in trials, and is a promising management tool for the future.

Grape Virus Diseases

What is a virus?

Grape virus diseases are caused by microscopic particles that are composed of genetic material (DNA or RNA) inside a protective protein coat. Viruses are much smaller than bacteria and fungi, and require very specialized tests for their detection. Once inside a living plant, viruses have the ability to multiply by taking over plant cells and reprogramming them to make more virus particles. In grapevines the virus will spread systemically to all parts of the vine (roots and vegetative parts). Once a plant is infected, it will remain so for life.

General Virus Symptoms

Viruses cause a wide range of symptoms, ranging from no visible symptoms to plant death. Many grapevine viruses cause a general decline in vigour and productivity, and delayed maturity. Other symptoms may also be present on foliage, stems, leaves or fruit.

It is possible for a virus to infect a grapevine without the plant showing any obvious symptoms (called a latent virus or sleeping virus). The degree of virus symptom development and effect on a plant is influenced by the virus strain, plant variety, and environment. A previously latent virus may become more virulent (or more severe) at some time due to changes in the environment or through propagation, often onto a different rootstock. The symptoms may be subtle, requiring proper experiments to demonstrate the effects of the virus. For example, the involvement of a virus may not be obvious in an increased susceptibility to winter injury or a gradual decline in yield.

Symptoms such as graft rejection, rapid decline of vines, severe stunting, late blossom and late or poorly ripening fruit are more obvious. Foliar, fruit or cane symptoms of virus diseases are also frequently visible. These may include any one of the following: red foliage (on red varieties), short internodes, mottling of leaves, fasciation of canes, double internodes, excessive growth from secondary buds, straggly bunches with both large and small berries, rolling of the leaves in the fall, wood pitting and grooving, etc.

Importance of Virus Diseases

Virus diseases can have a serious impact on vine health, yield and quality of the fruit. Symptoms are not always severe or obvious, but even a small decrease in yield will add up over time causing significant economic losses. Decreased yields of 5 to 10% are not uncommon for grapevine viruses, and losses can be much higher. Viruses may also influence wine quality by causing delays in sugar accumulation, poor acid development, and poor colour development.

The difficulty of detecting virus infection can lead to rapid dissemination of virus-infected material through propagation. When infected cuttings are used for propagation, whole vineyards can become infected.

How Viruses are Spread

Humans are the most effective transmitter of virus diseases through movement and propagation of virus infected rootstocks, cuttings and finished plants.

Most viruses also have other methods of spreading, although not all are known. Insects or other organisms that spread viruses are known as "vectors". Many serious grapevine viruses are classified as "nepoviruses" which are transmitted by certain species of nematodes. Examples of nepoviruses include *Grapevine fanleaf virus*, *Arabis mosaic virus*, *Tomato black ring virus*, *Tomato ringspot virus*, *Tobacco ringspot virus*, *Peach rosette mosaic virus* and many others. These viruses can cause significant economic losses. The nematode feeds on the roots of infected vines and retains the virus for several months. The disease is spread as the infected nematode feeds from grapevine to grapevine. Infected nematodes may be spread on the roots of nursery plants and through soil water (irrigation, seepage, flooding). Fortunately plant protection measures that require treatment of imported planting stock have prevented the most damaging virus-vectoring nematode of grapevines, *Xiphinema index*, from being introduced into British Columbia. However, other nematodes found in British Columbia, such as *Xiphinema americanum*, are known to vector nepoviruses. Some of these nepoviruses may also be spread through seeds of infected weeds in the vineyard. They may then be picked up by the nematodes and moved from the weeds to grapevines.

Other viruses are transmitted by soil fungi or insects such as aphids, leafhoppers, psyllids and mealybugs. Mealybugs and soft scale insects are known to be vectors of some of the grapevine leafroll-associated viruses, *Grapevine virus A* (causing Kober stem grooving disease, formerly *Grapevine stem grooving virus*), and *Grapevine virus B* (causing grapevine corky bark disease).

There are also virus-like diseases for which the method of transmission (apart from propagative) is not known or well documented. This group includes many damaging diseases such as Grapevine Enation, Grapevine Yellow Speckle, and Grapevine Shoot Necrosis. Little is known about some of these viruses beyond the symptoms they cause. This lack of knowledge forms a serious obstacle to effective disease management.

Control and Prevention of Viruses

- Prevention of virus diseases is critical, as there are no cures for virus-infected vines other than vine removal.
- Plant only fully virus-tested vines to reduce the risk of introducing virus diseases into your vineyard.
- If an insect vector is known to spread a virus, controlling the insect may help to limit or reduce the rate of spread within a vineyard.
- Canada has specific grapevine import regulations that help to protect grape growers from the introduction and spread of virus diseases and other pests which are not yet established in British Columbia. Selected grapevine varieties/clones and rootstocks from Canadian-approved nurseries in France and Germany are currently approved for importation into Canada. Under this program tests for regulated viruses/pests of grapevines are carried out both in the exporting country and in Canada, prior to the approval for the importation of any variety and rootstock. Canada has different import requirements for grapevines from the U.S, because of the similar pest situation and the proximity of the two countries. For more information on importing grapevines, contact the Canadian Food Inspection Agency (CFIA).

- Note that important viruses such as *Arabis mosaic virus*, *Grapevine fanleaf virus* and the viruses causing grapevine leafroll disease have been removed from the federal quarantine pests list. Although CFIA-approved foreign certification programs are supposed to produce plants free of these viruses, their removal means that foreign nurseries approved to ship grapevines into Canada no longer have to prove their vines are free of these viruses. Grapevines infected with these viruses have been imported since this de-regulation. It is recommended that growers importing vines request that they be tested for these viruses in the country of origin. These viruses cause serious economic diseases.

Clonal Selection

Removal of viruses from plant material is possible, but requires heat treatment of the vines to "kill" the virus. This process is both expensive and time consuming, as it must be verified that the virus was successfully removed. Such vines then become the foundation for propagation programs designed to produce "clean" vines for industry. Vines that are to be subjected to heat treatment should be chosen carefully, so that only the very best varieties or clones are selected. The CFIA Laboratory at Sidney, British Columbia (Centre for Plant Health) provides testing, virus indexing and therapy for viruses of grapevines, tree fruits and other crops. These tested mother plants may then be placed in a Nuclear collection (repository) at the Sidney Lab or become mother plants for growers or nurseries. Propagative material from these mother plants may be used to produce other plants for certification under the Canadian Export Certification Program for the eventual establishment of healthy vineyards.

Major Grape Virus Diseases

There are over 50 different viruses and viroids that infect grapevines distributed throughout the world. Several are known to exist in Canada already. With increasing international trade and travel it is expected that more of these viruses will arrive.

A national grapevine virus survey in 1994-1995 found vines infected with *Arabis mosaic virus*, *Grapevine fanleaf virus* and *Grapevine leafroll-associated viruses 1* and *3* in both Ontario and British Columbia. Leafroll 3 was the most commonly found virus, but the other viruses were present at very low levels in British Columbia. For example, out of 1485 BC samples, only 1 positive was found for fanleaf virus, and only 5 positives for arabis mosaic. Although the survey was not detailed enough to determine incidence, the low number of positives is an encouraging indication that BC remains largely free of these damaging viruses, and it is worthwhile to continue to prevent introduction through careful screening of nursery stock. However, additional grapevines infected with these viruses have been imported since 1995.

Grapevine Fanleaf Virus

Fanleaf degeneration disease caused by *Grapevine fanleaf virus* is thought to be the most serious grapevine virus disease. The severity of symptoms varies by cultivar.

Symptoms

Infected leaves are often malformed with abnormally gathered primary veins, giving the leaf the appearance of an open fan. Other symptoms may include a yellow mosaic pattern on leaves or bright yellow bands along major veins. Fan-shaped leaves may or may not be present with mosaic or veinbanding symptoms.

Affected vines tend to be smaller than healthy vines. Sensitive varieties show progressive decline, low yields (up to 80% losses) and low fruit quality. The productive life of the vineyard is shortened and winter hardiness is decreased.

Transmission

Fanleaf virus is transmitted by the nematodes *Xiphinema index* and *X. italiae*, which have never been found in Canada. There are no natural weed hosts. Long distance spread occurs primarily by movement of propagation material from infected plants.

Grapevine Leafroll - Associated Viruses

Grapevine leafroll is probably the most widespread virus disease of grapevines world-wide. There are currently 9 different viruses associated with leafroll, but *Grapevine leafroll-associated viruses 1* and *3* are most commonly found. In the national grapevine survey conducted in 1994-1995, GLRaV-1 was present in 1.0% of samples tested, whereas GLRaV-3 was present in 10.5% of samples tested nationally. Since then *Grapevine leafroll-associated viruses 2, 4* and *5* have been detected in imported grapevines.

Symptoms

Leafroll virus has impacts on both vine health and grape quality. Growth and yield may be reduced by 10-70%. The virus reduces yield by inhibiting cluster formation and development. Infected vines have an increased sensitivity to environmental stress. Impacts on quality included delayed maturity of grapes, a 25-50% reduction in sugar content, and poorly coloured fruit.

Typical leaf symptoms include reddening of the leaves between major veins in red varieties, and yellowing of the leaves between major veins in white varieties. Leaves become thick, brittle, and roll downwards.

Transmission

Long distance spread occurs primarily by movement of propagation material from infected plants. Several mealybug and soft scale insect species have been shown to transmit leafroll associated viruses under experimental conditions. Rapid leafroll spread has been reported in European vineyards having significant insect vector populations. In California, increasing natural spread within vineyards has been observed. The common grape mealybug (*Pseudococcus maritimus*) which occurs in the Okanagan is a vector of GLRaV-3.

Arabis Mosaic Virus

Symptoms

The most common symptoms include leaf mottling and flecking, stunting and leaf deformation including enations. Many infections are latent and plants do not show symptoms. Symptoms can vary greatly by variety, rootstock and environment conditions. Yield losses of up to 50% may occur through reduced growth, dieback and severe dropping of fruit.

Transmission

Long distance spread occurs primarily by movement of propagation material from infected plants. *Arabis mosaic virus* is transmitted by the nematode *Xiphinema diversicaudatum*, which has been found in scattered locations in Canada. This virus can also infect many other herbaceous and woody hosts such as raspberry, strawberry, rhubarb, cherry, peach, and plums.

Rupestris Stem Pitting Virus

Rupestris stem pitting associated virus-1 is a common and widespread virus of grapevines. It is not regulated in Canada or the USA. A recent survey found this disease in 4.6% of the samples in Washington State.

Symptoms

Rupestris stem pitting causes a slow decline in growth, resulting in vines that are smaller than normal with reduced yields. No leaf discoloration is observed. The disease affects only grafted vines; ungrafted vines may be infected, but usually do not show symptoms. Small pits may develop in the wood on rootstocks, in particular *V. rupestris* and American rootstocks. The severity of the disease is more pronounced in vines that are infected with other viruses of the **Rugose wood complex**, including ***Grapevine virus A*** **(GVA)** and ***Grapevine virus B*** (GVB). GVA is associated with kober stem grooving disease. Affected vines may show swelling at the graft union and fail to thrive. GVB is associated with corky bark disease, which may cause an incompatibility to develop at the graft union. Leaf symptoms resemble those of leafroll virus but are more severe.

Transmission

Spread is mainly through propagation. There is no known insect vector for *Rupestris stem pitting virus*. GVB can be transmitted by some species of mealybugs. Disease management depends upon use of certified healthy, virus-free stock. Remove vines showing suspicious symptoms.

Grapevine Phytoplasma Diseases

Phytoplasmas are microscopic plant pathogens, similar to bacteria, but much smaller and lacking cell walls. They live in the vascular system of plants and are spread by sap-feeding insects, including leafhoppers and planthoppers. There are several diseases of grapevine caused by phytoplasmas:

- Flavescence dorée
- Bois noir (black wood, vergilbungskrankheit)
- Grapevine yellows

Bois noir disease was detected in British Columbia and Ontario in plants imported from France. The plants were removed and subsequent surveys have not detected new infections.

Flavescence dorée is the most important and destructive phytoplasma disease of grapevines. It is known to occur only in France, Italy and Spain. Bois noir occurs in France and Germany, but is less serious due to a slower rate of spread. Diseases similar to bois noir have also been reported in Switzerland, Italy, Greece, Hungary, Israel, and are suspected to occur in Chile and South Africa. Phytoplasma diseases of grape elsewhere in the world are referred to as grapevine yellows, including an American grapevine yellows that occurs in New York and Virginia, and an Australian grapevine yellows.

Impacts

Flavescence dorée has been called "catastrophic" in France. Impacts include reduced vitality of vines, yield reductions, and reduced wine quality due to high acid and low sugar contents of fruit from infected plants. Without control measures, the disease spreads rapidly, affecting up to 80-100% of vines within a few years. Flavescence dorée has destroyed large viticultural areas in France and Corsica. It is still spreading despite mandatory control programs.

Popular cultivars such as Chardonnay, Cabernet Sauvignon, Pinot Noir, Riesling, Sauvignon Blanc, and Sémillon are highly susceptible to flavescence dorée. Some cultivars such as Sangiovese and Garganega are extremely susceptible and are killed quickly.

Symptoms

All grapevine yellows diseases have similar symptoms, including growth reduction, leaf discolouration, downward rolling of leaves, and reduced quality and quantity of fruit. Symptoms are not uniform, and may appear on some or all shoots of infected vines. A few rootstock varieties are tolerant to flavescence dorée, and can be symptomless carriers of the disease.

Leaf symptoms in white cultivars appear as small, yellow spots along the main veins. These spots enlarge to form yellow bands along the veins, which gradually extend over large parts of the leaf. Red cultivars develop a similar pattern on the leaves, but the discolorations are reddish.

Infected shoots often fail to lignify, and appear thin and rubbery. They later become brittle, sometimes with bud necrosis. Affected branches blacken and die during the winter. Numerous small black pustules form along the diseased branches of susceptible cultivars.

Fruit set is reduced on grapevines infected early in the season, as the inflorescences dry out and fall off. In later infections, bunches become brown and shriveled. Premature berry drop occurs in some cultivars.

Disease Cycle

Flavescence dorée is spread by the leafhopper *Scaphoideus titanus*, which is native to eastern North America. It is known to occur in Canada from the Maritimes through to Saskatchewan, but it has not yet been detected in B.C.

S. titanus spends its whole life cycle on grapevines. It is a highly mobile and efficient vector that is largely responsible for the epidemic spread of flavescence dorée. Both nymphs and adults are able to acquire the phytoplasma while feeding. After a latent period they are able to transmit the disease until they die. This leafhopper overwinters as eggs which are inserted (laid) into the bark of grapevines.

Bois noir is transmitted by a few planthopper vectors, the main one being *Hyalesthes obsoletus*. This insect is not known to be in Canada. It prefers herbaceous weeds over grapevines and transmits the phytoplasma from these weeds to grapevines. Bindweed (*Convulvulus arvensis*), nettle (*Urtica dioica*) and hedge bindweed

(*Calystegia sepium*) are the main reservoirs in Europe. Since the vector only feeds incidentally on grape, bois noir is a much slower spreading disease than flavescence dorée. It is widespread in many parts of Europe. The recent identification of new bois noir vectors in Europe raises concerns regarding related insect species in Canada.

Both Phytoplasmas and leafhoppers can be spread with propagation material. Flavescence dorée is symptomless in some cultivars, and it also has a long (up to 3 year) latent period before symptoms can be seen. Thus even apparently healthy vines may be carrying grapevine yellows diseases. A few rootstock varieties are symptomless carriers that have been responsible for spread of flavescence dorée in Europe.

Control

Control of phytoplasma diseases involves scouting and removal of infected or symptomatic vines, as well as control of the vector with insecticide sprays.

In France, flavescence dorée is a regulated disease. Compulsory control measures for both the disease and the vector were strengthened in 2003. When an infected grapevine is found, a quarantine area is delimited around it for a minimum of 2 years. All infected plants must be destroyed, and control of the vector with several insecticide sprays is required in that zone.

Prevention

Use only planting material from reliable, approved sources and produced in areas where phytoplasma diseases are not present. Canada has grapevine import regulations that help to protect grape growers from the introduction and spread of diseases and other pests which are not yet established in British Columbia. Selected grapevine variety and rootstock clones from Canadian-approved nurseries in France and Germany are currently approved for importation into Canada. Under this program, nursery plants are propagated from mother plants that were tested for regulated pests and diseases by the exporting country then grown under conditions to reduce the risk of contamination. The CFIA has tested samples of many of these grapevine varieties or rootstocks prior to approving their importation.

Note that stricter import requirements for grapevines from France and Germany were implemented by the CFIA in 2007 due to concerns about the increased incidence of flavescence dorée and bois noir in France. Under the new requirements plants and propagative material originating from, or propagated within, flavescence dorée areas of France, or any other infested area of a country where the disease occurs is prohibited. In addition all plants or propagative material imported from France or Germany must be treated in a hot water bath at a minimum of 50°C for a minimum duration of 35 minutes. Contact the Canadian Food Inspection Agency (CFIA) for more information.

Grape Root Rot and Decline

Root diseases caused by *Phytophthora* or *Pythium* spp. have not been common in the Okanagan/Similkameen in recent years. These diseases are typically sporadic, usually occurring on single vines that are excessively irrigated. Affected vines are smaller than nearby healthy plants and the foliage may become chlorotic or colour prematurely. A canker develops near the soil line and usually extends downward to the roots. Removal of the periderm exposes the necrotic woody tissue underneath. Roots may become blackened and decayed; and smaller fibrous roots may die. Death of the vines may occur within 2 years from the time symptoms appear.

A root rot caused by the fungus *Roesleria subterranea* has also occurred sporadically in Okanagan vineyards. It is considered to be a weak root pathogen that colonizes injured or dead roots, from where it may also invade healthy roots. During a 2007/08 survey of grapevine decline problems, roesleria root rot was found in several vineyards in vines that were also infected with *Cylindrocarpon*.

Control

Cultural Control

- Prevent root rots with good water management and by providing drainage if needed. *Phytophthora* and *Pythium* are "water molds" which are favoured by very wet conditions.
- In replant sites, remove as many old roots as possible before replanting vineyards.

Chemical Control

- There are no fungicides registered for control of these soil-borne diseases on grape in Canada.

Young Vine Decline

Decline of young vines may have several causes, including diseases, nematodes, environmental damage such as winter injury, and cultural factors. Often more than one factor or more than one disease may be involved.

Okanagan Survey Results (2007-2009)

A recent survey conducted by Agriculture and Agri-Food Canada investigated decline problems in Okanagan vineyards (O'Gorman, Haag & Sholberg). The survey confirmed the presence of several fungal pathogens causing vine decline symptoms. Diseases detected included:

- Black foot disease (*Cylindrocarpon* spp.) - isolated from vines ranging from 3-15 years of age in several vineyards. Infection was associated with both a gradual and a rapid decline of vines.
- Esca (*Phaeomoniella chlamydospora* and *Phaeoacremonium aleophilum*) - detected in necrotic vascular tissue on young vines up to 6 years old. Both *Phaeoacremonium* and *Cylindrocarpon* were recovered from vines in one vineyard where over 50% of the vines showed decline symptoms.
- Botryosphaeria canker (*Botryosphaeria parva* and *B. dothidea*) - detected in vines ranging from 3-11 years of age in several vineyards. The vineyards where *B. parva* was isolated showed severe decline problems.
- Eutypa canker
- Roesleria root rot (*Roesleria subterainia*) - found in several vineyards in vines that were also infected with Cylindrocarpon.

Note that black foot, esca, botryosphaeria canker and eutypa canker are all new diseases that have not been previously diagnosed in British Columbia vineyards. See below for more details on each of these pathogens.

General Symptoms

General symptoms of grapevine declines caused by fungal pathogens include delayed and stunted growth, short internodes, yellowing and premature loss of leaves, tendril dieback, trunk dieback, dead arm and cankers. Discolouration may be observed in the wood when vines are cut open. Decline may be rapid, causing plant death within 2-3 weeks, or slow, resulting in reduced vigour and yield over a period of years.

Diagnosis

Vine decline symptoms can be difficult to diagnose accurately. B.C. grape growers interested in diagnosis of decline problems should contact the provincial plant diagnostic laboratory or PARC Summerland for more information.

Further Information

For links to further information, visit the Ministry of Agriculture and Lands website at http://www.al.gov.bc.ca/cropprot/grapeipm/decline.htm

Esca / Young Vine Decline

Young Vine Decline is a disease complex with various names, including black measles, esca, young esca, Petri disease, apoplexy, and black goo disease. It has been an increasing problem in California vineyards, causing significant economic losses due to vineyard replanting and yield reductions. It has also increased in importance in Europe, most likely due to a reduction in the use of sodium arsenite fungicides, which have been banned in most countries.

In California, esca or black measles has been a problem in older vineyards for decades. More recently it has also become a problem in young vines, following a massive replanting effort which replaced phylloxera-susceptible rootstocks with other more resistant hybrid rootstocks. Unfortunately, the new rootstocks appear to be more susceptible to vine decline.

A 2007-2008 survey conducted by Agriculture and Agri-Food Canada investigated decline problems in Okanagan vineyards (O'Gorman, Haag & Sholberg). The survey confirmed the presence of several fungal pathogens causing vine decline symptoms, including 2 pathogens associated with esca.

Causal Agents

Esca and young vine decline are caused by several fungi which act alone, in combination or in succession to cause disease. Fungal pathogens involved in young vine decline in both British Columbia and California include *Phaeomoniella chlamydospora* and *Phaeoacremonium aleophilum*. Other species of *Phaeoacremonium* have also been associated with esca vine decline in California, but have not yet been detected in B.C.

Several wood rotting basidiomycete fungi including a *Phellinus* species (now known as *Fomitiporia punctatus*) and *Stereum hirsutum* were historically associated with esca. While these fungi could be isolated from diseased vines, it was not possible to reproduce the same symptoms by inoculating healthy vines. It is now thought that infection with *Phaeoacremonium* and *Phaeomoniella* species predisposes the vines to wood rots by breaking down toxic phenolics and other host-produced substances which are inhibitory to wood rot fungi.

There are also several other diseases which cause decline of grapevines including *Cylindrocarpon* black foot, *Botryosphaeria* canker, Eutypa, *Phomopsis* canker (not yet found in B.C.) and several root rot diseases.

Symptoms - Esca on Young Vines

Phaeomoniella and *Phaeoacremonium* infect the vascular tissue of young vines resulting in darkening and plugging of the xylem vessels. Symptoms range from mild to severe, and include chlorotic foliage, defoliation, stunting of growth and reduced yield and quality. Sudden wilting and death (apoplexy) of vines or cordons may occur in midseason, particularly during hot weather. Vine symptoms also include delayed and weak growth in spring, and reduced lignification of canes in the fall. Discolouration in the xylem vessels may appear as black streaks when vines are cut longitudinally or as black dots when cut in cross section. Wood rot is usually absent on young vines.

Foliar symptoms include light green or chlorotic spots between the leaf veins or along the leaf margins. The spots gradually expand and turn yellow brown or red brown, leaving only a narrow strip of green tissue along the main veins. In California, a mosaic has also been observed on terminal leaves followed by shoot tip dieback. It is thought that foliar symptoms are caused at least partially by toxins produced by the fungi and/or reaction products of the infected wood which are translocated to the leaves.

Symptoms on berries may be present without symptoms on the leaves and vice versa. Berries on affected plants tend to be small, and may not reach full maturity. Sugar content and flavour can be adversely affected. Berries sometimes develop spotting or black measles symptoms, with white cultivars being more susceptible. Berry spotting consists of brownish to purplish, small pinprick sized spots on the berry skin. Heavy spotting may lead to skin cracking, berry shrivel, and secondary berry rots.

Symptoms - Esca / Black Measles on Older Vines

Esca is known as a disease of adult plants (8-10 years and older). It is caused by the same fungi that cause young vine decline. However on older vines there are often wood rot pathogens involved as well. Symptoms are similar to those described on young vines. It causes a decline with characteristic leaf and fruit symptoms, and sudden wilting and death in severe cases.

Additional symptoms in older wood include an internal white heart rot which causes the wood to become soft and spongy. A dark line or a series of black dots generally surrounds the white heart rot. In longitudinal section, this vascular discolouration appears as black streaks.

Disease Cycle

Research underway in California is increasing our understanding of the biology of the fungi causing young vine decline. The method of disease spread is not yet certain, however spore trapping results from infected vineyards have found air-borne spores, with large numbers of spores trapped during rainfall. Infection most likely occurs through wounds.

Wet weather and warm temperatures appear to favour the disease. Years with above normal rainfall and high summer temperatures have resulted in more severe symptoms in California.

The wood rot fungi that are associated with esca are wound invaders, which infect through large wounds or pruning cuts on the trunk or cordons of mature vines. These fungi have a wide host range, and are commonly found as wood rots in other broad leaf tree species. Air-borne basidiospores produced by fruiting bodies (bracket fungi) on dead wood or other hosts can be spread long distances by wind, and can infect grapevines. Observed spread along rows in vineyards may also indicate that spores can be spread by tools during pruning and grafting.

Dissemination in Nursery Stock: The presence of vine decline affecting a high proportion of plants in recently established vineyards in California suggests that nursery stock may be carrying the disease. The pathogens have also been isolated from a high proportion of vine cuttings produced in Italy or France.

Prevention and Management

- Plant healthy vines with no sign of discolouration in the vascular tissue.
- Propagation material should be taken from healthy vines with no wood darkening.
- Burn prunings, or remove them from the vineyard.
- Prune healthy-looking vines before sick vines. Disinfect pruning tools periodically, particularly after pruning vines with symptoms.
- The type of vine training system can be a factor. Extensive pruning cuts create more potential infection sites. One study found 0.1% esca in lateral cordon vineyards, compared to 15-20% in vines trained by double Guyot.
- There are no fungicide treatments for esca/ young vine decline in Canada.

Botryosphaeria Canker

A survey of grape decline problems in Okanagan vineyards was conducted in 2007/08 by Agriculture and Agri-Food Canada (O'Gorman, Haag & Sholberg). Botryosphaeria canker (also known as bot canker and black dead arm) was detected in vines ranging from 3-11 years of age in several vineyards. Two species of *Botrytosphaeria* were identified, including *B. parva* and *B. dothidea*. The vineyards where *B. parva* was isolated showed severe decline problems. This disease had not been previously diagnosed in grapevine from British Columbia.

Bot canker is known to occur in most viticulture regions of the world. In California, recent research has shown that over 9 species of *Botryosphaeria* can infect grapevines, and that the disease is very prevalent in that state. The following information is based on information from California and other viticultural areas.

Symptoms

Botryosphaeria produces black streaks in the xylem of infected wood, typically causing wedge-shaped cankers in the trunk and cordons. The cankers are most easily seen when the vine is cut in cross section. Black pycnidia (fungal fruiting bodies) form on diseased vine parts under the bark of cordons, trunks, and spurs. Other diseases, including *Eutypa* canker cause very similar symptoms.

In California, botryosphaeria canker causes death of arms, cordons and vines, often so suddenly that there are no foliar symptoms. It is commonly seen in vines 10 or more years old. In other areas, foliar symptoms such as chlorosis and stunting are more common. Symptoms may vary depending on the species of *Botryosphaeria* present. Typically diseased vines fail to break dormancy or suddenly wilt during the following growing season.

Disease Cycle

The fungus overwinters as pycnidia on diseased wood. Pycnidia release conidia (spores) when wet by rain or irrigation. Conidia are spread by water splash and wind to cause new infections, primarily through fresh pruning wounds. Moisture is needed for infection, along with temperatures above 5 ° C.

Botryosphaeria can also infect other tree species, and could also be present in adjacent orchards, forests and riparian areas. The importance of spread from other host species to vineyards is not well understood.

Disease Prevention & Management

- Remove visible cankers and dead or declining arms, cordons and vines.
- Burn prunings from infected vines, or remove them from the vineyard.

- Prune healthy-looking vines before sick vines. Disinfect pruning tools periodically, particularly after pruning vines with symptoms.
- In California, late pruning during March results in less infection of pruning wounds. Optimal timing may be different in our climate. In general, warmer temperatures accelerate healing of pruning wounds, so wounds are susceptible for a shorter time. Pruning during a period of forecast dry weather would also help to reduce infection.
- Good cultural practices help to maintain vigour and reduce losses.
- There are no fungicide treatments for *Botryosphaeria* canker available in Canada.

Black Foot Disease
(*Cylindrocarpon* spp.)

A survey of grape decline problems in Okanagan vineyards was conducted in 2007/08 by Agriculture and Agri-Food Canada (O'Gorman, Haag & Sholberg). The causal agent of black foot disease (*Cylindrocarpon* spp.) was isolated from vines ranging from 3-15 years of age in several vineyards. Infection was associated with both a gradual and a rapid decline of vines. This disease had not been previously diagnosed in grapevine from British Columbia.

Cylindrocarpon is known to occur in all major viticulture regions of the world, but the disease is not well understood. It's importance in B.C.'s vineyards remains to be seen. The following information is based on information from California and other viticultural areas.

Symptoms

In California, *Cylindrocarpon* causes "black foot disease" in grape, affecting mainly young vines up to 8 years old. Roots show black, sunken, necrotic lesions. In cross section, the base of the trunk appears necrotic and xylem vessels may be black in colour. Leaves may appear to be water stressed or scorched, and vines may be stunted and/or killed. Cylindrocarpon may occur in combination with other plant pathogens.

Disease Cycle

Cylindrocarpon is a common soil-borne fungus which causes root rot in many plant species. It survives in soil as mycelium and also produces conidia (spores) and chlamydospores (spores that can survive adverse conditions).

Research in South Africa has shown that nursery soils can be a source of inoculum, and the disease can be carried on nursery plants.

Disease Prevention & Management

- Plant healthy vines with no sign of root deterioration or discolouration in the vascular tissue.
- Hot water treatment has been shown in South Africa to reduce the level of *Cylindrocarpon* infection in nursery stock. Hot water treatment at a similar temperature and duration is required for vines imported from France or Germany for the prevention of phytoplasma diseases.
- There are no fungicide treatments for *Cylindrocarpon* available in Canada.

Grape Nematode Problems

Nematodes are translucent, microscopic roundworms, typically measuring 0.25 to 1 mm in length and only about 0.1 to 0.2 mm in diameter. Most nematodes in soil are beneficial components of the soil ecosystem, where they feed on bacteria, fungi and other micro-invertebrates, stimulating and regulating the turnover of nutrients. Their abundance ranges from about 1000 per liter of degraded or infertile soil, up to 50,000 per liter of highly fertile soil. Some nematode species, however, parasitize plant roots and are economically important plant pathogens.

Symptoms

All plant-parasitic nematodes use hollow spear-like mouthparts called “stylets” to feed on plant roots. A few nematode species do not cause much direct damage on their own, but can transmit viruses while they are feeding (see section on dagger nematodes, below). Most species cause direct damage, including gall-like malformations that impair root function (see root-knot nematodes, below) or dieback of root tips and formation of lesions on the roots (see ring nematodes and root-lesion nematodes, below). When nematode population densities are large, root systems will be sparse, there will be few fine roots, and the damaged roots will appear reddish, brown or black rather than a healthy white colour. If root-knot nematodes are present, it may be possible to see characteristic swellings or galls on feeder roots. Vines severely damaged by plant-parasitic nematodes are stunted and have reduced yields.

At the field level, nematode damage is often overlooked because the above-ground symptoms are non-specific and difficult to distinguish from effects of other factors. Nematode populations usually exist in patches of high population densities; rarely, entire fields will be uniformly affected. Thus typical symptoms include poor vine vigour in patches of one to dozens of vines. This patchy, uneven growth caused by plant-parasitic nematodes may occur within a vineyard with uniform soil conditions. Areas with high nematode population densities may also be correlated with other soil factors that can affect vine vigour. For example, many species of plant-parasitic nematodes reach higher populations and cause more damage in sandy soils than in finer-textured soils. As a result, poor vine growth in sandy soils can be the result of low water or nutrient availability as well as the interaction of these additional stresses with nematode damage.

Nematode Species

The main nematode species of significance to winegrape production in British Columbia are ring nematodes (*Mesocriconema xenoplax*), dagger nematodes (*Xiphinema* species), root-knot nematodes (*Meloidogyne hapla*) and root-lesion nematodes (*Pratylenchus penetrans*). Vineyards in British Columbia often have more than one species.

Ring nematodes (*Mesocriconema xenoplax*): These nematodes are ectoparasites that use long stylets to extract the contents of root cells, especially at root tips. They cause necrosis or blackening of roots like root-lesion nematodes, but their preferential feeding at root tips also causes stunting and sometimes formation of swollen or malformed root tips without obvious necrosis. Preferred hosts for ring nematodes include cherry, peach, apricot, and plum in addition to grape. These nematodes are known to cause significant damage to grape in California and Oregon. Ring nematodes have recently been found to be relatively widespread in the Okanagan Valley, and preliminary research at the Summerland Research Centre indicates that they can cause significant growth reduction of young grapevines, particularly self-rooted vines, under Okanagan growing conditions.

Root-knot nematodes (*Meloidogyne hapla*): These nematodes are endoparasites; infective juveniles invade root tips and establish permanent feeding sites. As the nematodes feed and mature in the root, galls or "knots" of root tissue form around them. These galls, which typically range in size from 3 to 12 mm in diameter, interfere with water and nutrient uptake. Several species of root-knot nematodes are recognized to be significant pests of grape in most grape-growing regions. To date, only one species has been found in B.C. vineyards, *Meloidogyne hapla*. The damage caused by *M. hapla* has not been studied as extensively as other species, and its impact on grapevine health under Okanagan growing conditions is not clear.

Dagger nematodes (*Xiphinema* species): *Xiphinema americanum* and several closely related species of *Xiphinema* are commonly found in B.C. vineyards. These nematodes are ectoparasites; they do not burrow into roots, but insert their long stylets deep into root tips, where they feed on root tip cells. Dagger nematode feeding causes limited necrosis and stunting and swelling of root tips, but they seldom cause significant damage on their own. Dagger nematodes are mostly important as vectors of viruses; *X. americanum* and related species transmit *Tomato ringspot virus*, *Tobacco ringspot virus*, *Peach rosette mosaic virus* and several other minor viruses.

Xiphinema index transmits the devastating *Grapevine fanleaf virus*. This nematode species can also cause significant direct damage in the absence of the virus. Plant protection measures that require treatment of imported planting stock have prevented *Xiphinema index* from being introduced into British Columbia.

Root-lesion nematodes (*Pratylenchus* species): These nematodes are migratory endoparasites, burrowing into roots to feed, and migrating freely between root tissue and soil. Root-lesion nematodes cause symptoms that range from many small lesions on young feeder roots to abnormal darkening and necrosis or death of the roots. Severely damaged root systems will have few newly formed feeder roots and sparse tufts of fine roots that will be blackened and crumbly. Most research documenting impacts of root-lesion nematodes has been conducted on *Pratylenchus vulnus*, a species that does not occur in B.C. The species most commonly found in the Okanagan Valley is *P. penetrans*. While this nematode clearly damages roots, the relationship between *P. penetrans* population densities and overall vine vigour is not well understood.

Nematode Resistant Rootstocks

Rootstocks that are tolerant or resistant to plant-parasitic nematodes are available. These rootstocks have been evaluated against nematode species found in California and Mediterranean regions of Europe. Consequently, it is not clear if they would express the same tolerance or resistance to nematode species found in B.C. Rootstocks reported to be tolerant or resistant include: Dogridge, Harmony, Freedom, Ramsey, Teleki 5C, K51-32, and 1613C. Two other rootstocks, 420A Mgt and 101-14 Mgt, are reported to be resistant to ring nematodes, which are overall probably the most important nematodes in B.C. vineyards.

Prevention and Control

Nematodes are best managed before planting. Prevention involves testing for the presence of pathogenic nematodes followed by pre-plant soil fumigation to reduce nematode populations. There are no chemical treatments for nematodes that can be used on established vines in Canada.

Pre-plant Soil Fumigation

Soil fumigation with chemicals such as Vapam (metam-sodium) and Basamid (dazomet) are an option for reducing the population of pathogenic nematodes in soil prior to planting. They will also help to reduce the levels of soil-borne plant pathogens and viable weed seeds. Soil must be well prepared before fumigation, and should be moist. As many old grape roots should be removed as possible. These products release toxic gases on contact with moist soil. Following application, the soil surface should be sealed by watering and rolling or with polyethylene sheets. Refer to the product labels for detailed information on application and safety precautions.

Soil fumigation is expensive. Before considering, have samples of your soil analyzed for nematodes.

Alternatives to fumigation

Soil solarization is a non-chemical technique that will help to reduce the population of nematodes and other soil-borne pests. Solarization involves capturing the heat of the sun by covering the soil with transparent polyethylene plastic sheets during warm sunny months. The soil temperatures under the plastic increase to levels lethal to many soil-borne plant pathogens, weed seeds, seedlings, and nematodes. It is usually necessary to take the land to be solarized out of production for a year. Soil should be tilled before solarization, and should also have a good soil moisture level. The area to be treated should be free of weeds, plant debris, and large clods which would raise the plastic off the ground. Cover the area with a double layer of clear polyethylene sheet, seal the edges with soil and leave it in place for 4-6 weeks during the heat of the summer (mid-June through mid-August). If possible, leave the poly in place until replanting to prevent re-contamination. Black plastic is less effective than clear plastic.

Other cultural management techniques include green manuring, and/or rotating crops to reduce the numbers of pathogenic nematodes. These tactics do not guarantee a reduction in nematodes, as populations may be sustained on other species of plants including weeds.

Nematode Testing

Consider testing your soil for plant-parasitic nematodes before planting new vineyard blocks. If damaging populations are present, consider soil fumigation before planting.

Sampling strategies and interpretation of the results depend on the nematode species suspected and environmental conditions, and should be developed in consultation with a diagnostic laboratory. Populations of all nematode species vary seasonally. Since some nematode species migrate between roots and soil, it is usually necessary to collect both soil and root samples for testing. The laboratory analysis includes extraction of nematodes from soil and plant tissue, identification of the species present, and enumeration. The absence of recognized nematode pathogens in diagnostic samples can be used to rule-out nematodes as the cause of poor crop growth.

Soil analysis for the presence of nematodes is provided by the following laboratories. Contact the labs directly for information on fees and sampling instructions:

M&B Research Ltd.
10115C McDonald Park Road
Sidney, BC V8L 5X5
Tel: 250-656-1334 Fax: 250-676-0443

BC Ministry of Agriculture and Lands
Plant Diagnostic Laboratory
Abbotsford Agriculture Centre
1767 Angus Campbell Road
Abbotsford, BC V3G 2M3
Tel: 604-556-3126 (directly) Fax: 604-556-3154
Toll Free: 1-800-661-9903
http://www.al.gov.bc.ca/cropprot/lab.htm

Other Grape Diseases

There are many grapevine pests and diseases that are not yet established in British Columbia grape growing areas. Some of these are downy mildew, black rot, phomopsis, flavescence dorée, Pierces' disease, anthracnose, rust and dead arm.

If you suspect a new disease, contact the BC Ministry of Agriculture and Lands to confirm identification, or send a sample to the provincial Plant Diagnostic Laboratory in Abbotsford.

Plant Diagnostic Lab
BC Ministry of Agriculture and Lands
Abbotsford Agriculture Centre,
1767 Angus Campbell Road,
Abbotsford BC V3G 2M3
Tel: 604-556-3126 (directly) or 1-800-661-9903 (main office) Fax: 604-556-3154
Web: www.al.gov.bc.ca/cropprot/lab.htm

Online resources for Grape Disease Information:

- BC Ministry of Agriculture – Grape Diseases www.al.gov.bc.ca/cropprot/grapeipm/index.htm
- InfoBasket - http://www.kmwpp.ca/
- UC IPM Pest Management Guidelines - University of California www.ipm.ucdavis.edu/PMG/selectnewpest.grapes.html
- Northwest Berry and Grape Information Network - Oregon State University http://berrygrape.org/
- Grape and Small Fruit Virology -Washington State University - wine.wsu.edu/virology/

5.3 Insect & Mite Pests of Grape

D. Thomas Lowery, AAFC-PARC, Summerland
(Graphics by Robyn DeYoung)

Fewer insect pests attack grapes grown in British Columbia compared with most other major grape producing regions. For this reason, growers in British Columbia are able to pursue 'soft' programs that preserve populations of beneficial insects and predacious mites that help control secondary pests such as spider mites and thrips. **Adoption of integrated pest management (IPM) practices that minimize the use of chemical sprays can also help lower production costs, reduce human exposure to insecticides, and preserve the local environment.** Additional sources for information on insect and mite pests of grapes are listed at the end of this section.

Integrated Pest Management

IPM utilizes a number of principles and practices to manage pest populations, including biological, cultural, and physical control methods. **Insecticides remain an essential component of an IPM program, but they are applied as a last resort only when monitoring has shown that pest numbers are likely to exceed the economic threshold.** When insecticides are required, their selectivity, persistence, and effects on non-target organisms should be considered. Some have minimal effects on beneficial insects and predacious mites, while others cause significant reductions in natural enemy populations. A brief description and a few examples of the various components of a grape IPM program are outlined below. For additional information, refer to the Integrated Pest Management section of this guide.

Biological Control of Insects and Mites

Insect and mite pests of grapes are attacked by many species of beneficial organisms, including bacterial and viral diseases, spiders and insect predators, predacious mites, and vertebrates such as toads and birds. **Maintaining and enhancing numbers of these natural enemies of grape pests forms the cornerstone of a successful IPM program.** Healthy populations of predators and parasites prevent outbreaks of secondary pests and reduce the numbers of sprays required for the control of primary pests such as leafhoppers and climbing cutworm.

Beneficial organisms can be preserved or enhanced in several ways. The negative impact of pesticides can be minimized by spraying only when and where required. Monitoring of pest numbers will often indicate that only a small portion of a vineyard requires chemical treatment, while selecting the most appropriate spray material will help reduce damage to non-target organisms. Broad spectrum insecticides such as the pyrethroids, for example, act on contact and by inhalation and are often more toxic to beneficial insects than the pests they are intended to control. Some organophosphates, such as malathion, also act primarily on insects as a contact and fumigant, but they are considered to be less damaging to beneficial insects and mites. Other materials, such as the microbial insecticide Dipel (*B.t.*), are highly selective and require that the pest consumes the treated plant part, reducing toxicity to most non-target species. Refer to the fact sheet *Pest Control Products Recommended for Use on Grapes in British Columbia*, posted at http://www.al.gov.bc.ca/cropprot/grapeipm/grape_pesticides.pdf for additional information.

Thoughtful choice of management practices can also help preserve beneficial insects. Mowing or discing less often is a simple and cost effective way to increase populations of most natural enemies. Adults of many beneficial species feed on nectar of flowering plants that also serve as hosts for alternate prey species. As a general rule, increased plant diversity is associated with greater numbers of beneficial insects. A diversity of plants can be provided in the vineyard in mixed ground covers, or in hedgerows and waste areas within or adjacent to the vineyard.

Cultural and Physical Controls

Vine Vigour and Resistance

For most crops, varieties can be selected that are partially or wholly resistant to one or more pests and diseases. Except for rootstocks that are resistant to grape phylloxera or nematodes, this is generally not a viable option for wine grapes. Most desirable wine grape varieties possess little resistance to foliar feeding pests. Vine vigour does, however, influence insect and mite numbers. Leafhoppers and grape mealybug, for example, will reach significantly higher numbers on overly vigorous vines, as they prefer the darker, sheltered environment and elevated humidity that excessive vine growth provides. Insects developing on these plants survive better and grow faster due to better nutrition, softer tissues, and changes in concentrations of secondary plant compounds. At the other extreme, chlorotic vines with low vigour are less able to tolerate insect feeding damage and are more susceptible to attack by scale insects and wood boring beetles. **Fortunately, the optimum balance in vine growth that results in the highest quality wines is also best for minimizing the growth of pest populations.**

Management of vine vigour is an important consideration in the establishment of a new vineyard and is discussed elsewhere in this guide. After vines are established, growth is controlled mainly by pruning, cropping, selection and management of appropriate groundcover plants, and the provision of water and nutrients. Recent research in California has shown that deficit irrigation from berry set to veraison reduced leafhopper numbers by more than 60%. The modest reduction in yield, around 15%, was more than offset by a significant improvement in wine quality. In addition, berries were smaller and exposed to more light and air and pruning costs were slightly lower.

The presence of broadleaf weeds in and between vine rows is associated with lower levels of cutworm damage. Where possible weeds should not be controlled in spring until after buds have broken, as removal of alternate sources of food forces cutworm larvae to feed on the buds of grapes.

Pruning

Pruning can be altered to help reduce damage from cutworm larvae. Slightly more buds can be left on vines to compensate for damage, but this will require the removal of unwanted shoots later in the season. Earlier pruning advances bud break, reducing slightly the amount of time that buds are susceptible to cutworm feeding. Vines that break bud earlier are more susceptible to frost damage, however. To reduce damage from spring-feeding pests, some growers delay suckering and shoot thinning to divert feeding to these unwanted plant parts.

Leafhoppers and erineum or blister mites infest the first leaves that emerge in spring and these can be removed in June to reduce numbers of these pests. A recently completed study conducted in commercial British Columbia vineyards showed that removal of basal leaves in June rather than August reduced numbers of leafhoppers and the incidence of bunch rot. Vine vigour and berry size were reduced only slightly and there was little effect on ripening or quality of fruit. Early season leaf removal might not be suitable for stressed vines or vines on sandy sites with intense heat and light where fruit can become sunburned. As for late season removal, partial removal of leaves from only the shaded sides of the vines might be more suitable in these areas.

Physical controls

For some vineyards, the use of yellow sticky tape applied below the cordon in spring can be an economical way to manage leafhoppers. Although costly, this physical control method preserves beneficial insects and reduces or eliminates the need for additional insecticides later in the season. Use of yellow sticky tape is most practical in vineyards where damaging numbers of leafhoppers occur in small, isolated areas or on a few outer rows of the vineyard. Other physical controls include pruning out of canes infested with scale insects and application of barriers to prevent climbing cutworm from reaching developing buds.

Monitoring and Chemical Controls

Insecticides should only be applied when monitoring indicates that sprays are warranted. **The mere presence of a pest does not indicate that a spray is required.** Established grapevines can tolerate moderate amounts of leaf damage and small numbers of pests may have little or no effect on vine growth and yields. Some studies have actually shown that low numbers of some pests can stimulate vine growth and improve fruit quality. Even when pests have reached damaging levels sprays should be withheld until the economic benefit of treating the crop exceeds the cost of controlling the pest, including possible disruption of beneficial insects. In other words, **sprays should only be applied when pest populations reach the economic injury level where control of the pest provides an economic return to the grower.**

Thresholds for grape pests are currently based mostly on visual inspections. Yellow sticky cards can be useful indicators of general population trends and pest developmental stages. Care should be taken to conduct a thorough inspection that takes into account the variable nature of the crop and the uneven distribution of most grape pests. Particular attention should be given to field edges and to areas that have experienced damage previously. The use of double sided clear tape applied around shoots or the vine cordon can be used to assist with timing of sprays for the control of motile stages of grape mealybug and scale insects.

Grapevines need to be monitored for pests throughout most of the year. It is easier to spot scale infestations during pruning or early in spring before leaves are present. Grapes need to be visually inspected frequently in spring when unopened buds are susceptible to cutworm damage. When the first leaves have fully expanded, watch for early infestations of erineum mite and note the presence of leafhopper adults that begin laying eggs at this time. Thrips damage table grapes from 75% bloom to fruit set, and if scale or mealybugs were noted earlier, sprays can be timed based on the presence of crawlers. The need to spray for first generation leafhoppers should be based on monitoring for small nymphs from mid June to mid July, while second generation nymphs will reach their peak usually after the middle of August. Throughout summer, monitor for mealybug, thrips, and mites. For table grapes, watch for mealybug infesting clusters in mid-summer and for snail-case bagworm and earwigs closer to harvest.

If chemical control of a pest is indicated, refer to the BCMAL fact sheet *Pest Control Products Recommended for Use on Grapes in British Columbia*, for suitable spray materials, or consult with private consultants or your chemical supplier. **It is the legal responsibility of pesticide applicators to follow the label instructions and apply only those products that are registered for use on grapes. The BC Wine Grape Council and the authors of these pest management sections do not assume legal responsibility for the misuse of any pesticides mentioned in this guide**. For grapes or wines destined for export, check to ensure that the importing country has maximum residue levels (MRL) for the control products. Observe the days to harvest interval (PHI = pre-harvest interval) to avoid exceeding the MRL. Producers of organic grapes should also refer to the list of acceptable products and consult with an organic growers' organization.

Major Pests of Grape

The major insect and mite pests of grapes grown in British Columbia are cutworm larvae that attack buds in spring, leafhoppers that feed on leaves throughout the summer, and wasps that feed on ripening fruit in fall. Grape phylloxera is an important pest of grapes worldwide but it occurs in only a few scattered locations in the southern interior of British Columbia Other than wasps, these pests are largely absent from the Lower Mainland and Vancouver Island. Proper management of these primary pests is the most important consideration in an IPM program. Grape pests and the damage they cause needs to be recognized so that populations can be monitored at the appropriate time of the season to determine if insecticide applications are warranted. Avoiding unnecessary sprays will help prevent outbreaks of secondary pests that are normally regulated by an assortment of predators and parasites.

Leafhoppers

(Virginia creeper leafhopper, Erythroneura ziczac Walsh)
(Western grape leafhopper, E. elegantula Osborn)

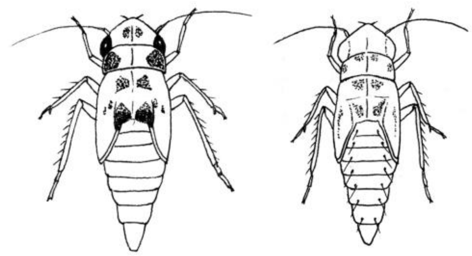
In addition to the widespread Virginia creeper leafhopper (VCLH), the western grape leafhopper (WGLH) occurs on the east side of the Okanagan Valley from the north end of Penticton south to the U.S. border. The WGLH is more tolerant to insecticides and it is important to determine if it is present in your vineyard. Leafhoppers are often distributed unevenly in vineyards and monitoring will help determine which areas require treatment. Unnecessary sprays reduce numbers of beneficial insects and spiders, resulting in a rapid resurgence in pest numbers and outbreaks of thrips, mites, and mealybugs. Experience has shown that WGLH

numbers are low in organic vineyards; damaging populations in conventional vineyards generally result from repeated sprays of insecticides that do not control this species but damage numbers of the egg parasite, *Anagrus erythroneurae*. Successful control of leafhoppers relies on proper monitoring of numbers throughout the vineyard and the judicious use of insecticides in order to preserve beneficial insects and spiders.

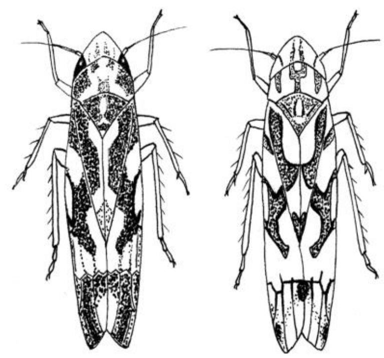
Identification

Adults of both species are similar in appearance, nearly ½ cm in length with reddish-brown markings on a pale white or yellowish background. Adult WGLH can be distinguished by their pale eyes and irregular reddish-orange markings on a whitish background. VCLH have reddish-brown eyes and a more regular reddish-brown zigzag pattern on the wings. The background body colour is pale yellow to light brownish-yellow, producing an overall darker appearance. Adult leafhoppers are best identified on yellow sticky cards placed in outer vineyard rows during late April and May that can be inspected with the aid of a hand lens or magnifying glass.

Immature stages (nymphs) of WGLH are distinguished by their pale white colour, lack of pigmentation in the eyes, and the presence of one to three pairs of pale indistinct yellow spots on the thoracic segments of larger nymphs. VCLH nymphs have reddish-brown eyes and a pale yellowish body colour. Larger VCLH nymphs develop a pair of dark reddish-brown spots on the first body segment behind the head and a pair of reddish-orange spots on the other two thoracic segments. Nymphs can be identified feeding on the undersides of fully expanded leaves that show signs of feeding damage (stippling).



VCLH nymph (left) and WGLH nymph (right)



VCLH adult (left) and WGLH adult (right)

Life Cycle and Damage

The biology and life cycles of the two species are similar. There are two generations each year. Adults of both species spend the winter in leaf litter or under plant debris in the vineyard or in nearby vegetation. Adults emerge on warm spring days to feed on a wide variety of plants, moving to grape, Virginia creeper and Boston ivy when the first leaves appear. The overwintered females deposit eggs in the leaf tissue on the undersides of fully expanded leaves during May and June. The small, flattened opaque eggs are deposited side by side, usually in small groups of around two to six for the VCLH and singly for the WGLH. Nymphs of this 1st generation hatch mainly from mid June to the end of July. There are five nymphal stages. Winged adults that appear during July and August lay eggs that develop throughout the fall into overwintering adults. The WGLH develops more slowly than the VCLH and nymphs will occur later into the year.

Both adults and nymphs feed by piercing individual leaf cells and sucking out the contents. Light infestations cause leaves to appear stippled due to the death of individual cells. Heavier feeding results in brown, dried leaves that fall prematurely. Some studies have shown that light infestations can actually improve the quality of grapes on vines that are overly vigorous, but excessive feeding reduces the photosynthetic activity of the vines, resulting in delayed maturity, yield losses, and reduced fruit quality. Large infestations deplete carbohydrate stores and weaken the vines. Light coloured varieties can become spotted and unsightly with excrement, which is a particular concern for table grapes. Adult leafhoppers are also an annoyance to pickers during harvest. Neither species is known to transmit viruses or other plant diseases.

Monitoring and Spray Thresholds

Overwintered adults usually congregate in higher numbers on the edges of vineyards or in sheltered locations and these areas should receive particular attention in the spring. Leafhoppers also prefer vigorous vines and those that leaf out earliest. Monitoring numbers of adults captured in spring on yellow sticky cards can help determine relative infestation levels, but because some eggs fail to develop and predation rates are variable, these numbers do not correlate well with subsequent nymph counts. It is helpful to note where large numbers of adults occur early in the season, as these areas should be observed more closely later on.

Adults are more tolerant of insecticides and sprays should be targeted against the wingless immature stages. Depending on the location of the vineyard, monitoring of 1st generation nymphs should begin in early to mid June. Monitor populations by counting numbers of nymphs on the lower surfaces of 5-10 leaves in at least 5 locations per block or variety. Select older bottom leaves up to just above the fruiting zone. In order to prevent damage to any vines, sampling should focus on more heavily infested areas. Sample from the north and east sides of rows where more nymphs will be found and focus on the leaf zone showing signs of feeding damage. Infestation levels are based on the average number of nymphs per leaf.

Established grapevines are tolerant of leafhopper damage during the first half of the season when growth is rapid. Because of this, there are no established thresholds for 1st generation nymphs. The threshold of approximately 20-25 nymphs per leaf established for the 2nd generation in late summer can also be used as an approximate threshold for early summer sprays. A higher threshold can be used for 1st generation nymphs if healthy populations of predators are present and a high rate of parasitism is likely. Control of 1st generation nymphs is often more effective as there is less foliage, nymphs are confined to leaves around the fruiting zone, and sprays can be directed in a narrow band to ensure good coverage. It is recommended, therefore, to treat vineyards with a history of heavy leafhopper damage during this time. Soap sprays are much more effective when targeted against 1st generation nymphs when approximately 80% of the eggs have hatched. Egg hatch can only be determined with the aid of a low power microscope, but the presence of mostly small, young nymphs can be used as an approximate measure. Because soaps are not as effective as other insecticides, the threshold for vineyards that are managed organically should be reduced considerably, perhaps to around 5-10 nymphs per leaf.

Second generation nymphs should be monitored beginning in August in a manner similar to that outlined above. Greater attention should be paid to vines in the center of the field, however, as infestations will have spread from field edges and 'hot spots' to a larger area of the vineyard. Nymph counts should be collected initially every other week, and then weekly when the time for spraying approaches. **For wine grapes, an approximate threshold of 20-25 nymphs/leaf on the more heavily infested leaves can be used as a rough guideline.** This is an average value based on counts from several leaves as outlined above. Again, for a particular area of the vineyard, collect at least 5 leaves from 5 areas and calculate the average number of nymphs per leaf. For 2nd generation nymphs, sample leaves from the middle of the canopy above the fruiting zone and from the north or east sides of vines where numbers will be higher. Leafhoppers will be distributed unevenly in a vineyard and it is important to sample thoroughly to determine which areas require treatment. Although the above threshold provides a rough guideline, an acceptable spray threshold should be determined by individual growers based on their past experience and additional factors such as vine vigour and numbers of beneficial insects.

Biological Control

Birds, spiders, predators, parasites, and diseases attack leafhopper eggs, nymphs or adults. A small egg parasite, *Anagrus daanei*, helps control VCLH in some vineyards where parasitism rates approach 100% late in the season. A different parasite, *A. erythroneurae*, parasitizes eggs of the WGLH and is largely responsible for the control of this pest. *A. erythroneurae* overwinters in eggs of the rose leafhopper on wild and domestic roses, apple, blackberry and plum. In early spring this parasite utilizes eggs of a leafhopper found on a wide range of mints, including catnip and catmint. Most vineyards have large numbers of *A. erythroneura* and outbreaks of WGLH are largely associated with sprays of insecticides that do not control this leafhopper but are toxic to the parasite. Excessive rates or unnecessary sprays of insecticides will also reduce numbers of other beneficial insects and spiders.

Cultural and Physical Control

Leafhoppers prefer excessively vigorous plants and vines should be irrigated and fertilized to maintain moderate growth best suited to the production of high quality wine grapes. The use of yellow sticky tape applied below the cordon in spring can be an economical way to manage leafhoppers in some vineyards. Although costly, this method helps preserve beneficial insects and reduces or eliminates the need for additional insecticides later in the season. The use of sticky tape is likely not cost effective for large areas but it can be a useful method where infestations are confined to small areas or to the edges of vineyards.

A recently completed study demonstrated that removal of basal leaves early in the season (mid to late June) when most eggs of the 1st generation have been laid effectively reduced numbers of leafhoppers and the incidence of bunch rots. No significant differences were noted in fruit quality other than a slight reduction in yield and berry size, but it is recommended that growers first assess the effectiveness of early leaf removal on only a few vines of each variety. Removal of leaves around the fruiting zone at any time of the season might not be suitable for stressed vines or on sites with intense heat and light that might lead to sunburn. This practice is labour intensive, but growers often remove these leaves later in the season in order to improve grape quality. Removing basal leaves too early will force leafhoppers to deposit their eggs higher up the vine and might inhibit bud initiation required for the following year.

Chemical Control

Some insecticides registered for the control of leafhoppers are ineffective for the WGLH and it is important to determine if this species is present in your vineyard. If only the VCLH is present, natural enemies should be preserved by applying the lowest effective rate only to areas where the pest has exceeded the threshold level. To date, this species has not yet developed resistance to insecticides.

When monitoring of leafhopper nymphs indicates that insecticide sprays are required, apply one of the materials listed in *Pest Control Products Recommended for Use on Grapes in British Columbia*, posted at http://www.al.gov.bc.ca/cropprot/grapeipm/grape_pesticides.pdf.

It is often sufficient to spray small areas or treat only the perimeter of the vineyard. Spraying in this fashion is more economical and helps preserve beneficial insects. Although reduced rates (640 ml/ha) of carbaryl (Sevin XLR Plus™) suggested in earlier editions of this guide to help preserve beneficial insects are likely sufficient to control VCLH, full label rates will provide only moderate control of the more resistant WGLH. Malathion is currently registered for the control of leafhoppers on grapevines but it is unlikely to be effective against the WGLH. Assail™ (acetamiprid) has been shown to be repellent to adults and will cause them to move to unsprayed portions of the vineyard. Sprays should be targeted against small nymphs. Although Assail is less damaging to some beneficial insects compared with many broad-spectrum insecticides, it is toxic to predacious thrips and can cause spider mite numbers to increase. Safer's Insecticidal Soap™ applied for the control of mites and grape mealybug will reduce leafhopper numbers somewhat. Apply soap in high volume sprays and ensure that the bottom leaf surfaces are covered thoroughly. Recent research at AAFC-PARC Summerland has shown that some newer fungicides and surfactants are repellent to adult leafhoppers and their use might eliminate the need for additional sprays. Increased movement of adult leafhoppers within and between vineyards requires greater vigilance, however.

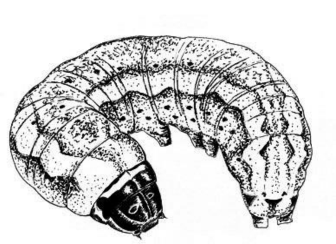
Climbing Cutworms

(Lepidoptera: Noctuidae)

To date, 17 species of cutworm have been identified feeding on the buds of grapevines in the southern interior of British Columbia; the three most common species being *Abagrotis orbis* (Grote), *A. reedi* Buckett, and *A. nefascia* (Smith). **Damage can vary greatly between years and locations and it is not uncommon for only parts of vineyards to be seriously damaged**. Because populations fluctuate greatly and monitoring of cutworm larvae is difficult, damage can be considerable.

Identification

Cutworm larvae are smooth, soft, thick-bodied caterpillars measuring about 4 to 5 cm when fully grown. Larvae typically live in the soil or under debris and will curl up when disturbed or handled. Depending on the species, larvae are most often light to dark brown, and are usually marked with spots or stripes. Adults are drab moths with bodies around 2 to 2.5 cm long. The hind wings, which are sometimes distinctly marked, are usually lighter in colour than the forewings. Adults are active at night and rest during the day in sheltered locations under bark, debris, or leaves.



Life Cycle and Damage

Cutworms that feed on grapes spend the winter as small larvae in the soil or under fallen leaves or debris. When the weather warms in spring they resume feeding and complete their development. Damage to grapes occurs during this time when the rapidly growing larvae feed on unopened buds and new shoots. Moths emerge in June and remain in a quiescent state throughout the summer until fall when they become sexually mature and begin laying eggs that hatch into the overwintering larvae. There is a single generation each year.

Damage to grape buds varies with the size of the cutworm larvae. Small larvae will often burrow into a bud, creating nearly circular holes that were previously attributed to feeding by adult click beetles. Larger cutworm larvae will chew large, somewhat ragged holes and remove a large portion or all of the bud. Feeding on new, tender shoots can cause the shoots to break or wilt. Larvae climb the vine trunks or support posts each night and return to the soil during the day, or they will find refuge under loose bark of older vines.

Monitoring and Spray Thresholds

Cutworm numbers vary over time and between and often within vineyards. Some vineyards rarely experience significant levels of cutworm feeding damage while others are damaged yearly. Mild, dry conditions during the winter increase survival rates, while outbreaks of viral and other diseases that affect cutworms can reduce numbers to low levels. Cutworm damage is often higher in areas with dry gravelly or sandy soils that do not support good stands of broadleaf weeds, with drip irrigation systems, or as a result of weeds being controlled too early in the spring before shoots have elongated. Maintaining a record of previous damage can help suggest which areas need to be monitored most closely and where damage is likely to occur first, but bud damage needs to be assessed throughout the vineyard.

New vines planted in untreated land previously in pasture are prone to damage, and larvae are often sheltered and somewhat confined within the protective milk cartons or sleeves placed around new vines. Loss of buds on new vines can retard growth and delay fruiting and they should be closely inspected in spring for signs of damage and treated when necessary.

Significant amounts of damage can occur over a period of two or three days when the nights remain warm, and it is especially important to monitor for damaged buds frequently during this time. At other times it is usually sufficient to monitor vines weekly or twice weekly until shoots have elongated. An accurate threshold based on the degree of bud damage is difficult to determine, as it is influenced by the variety, training system and method of pruning, presence of predators and parasites, and tolerance level of the individual vineyard manager.

Suggested economic thresholds from growers range from virtually zero to over 15%; a value around 3% bud loss is likely for most *vinifera* varieties. Establishment of spray thresholds should also consider the potential for secondary pest outbreaks that will require additional insecticide sprays later in the season.

Biological Control

Cutworm eggs are consumed by various predators and are parasitized by small wasps. Larvae are eaten by ground beetles, hunting spiders and birds, and are parasitized by wasps and flies. Fungal and bacterial diseases that attack cutworm larvae are very common, particularly when conditions are cool and wet. The combined effect of these natural controls is to eliminate most cutworm eggs and larvae. Of the 300 or more eggs laid by a female moth, only a few survive to become reproductive adults. Even so, damage resulting from the few remaining larvae can be considerable.

Cultural Control

Broadleaf weeds should not be controlled in spring until shoots have elongated and the first leaves have expanded. Damage is generally much lower in vineyards with mixed ground cover vegetation and where broadleaf weeds, particularly winter annual mustards such as *Draba verna* and Shepherd's purse, *Capsella bursa-pastoris*, are present in the vine rows in spring. Larvae are usually more common in areas with well-drained sandy or sandy-loam soils that support fewer broadleaf weeds. Diseases that infect larvae are also likely to be more prevalent in soils that retain moisture. Control of vegetation with herbicides or repeated discing during the fall prior to the establishment of a new vineyard will help reduce damage to newly-planted vines.

Cutworm damage is partially related to pruning practices and grape varieties. Vines with a greater number of retained buds in spring will suffer marginally less damage, but there will be added costs related to removal of extra shoots. Some grape varieties will produce fruit on secondary shoots, but yields will still be reduced and ripening can be delayed or uneven.

Chemical Control

Sprays of the pyrethroid insecticide Pounce™ (permethrin) should be directed to the soil at the base of vines, to vine trunks, and to support posts so that larvae contact the insecticide while moving from the soil to the canopy. Do not cultivate or disturb the soil for several days after treatment. For young vines, sprays should be directed into the milk cartons or other protective structures applied around newly planted vines. **Avoid spraying insecticides unnecessarily, as these are very damaging to beneficial insects and can result in outbreaks of secondary pests later in the season.**

Altacor™ (rynaxypyr) was recently registered for cutworms on grapes. Rapid cessation of feeding and toxicity result largely through ingestion and sprays should be directed to the developing buds. Altacor is considered a reduced–risk material due to its greater selectivity and reduced toxicity to non-target organisms. Follow the label instructions and wear appropriate protective clothing as for all pesticides. The list of materials registered for cutworm control is likely to change before the next printing of this guide and it is important to refer to the most recent edition of *Pest Control Products Recommended for Use on Grapes in British Columbia* for appropriate and registered materials.

Grape Phylloxera

(*Daktulosphaira vitifoliae* (Fitch)

Grape phylloxera (Homoptera: Phylloxeridae), native to eastern North America, are a type of aphid found on the roots of grapes or in galls formed on the leaves of wild grapes or hybrid varieties. European *vinifera* varieties are particularly susceptible to this pest, and the accidental introduction of phylloxera to California, Europe, and elsewhere initially devastated these industries. Management of phylloxera with insecticides was not successful and the wine grape industry was only rescued with the development of resistant rootstocks derived from American *Vitis* species or hybrids between these and susceptible *V. vinifera*. Phylloxera were first identified in the Penticton area in 1961; infestations currently are scattered and at relatively low levels in British Columbia vineyards, mostly due to the use of resistant rootstocks and the failure of this pest to thrive on sandy soils.

As early as 1914 it was recognized that grape phylloxera consisted of several distinct biotypes or races. Biotypes differ in their ability to form galls on the leaves of certain cultivars, in the degree of feeding damage caused to roots, and their propensity to form sexual or winged forms. One study demonstrated that rootstocks with unsatisfactory levels of resistance to phylloxera in Europe and South Africa were suitable for California, Australia and New Zealand. Loss of resistance can also occur over time as new biotypes of phylloxera arise.

Identification

Adults are very small, usually wingless, and less than 1mm long and half as wide. Colour varies from pale green, yellowish-green or light brown on vigorous roots, to brown or orange-brown on declining roots; as adults age they become a darker brown or even purplish-brown. Winged sexual forms are rare in British Columbia and the northwestern U.S. and they do not appear able to reproduce sexually on *vinifera* grapes. Leaf galls are formed on French-American hybrids, Concord juice grapes and some rootstocks. The relatively small galls on the undersides of leaves are green and roughly circular. These should not be confused with the white or brown fuzzy galls of variable sizes and shapes formed on the undersides of leaves by erineum (leaf blister) mite.

Life Cycle and Damage

Phylloxera overwinter on roots as small, dark hibernating nymphs that complete development in spring to become females that reproduce without having mated. Two or three generations are produced each year. When populations are large or the vines are declining, some newly hatched nymphs leave the roots through cracks in the soil and migrate to the roots of nearby vines. These small crawlers have been known to climb vine trunks and be blown on the wind for some distance. In late summer a portion of the nymphs develop into winged females (alates) that leave the soil and fly to other vines where they lay eggs in the crevices in the bark that hatch into males and females. After mating females produce a single larger overwintering egg. In spring the eggs hatch into females that feed on developing leaves and produce galls on susceptible varieties. Nymphs produced in the galls can infest other leaves or migrate down to the roots. Most grapes grown in British Columbia are not susceptible to leaf galls and the life cycle here largely consists of asexual forms confined to the roots of grapes. For this reason, infestations spread at a relatively slow rate.

Feeding of phylloxera on the roots of grapevines results in severe water and nutrient stress and eventual death of the vines. Roots become stunted and galled and die prematurely from the injection of harmful saliva and invasion of fungal pathogens. Depending on vine vigour and the size of the infestation, vines can slowly become stressed and chlorotic, or they can decline rapidly.

Monitoring and Spray Thresholds

Vines that fail to thrive and become chlorotic and unproductive should be inspected for the presence of phylloxera. Galls on leaves are an obvious indication of phylloxera on hybrid varieties, but damage confined to roots of *vinifera* wine grapes can be confused with damage from nematodes or root diseases. Carefully expose the roots and search for the typical swellings and dying roots. A hand lens or dissecting microscope will help verify the presence of phylloxera.

Insecticide treatments were previously not effective and there are no spray thresholds for phylloxera on roots. Hybrid cultivars that develop leaf galls are better able to tolerate or resist feeding damage to roots, but elimination of the leaf gall forms soon after they are detected might help reduce the extent of the infestation.

Biological Control

Biological control of phylloxera has not been studied in detail. A number of generalist predators are known to feed on phylloxera in leaf galls. In Ontario, larvae of two species of predaceous flies were commonly associated with leaf galls. Predaceous soil-dwelling carabid beetles undoubtedly feed on phylloxera infesting roots, and because they do not produce honeydew, ants are likely to feed on phylloxera rather than protect and 'milk' them. Although natural enemies are unable to effectively control populations of phylloxera, diseases and predators will help keep populations low and reduce the rate of spread.

Cultural Control

When establishing a new vineyard, purchase plants from reputable suppliers and ensure that planting material is healthy and free of phylloxera. The Phylloxera and Grape Industry Board of South Australia requires that grapevine nursery material originating from infested areas be immersed for 5 minutes in a hot water bath heated to 54°C (or 50°C for 30 minutes) and cautions that plants can be harmed by this treatment. Previous versions of this guide recommended that the soil should be washed from the roots of dormant, well matured nursery plants before they are immersed for 5 minutes in a water bath heated to 43.3°C, after which they are immediately moved to a second bath at 51.7°C for 5 minutes. It is important that the water bath be agitated during the treatment period to ensure an even temperature distribution. After treatment the plant material should be immediately immersed in cold water until it is thoroughly chilled.

To ensure that phylloxera are not moved from infested to clean areas on farm machinery, disinfest all equipment. Less frequent cultivation that penetrates the root zone is thought to be helpful.

Resistant rootstocks provide an effective means of combating phylloxera. Almost all resistant rootstocks were developed from crosses between several species of wild grapes native to eastern and southern North America (*V. riparia*, *V. rupestris*, *V. berlandieri* and others). Some of the more common grape rootstocks with good phylloxera resistance include SO4, 5BB, 5C, 420A, and 161-49C. Rootstocks vary in characteristics such as vigour and it is often difficult to select an appropriate rootstock for a particular vineyard. Soil types, resistance to nematodes, vine spacing and several other factors need to be considered in addition to phylloxera resistance. Prior to planting it is advisable to read appropriate publications and consult with vineyard managers or consultants.

Vigorous vines resist phylloxera damage better than stressed vines. Provision of additional water and nutrients can help delay the rate of decline. Infested vines should not be heavily cropped and extra care is required to prevent additional stresses from insects and diseases.

Some varieties are more vigorous and are better able to resist damage. **Phylloxera infestations are more damaging and spread more rapidly on heavier soils that are prone to cracking**, while vines planted in sandy soils can be nearly immune to attack.

Chemical Control

Movento™ (spirotetramat), a systemic insecticide effective against plant-feeding insects with sucking mouthparts, was recently registered for the control of grape phylloxera and mealybug. Sprays should be applied in a minimum spray volume of 500 L/ha as per the label instructions.

Wasps

A number of species of yellowjacket wasps (Hymenoptera: Vespidae) are pests of grape; the most numerous and troublesome being *Vespa pennsylvanica* (Saussure). Two uncommon species of paper wasp (*Polistes* sp.) are native to our area. The European paper wasp, *P. dominulus*, was found in British Columbia in 2003 and has since become very common, particularly around buildings. Yellowjackets, hornets and paper wasps are important predators of grape pests throughout most of the year, but in fall they often feed in large numbers on damaged fruit. Wasps are also an annoyance to vineyard workers and to pickers during harvest operations. Paper wasps are less aggressive than yellowjackets or hornets and are not as prone to sting.

Identification

Yellowjacket workers are about 1.5 cm in length; the abdomen appears largely yellow with thin black bands. Hornets are slightly larger and appear largely black with yellow or white bands. Paper wasps have thinner bodies with a more pronounced constriction (stalk) between the thorax and abdomen. The body is dark with some yellow markings, but they appear reddish-brown due to the colour of the wings and distal parts of the legs. In flight the legs of paper wasps dangle visibly below the body. All of these wasps produce paper nests, but the brood cells of paper wasps are exposed.

Life Cycle and Damage

Yellowjackets and paper wasps overwinter as fertilized females in sheltered locations. These queens seek suitable nest sites in spring and establish a new colony. Nests are initially small, consisting of only a few paper cells, but as workers develop they assist in building up colony numbers and the size of the nest. Depending partly on the species, nests can be in the ground, under the eaves of houses, in hollow trees or the walls of buildings, or exposed in trees. In fall, in addition to workers, colonies produce both males (drones) and queens. When freezing weather arrives, all the drones and workers, as well as the undeveloped larvae and pupae are killed.

Wasps prey on other insects, scavenge food and feed on nectar and the juices of fruit. It has been reported that wasps do not damage fruit themselves but take advantage of injury caused by other insects or birds, diseases such as sour rot, or splitting of fruit. There are contrary reports, however, particularly relating to the European paper wasp, that they are able to directly feed on intact fruit. As mentioned above, the greatest detriment is from annoyance or injury to pickers. Their stings result in swelling and a painful itch and can trigger severe allergic reactions in some individuals.

Monitoring and Spray Thresholds

Wasps are generally considered to be beneficial or of little economic importance. There are no established thresholds and the need to spray is determined by the tolerance level of individual vineyard managers. The recent arrival of the European paper wasp will likely make it necessary to control wasps more frequently.

Biological Control

Wasp colonies can be attacked by other wasps. Eastern and western kingbirds feed on foraging adults and larvae are subject to certain diseases. The onset of winter eliminates established colonies and overwintering queens often succumb to cold or are eaten by other insects, or even by mice.

Cultural Control

Elimination of nests early in the season can be an effective management strategy, but they are often located outside the vineyard or well hidden. Aerial nests in trees or under eaves can be removed and placed in a plastic bag at night when wasps are inactive. Nests in walls or natural cavities can be treated by blowing or puffing commercial wasp control products into the entrance holes at night. Sealing of entrances can help prevent future nests.

Trapping can be used to reduce numbers of foraging wasps in localized areas. Commercial wasp traps are available, or homemade versions can be made from recycled 1 litre plastic pop bottles. Sugary solutions are contained in the bottom of the trap and wasps that enter the small holes eventually fall into the liquid solution and drown. Trapping early in the season when populations are low is generally more effective than attempting to remove large numbers of wasps later in the season. For additional information on social wasps, management strategies, and design of wasp traps, visit the University of California Statewide Integrated Pest Management Program, 2008, website at:
http://www.ipm.ucdavis.edu/PMG/Pestnotes/pn7450.html.

Chemical Control

There are currently no insecticides registered specifically for the control of wasps feeding on grapes.

Spotted Wing Drosophila

(*Drosophila suzukii* (Matsumura))

This potentially damaging pest of grapes was first found in Canada infesting blueberries in the Fraser Valley in September 2009, and soon after in fruit fly traps in a cherry orchard near Kelowna. It is native to Southeast Asia where it feeds on a range of soft skinned fruit. Unlike most species of fruit fly (vinegar fly) that feed on very ripe, damaged, or rotting fruit, the spotted wing drosophila is able to attack sound, ripening fruit. Surveys are being conducted in 2010 in the Fraser Valley and the interior of British Columbia to help determine the distribution and abundance of this new pest. Although it has been reported to infest grapes in other regions of the world, it is unknown at this time if it will become an economically important pest of grapes in this province.

Identification

Adult spotted wing fruit flies are slightly larger (2-3 mm) than other fruit flies and males have a dark grey to black spot toward the outer margin of each wing. Females lack the wing spots and have a saw-like ovipositor visible with the aid of a good hand lens or microscope. The elongate creamy white legless larvae, up to 3 mm long, are difficult to distinguish from other species of fruit fly.

Life Cycle and Damage

It is currently unknown if adults of the spotted wing drosophila will successfully overwinter in significant numbers in the interior of British Columbia. Beginning in spring, several generations develop throughout the year on a range of available fruit (strawberry, blackberry, cherry, etc), including grapes in the late summer and fall. Typical for fruit flies, females lay large numbers of eggs that hatch rapidly into larvae that mature at a rapid rate. A generation can develop in as little as 1 to 2 weeks when temperatures are warm, resulting in rapid increases in numbers and significant damage to crops.

Larvae of several species of fruit fly develop in damaged or decaying grapes late in the season, causing little damage to the crop. Female spotted wing drosophila, however, can deposit eggs into undamaged, ripening fruit using their strong serate ovipositors. Feeding by larvae directly damages the fruit, and the holes created during egg-laying allow the entry of disease-causing microorganisms. The presence of fruit fly larvae and pupae in fresh table grapes is also a great concern.

Monitoring and Spray Thresholds

There are no established thresholds for this pest and it is presently unclear if it poses a serious threat to grapes produced in British Columbia. Fruit fly traps are available commercially or they can be made from recycled plastic pop bottles containing mixtures of yeast, sugar and water or apple cider vinegar as bait. Fruit can also be carefully inspected for the presence of larvae or pupae. Adults need to be reared from infested fruit in order to provide an accurate identification.

If you think you have this pest, consult the 'Spotted Wing Drosophila (Fruit Fly) Pest Alert' factsheet, BCMAL (www.al.gov.bc.ca/cropprot/swd.htm) for additional information.

Biological Control

Little is presently known about natural control agents of the spotted wing drosophila in western North America. Predators and parasites of other species of fruit fly are likely to also attack this species.

Cultural Control

Sanitary measures suggested for other fruit crops (i.e. removal of infested and unharvested fruit) are generally not considered to be practical for commercially produced grapes.

Chemical Control

Ripcord (cypermethrin), Malathion, Delegate (spinetoram), and Entrust (spinosad) received emergency registration for the control of spotted-wing drosophila on grapes for 2010. Entrust is a product approved by the Organic Materials Review Institute (OMRI) for use in organic vineyards. Sprays are required near to harvest to control this pest, and it is important to consult the label and observe the pre-harvest interval (PHI). These emergency registrations expire October 31, 2010. Check for current recommendations after this date.

Minor or Secondary Pests

A number of insect and mite pests of grapes occur only infrequently or cause significant amounts of damage only after chemical treatments have reduced numbers of predators and parasites that normally regulate their numbers. The best way to manage these pests, then, is to properly manage populations of primary pests so as to preserve and enhance numbers of beneficial insects and mites.

Thrips

(Western Flower Thrips, *Frankliniella occidentalis* Pergande)
(Grape Thrips, *Drepanothrips reuteri* Uzel)
(Flower Thrips, *Frankliniella tritici* Fitch)

Several species of thrips can be found feeding, at least occasionally, on grapes; the three most common are the western flower thrips (WFT), the grape thrips (GT), and the flower thrips (FT). **Thrips are generally minor pests of wine grapes, but are important pests of table grapes due to scarring of fruit.** Their populations often increase following applications of broad-spectrum insecticides that reduce numbers of beneficial insects. All species feed in a similar manner, but differences in biology and timing of infestations results in differential damage to grapes.

Identification

All species have long, slender bodies with dark protruding eyes and relatively short beaded antennae. Adults have two pairs of wings that are heavily fringed along the edges. WFT are dark yellow to brown and 1- 1.5 mm long. GT and FT are both around 1 mm long, the former is amber yellow with a yellowy-orange thorax, and the latter is uniformly pale yellow to nearly white. Nymphs of all species are similar in appearance to the adults except that they are smaller, slightly paler in colour, and lack wings. Thrips tend to be very active; adults not only fly but also run and hop rapidly.

Plant feeding thrips should not be confused with predaceous thrips. Adults of beneficial thrips may be dark black or purplish black with clear wings or wings that appear light grey with white bands, or they are pale with dark bands on the wings. They are slightly larger to nearly twice as large as the pest species. Nymphs of predaceous thrips have bodies that are banded yellow and orange, are reddish purple in colour, or are pale with the joints of the appendages dark. Compared with phytophagous species, predaceous thrips have front legs that are enlarged and slightly curved that they use for grasping prey. These features and the slightly larger mouthparts are best observed under a dissecting microscope.

Life Cycle and Damage

Adult female thrips overwinter under leaves and plant debris on the ground. In spring they deposit their eggs into developing leaf, stem, and flower tissues. The time from egg to adult is about three weeks during warm weather, and several generations are produced yearly. Most thrips feed on a wide range of host plants, and large numbers will often move to a succession of new succulent hosts throughout the year. Both adults and nymphs feed by rasping the leaf surface and sucking up the escaping fluids.

WFT adults enter vineyards in early spring, often in large numbers, when saskatoon bushes have finished flowering and other native vegetation is beginning to dry down. In addition to ground cover plants, WFT feed on flower and fruit tissues of grapes from bloom to just after fruit set. Their feeding under caps and persistent flower parts causes berry scarring and russeting. White and green grape varieties are also damaged when females insert their eggs into fruit, causing dark spots or halo spots. Feeding on developing shoots is occasionally so heavy that shoots are stunted and leaves deformed, but damage of this sort often only occurs around the perimeter of vineyards. WFT usually decline greatly in numbers following fruit set. FT have a similar biology and contribute to the damage caused to fruit in spring, but they are not as numerous as WFT.

GT are generally only found in significant numbers on grape during the summer months, and their feeding is largely confined to leaves and shoots. Numbers can build up rapidly, however, particularly following insecticide treatments for other grape pests. Leaf veins can be scarred and fail to expand properly, leaf edges can become necrotic, and shoot growth inhibited, resulting in shortened internodes.

Monitoring and Spray Thresholds

WFT often invade vineyards in large numbers for only brief periods in spring and it and the FT are not normally an economic concern for wine grapes. Scarring of fruit has not been shown to affect wine quality and damage to leaves and shoots is usually minor. Damage usually occurs over a short period of time, which makes early detection and control difficult. Inspect table grapes for the presence of WFT and FT in spring from around 75% bloom to the end of fruit set and apply insecticides as required. Verify the presence of thrips by sharply striking fruit clusters or leaves against a dull white or green coloured surface. The decision to spray should be based partly on the table grape variety, records of past damage, and the intended market for the fruit. There are no firm thresholds for thrips infesting grapes in British Columbia

Watch for GT damage to young leaves and shoots during summer and early fall. Use an eyepiece or magnifying glass to verify that thrips are present. As for fruit clusters, leaves and shoots can be held over a piece of white cardboard and sharply hit to dislodge the thrips. Control on mature vines is usually only warranted when growth is stunted sufficiently early in the summer to delay ripening and affect growth the following season.

Biological Control

Predatory bugs such as the minute pirate bug (*Orius tristicolor)*, anthocorids (*Anthocorus melanocerus*), and Deraeocoris (*Deraeocoris brevis*) are all known to feed on thrips. Studies in the Okanagan and Similkameen Valleys have indicated that predatory thrips are important regulators of pest thrips populations. In the laboratory, predatory thrips at a density of one every 10 to 15 leaves is sufficient to control WFT.

Cultural Control

So that thrips are not forced to feed on table grapes when they are most susceptible to fruit damage, avoid mowing cover crops during bloom and fruit set.

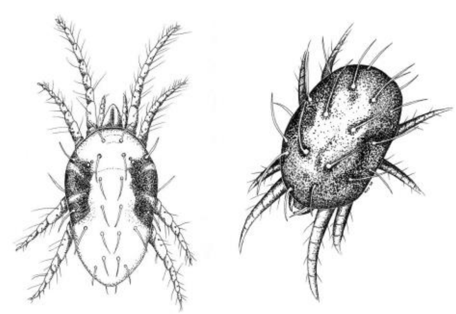
Chemical Control

Success™ (spinosad) was recently registered for suppression of thrips on grapes. Insecticidal soap applied for mites and grape mealybug will also help suppress thrips populations.

Spider Mites

(European Red Mite, *Panonychus ulmi* (Koch))
(Two-spotted Spider Mite, *Tetranychus urticae*Koch)

The main species of spider mites infesting grapes in British Columbia are the European red mite (ERM) and the two-spotted spider mite (TSSM). They differ somewhat in biology, but feeding damage and management strategies are largely the same. **Spider mites should be considered secondary or induced pests of grapes; their numbers increase following the use of broad-spectrum insecticides that reduce numbers of spider mite predators.** Although it is somewhat selective in action and preserves populations of some predators, the insecticide Assail is toxic to predacious thrips that are effective predators of mites in B.C. vineyards. Studies in Washington State have also shown that the active ingredient in Assail and related materials increases spider mite reproduction. Due to its persistence, increases in mite numbers can occur up to several months after application.



TSSP (left) and ERM (right)

Identification

Adults of both species are small, around 0.5 mm in length, and just barely visible to the naked eye. They are nearly spherical in shape and have eight legs and short piercing mouthparts. The ERM is dark red in colour with long pale hairs (setae) projecting from small pale circular areas on the dorsal surface. The oval eggs are bright orange with a distinctive hairlike projection on the upper side. The TSSM varies in colour from pale yellow to greenish yellow to bright orange;

the common pale form has a distinct dark dorsal spot on each side of the body. Its eggs are white. Both species feed on the undersides of leaves. TSSM usually congregate in clusters and produces large quantities of silk webbing, while ERM produce less webbing and are more evenly distributed over the leaf surface.

Life Cycle and Damage

ERM, our most common species, pass the winter as eggs laid on vine canes and trunks. Eggs hatch in spring and the young microscopic nymphs begin to feed on young foliage. TSSM overwinter as fertilized females under the bark or in other sheltered areas around the base of vines. When warmer weather arrives in spring the females begin to feed and deposit eggs. Both species can produce around six to eight overlapping generations each season, and all stages can be found on grapes at any time during the summer months. Females of both species are capable of producing 200 or more eggs each and development can be rapid during warm weather. **Spider mite populations can, therefore, explode rapidly under favourable conditions**.

Both adults and nymphs feed by piercing individual leaf cells and removing the fluid contents. Healthy grapevines can tolerate moderate numbers of spider mites, which will cause chlorotic spots on the leaves. Heavy feeding results in brown leaves that fall prematurely; reducing photosynthetic activity and vine vigour. Heavy feeding damage can delay ripening of fruit. The large amount of webbing produced particularly by the TSSM is also a cosmetic problem for table grapes.

Monitoring and Spray Thresholds

Spider mites rarely cause significant damage to grapes prior to mid-summer. No firm thresholds have been developed for spider mites on grapes in British Columbia, but approximate guidelines can be suggested from research conducted in other countries. In Europe, a threshold for ERM on grapes was determined to be 60 to 70% infested leaves in spring, while in summer leaves with 1 or more mites should not exceed 30 to 45% of total leaves on a shoot. Because a similar threshold has been suggested for TSSM in Switzerland, numbers of both species can be combined into a single spider mite count. A good hand lens or low-power dissecting microscope would help provide accurate counts of infestation levels. A fairly reliable method is to monitor damage to leaves and spray when a moderate amount of 'bronzing' has occurred, around 10% defoliation. Because mite numbers can increase very rapidly it is necessary to monitor grapes frequently during hot weather.

When monitoring for mite damage it is useful to consider previous infestation levels. Vineyards with low chemical inputs that have not experienced severe spider mite outbreaks in the past are unlikely to require treatment, while those that have been treated with broad-spectrum insecticides should be observed closely.

Biological Control

Spider mites were of minor importance prior to the widespread use of synthetic pesticides. Due largely to the harmful effects of pesticides on populations of predators, spider mites are now the most important pests of grapes in many regions of the world. **The first course of action for the management of spider mites is the preservation and enhancement of beneficial species**. Pesticides should only be applied when necessary and only to parts of the vineyard where pest populations are sufficiently high to warrant control. Whenever possible select materials that are least damaging to non-target species. Numbers of spiders and beneficial insects are usually higher in vineyards with permanent, mixed groundcover that provides pollen and alternate sources of prey. Proximity to uncultivated or unsprayed areas allows beneficial insects to re-colonize vineyards following spray treatments.

Several species of predatory mites (e.g. *Metaseiulus*, *Typhlodromus* and *Amblyseius* species) feed on spider mites and their eggs. Most beneficial mites are a pale opaque colour but they can appear light orange if they have been feeding on ERM. They are oblong in shape and slightly smaller than adult spider mites. The long-legged orange whirligig mite (*Anystis agilis*) is uncommon on grapes in British Columbia Like most other predatory mites, this large species is more active than its prey. Predatory mites are very sensitive to a range of pesticides, including sulphur fungicides and pyrethroids such as permethrin (Pounce™).

A number of spiders and predatory insects feed on spider mites or their eggs. Many species, such as the minute pirate bug (*Orius tristicolor*), are generalist predators that do not specialize on mites, while others such as the aptly named spider mite destroyer, *Stethorus picipes*, are very effective predators that feed almost exclusively on mites. *Stethorus picipes* is a small, dark species of ladybeetle with a slightly hairy appearance. The elongate bodies of the larvae are also nearly black in colour with a body covered with numerous hairs. At least four species of predatory thrips can be found in Okanagan Valley vineyards; adults of three of these are black, while the fourth, the six-spotted thrips, *Scolothrips sexmaculatus*, is pale with dark spots on the wings. All 4 species feed on spider mites, and healthy numbers of these predators are usually associated with low populations of their prey. The western flower thrips is considered a pest of grapes, but it is also known to feed on the eggs of spider mites.

Cultural Control

Vineyards can be managed in ways that help alleviate mite problems. Hot, dry and dusty conditions favour the buildup of spider mite populations. Where mites are a problem, roadways can be treated with oils or other materials to reduce dust. Vineyards that are continuously cultivated will produce more dust than those with permanent ground covers. Moreover, a permanent mixed groundcover will support greater numbers of beneficial insects and predaceous mites. Compared with bare soil, planted aisles will decrease air temperatures and raise humidity levels somewhat, providing less favourable conditions for spider mites. Spider mite populations can become elevated on vines suffering severe drought stress, and these plants are also less able to tolerate damage. Overhead irrigation will help reduce mite infestations.

Chemical Control

A number of miticides (e.g. Acramite™, Kelthane™ , Envidor™ and Pyramite™) are registered on grapes for mite control. Insecticidal soap applied for the control of leafhoppers will help suppress mites. Refer to *Pest Control Products Recommended for Use on Grapes in British Columbia* and rotate materials with different modes of action (chemical group) to help prevent development of mite resistance.

Grape Erineum Mite

(= Grape Leaf Blister Mite, *Colomerus vitis* (Pagenstecher))

Identification

Adult erineum mites are only 0.2 mm long and a dissecting microscope is required to observe them properly. Their creamy pale bodies are elongate with only two pairs of legs. Although erineum galls can be confused with certain fungal diseases or phylloxera leaf galls by inexperienced growers, their characteristic appearance is the best way to identify these pests. **The hemispherical concave galls or erinea formed on the undersides of leaves initially have a felty white appearance due to the presence of densely packed long leaf hairs.** Opposite to these galls, bumps will be visible on the upper surfaces of leaves. These swellings are a reddish colour in spring and turn green as the leaves mature. Small numbers of mites feed on the dense hairs in each gall, which eventually turn brown. Having been reported recently from Washington State, two other forms of erineum mite, the leaf-curling strain and bud-inhibiting strain are possible in British Columbia The former causes slight to severe downward curling of leaves in summer with stunting of shoots and increased growth of lateral shoots. Feeding of the bud-inhibiting strain on buds causes a range of abnormalities, including scarified shoots, short zigzagging internodes, dead terminal buds and malformed leaves. For additional information on erineum mites and other pests of grapes, visit the University of California Integrated Viticulture Online website (Viticultural Information> Insects and Mites).

Life Cycle and Damage

Adult erineum mites overwinter under the scales of buds. Mites move in spring to developing shoots and create galls on young leaves around the fruiting zone. Several generations are produced each year, with new galls developing higher up the shoots. Beginning in late summer, adult mites move back to the buds for winter.

Leaves with a few too many erineum galls appear to function normally and there is little or no economic damage to mature vines until almost all leaves are covered with galls. Even then, damage usually only occurs if vines are also suffering from other stresses. Establishment of newly planted vines can be delayed somewhat by erineum mite feeding, which will retard or reduce fruiting.

Monitoring and Spray Thresholds

Erineum galls are usually very apparent during routine vineyard operations. Grape varieties differ in susceptibility to this pest and it is important to check individual blocks for the presence of mites. In order to prevent premature loss of leaves, new vines should be inspected and treatments applied if large numbers of galls are found on most leaves during the spring or summer months.

Biological Control

The western predatory mite, *Galendromus occidentalis*, is an important erineum mite predator. Predaceous thrips will feed on exposed mites, but their effectiveness is likely limited when mites are protected within the dense hairs of the galls.

Cultural Control

New plants may become infested in the nursery. **Ensure that material used to establish new vineyards is free of mites and other pests or diseases.** Removing galled leaves can control light infestations to some extent. Research conducted in the Okanagan Valley demonstrated that removal of infested leaves in May from Sauvignon Blanc vines did not alter yields or fruit quality.

Chemical Control

Erineum mite is seldom a problem in vineyards where sulphur is applied routinely for powdery mildew control. **Applications of sulphur (e.g. Kumulus™ DF, or wettable sulphur) are most effective early in the season when galls are first being formed on new leaves**. Sulphur sprays should not be used on Foch or *Vitis labrusca* varieties, as they are susceptible to leaf and fruit damage. Miticides (acaricides) such as Pyramite™ or Kelthane™ applied against spider mites and sprays of organophosphates (e.g. malathion and Sevin™) for control of leafhoppers will also reduce numbers of erineum mite somewhat.

Grape Leaf Rust Mite

(*Calepitrimerus vitis* (Nalepa))

Grape leaf rust mite, which belongs to the same family (Eriophyidae) as grape erineum mite, was identified for the first time on grapes in the Okanagan Valley in 2009. Growers are referred to the following source for additional information: Grapevine pests and their management, by A. Loch. Primefact 511, New South Wales Dept. of Primary Industries, NSW Australia posted at: www.dpi.nsw.gov.au/primefacts.

Identification

A microscope is required to properly identify these 0.2 mm long pale white wormlike mites that closely resemble erineum or blister mites, but do not form leaf galls. They are much smaller than spider mites and elongate rather than round, tapering at the rear, and having two pair of legs near the head. Their presence is best determined by the bronzing of leaves during July and August that results from their feeding. Unlike spider mites that cause similar damage to leaves, grape leaf rust mites do not produce webbing.

Life cycle and damage

Adult rust mites that spend the winter under bark or bud scales move in spring to the developing buds to feed and lay eggs. Large numbers of adults concentrated on the available green tissue in early spring can damage buds, resulting in deformed leaves, scarring of shoots, reduced shoot growth, and even bud death. Early season rust mite damage can be confused with cold injury or damage from other causes. Damage becomes less visible as the season progresses and shoots lengthen. Immature mites that hatch over a period of several weeks feed under the bud scales, eventually moving to feed on developing leaves. Unlike spider mites, rust mites infest equally the upper and lower leaf surfaces. Many generations are produced throughout the summer, and before leaves drop in the fall adult rust mites migrate to the cordon and trunk for the winter. Bronzing of leaves is most obvious during July and August, but damage to leaves is not thought to cause serious damage to the vines. Extensive bronzing of leaves is an indication that rust mites need to be controlled the following spring.

Monitoring and Spray Thresholds

There are no established thresholds for this pest. Control is indicated when a significant proportion of leaves become bronzed in late summer.

Biological Control

As for erineum mite, western predatory mite, *Galendromus occidentalis*, other mite predators, and predacious thrips are often able to keep rust mites in check. To maintain healthy populations of beneficial insects and predatory mites, it is important whenever possible to limit the use of insecticides and to apply selective materials that are less toxic to predatory mites.

Chemical Control

A successful rust mite control program developed in Australia relies largely on spring applications of sulphur **(e.g. Kumulus™ DF, or wettable sulphur) in high volume sprays during bud swell to woolly bud stage**. Sulphur sprays should not be used on Foch or *Vitis labrusca* varieties, as they are susceptible to leaf and fruit damage. There are no miticides currently registered for the control of grape leaf rust mite.

Grape Mealybug

(*Pseudococcus maritimus* (Ehrhorn))

Mealybug were seldom a concern on grapes prior to the widespread use of synthetic insecticides. Individual bunches of table grapes that touched infested vines would occasionally become infested. **Largely due to the detrimental effects of broad-spectrum insecticides on beneficial insects, damaging populations of mealybug have become more common in recent years**. As for many other secondary pests, the most important management strategy is to apply chemicals against major pests (leafhoppers, cutworm) only when required and only to portions of the vineyard where control is warranted. Whenever possible, select pesticides that are least damaging to predators and parasites.

Identification

The grape mealybug (Homoptera: Pseudococcidae) has a flattened, oval pink body covered in a mealy white wax coating. It is somewhat segmented in appearance, but the divisions between head, thorax and abdomen are not distinct. Mature wingless females are about 5 mm long. They have long waxy filaments along the edge of the body that are longest at the rear and become progressively shorter toward the front end. Large numbers of eggs are laid in cottony masses. The smaller, winged males have a pair of long, white anal filaments. Yellow to brown crawlers that emerge from the oval, orange eggs are not covered in wax. All stages are mobile.

Life Cycle and Damage

Females move in late fall to old wood and lay overwintering eggs in cottony egg masses under loose bark. Crawlers, some of which might have hatched in fall and remained dormant throughout the winter, move to new shoots in spring. Grape mealybugs mature around mid-summer and produce a 2nd generation that matures in late autumn. They can occur on all plant parts but are more common in summer on leaves and new growth, usually hidden within the canopy.

Damage is similar to that for soft scale. Plant sap is removed during feeding and large amounts of honeydew foul the fruit and promote the growth of sooty mold fungus. Most fruit damage occurs during the development of the second brood in late summer. Mealybugs can infest grape bunches and are known to transmit certain strains of leafroll virus.

Monitoring and Spray Thresholds

To detect when crawlers are active, remove the loose bark in an area near the infestation and encircle the vine with clear tape applied sticky side out, or use double sided adhesive. Replace the tape every three or four days and check for the yellowish brown crawlers. A good magnifying glass or dissecting microscope is useful for this purpose. **Unlike scale insects, grape mealybug prefer vigorous vines with thick canopies**. The need to inspect vineyards for mealybugs can be based partly on past infestations, vigorous growth, and prior use of broad-spectrum insecticides.

Biological Control

Parasitism of grape mealybug has not been studied in British Columbia Research in California has shown that at least six species of parasitic wasps attack grape mealybug - late summer and fall rates of parasitism often exceed 90%. Predaceous midge larvae attack mealybug egg masses. Lacewings, several species of lady beetles, and many other generalist predators feed on adults. Mealybug and other homopteran insects (scale, whitefly, aphids, etc.) are susceptible to several diseases, including *Entomopthora* fungus.

Cultural Control

Mealybugs prefer vigorous vines. Ensure adequate nutrition and moisture to produce an optimum crop, but avoid excessive vigour. Research in California has shown that fruit on cane-pruned varieties is less likely to suffer damage compared with spur-pruned vines. Clusters on cane-pruned vines hang farther away from the mealybug overwintering sites on old wood. Earlier varieties often escape damage as they are not exposed to honeydew to the same extent as later varieties.

Heavy infestations of mealybugs and other honeydew-producing pests of grape are usually tended by ants that feed on the sugary excretion and protect the mealybugs from predation. Control of ants can often contribute to a significant decline in mealybug numbers. For small backyard plantings with an isolated infestation, painting a sticky material around vine trunks and posts and ensuring that ants cannot gain access to the mealybugs often eliminates the problem. Trials in California have also shown that sprays directed against the Argentine ant, *Iridomyrmex humilis*, controlled damaging populations of the obscure mealybug, *Pseudococcus affinis*. Insecticides are not currently registered for the control of ants in BC vineyards.

Chemical Control

Malathion, Diazinon and Safer's Insecticidal Soap can be applied against the crawler stage, while Movento™ (spirotetramat) is active against all stages due to its good systemic activity. Consult the BCMAL fact sheet, *Pest Control Products Recommended for Use on Grapes in British Columbia*, posted at http://www.al.gov.bc.ca/cropprot/grapeipm/grape_pesticides.pdf.

Scale Insects

(European Fruit Lecanium Scale, *Parthenolecanium corni* (Bouché))
(Cottony Maple Scale, *Pulvinaria vitis* L.)

About a dozen species of scale insects are known to attack grapes in various regions of the world, but only two are commonly found on grapes in British Columbia The European fruit lecanium scale (EFLS) and cottony maple scale (CMS) are both soft scales (Homoptera: Coccidae) that rarely cause economic injury to grapes. They are a greater concern in the production of table grapes. The large quantities of honeydew they produce supports the growth of sooty mold fungus that can leave fruit unmarketable. Two species of hard scale (Homoptera: Diaspididae), the oystershell scale, *Lepidosaphes ulmi* L., and San Jose scale, *Quadraspidiotus perniciosus* Comstock, can occasionally be found attacking 2 year old wood of weakened vines. Hard scales do not produce large amounts of honeydew and are currently of little importance to the B.C. grape industry.

Identification

Female EFLS, also known as brown apricot scale, when fully grown have a chestnut brown, smooth and slightly shiny protective shell that is around 5 to 8 mm long and slightly longer than wide. Certain races in some regions reportedly produce male scales, but most females reproduce without mating. The small nymphs or crawlers that hatch from the small oval, pearly white eggs are yellow to orange in colour. Mature female CMS are similar in size, shape and colour to EFLS, except that a mass of cottony material containing the eggs, up to 1,000 per sac, extrudes from the rear end. The much smaller winged males produced in late summer have no mouthparts and live for only 1 or 2 days. Males mate with the immature females. Mature scales of both species become brittle after the eggs are laid in mid-summer and can easily be detached from the one to three year old wood with a fingernail. The smaller hard scales (1-2 mm), which are much longer than wide, remain firmly attached to the canes even after death.

Life Cycle and Damage

EFLS and CMS overwinter as partly grown scales on new canes. Growth resumes in spring and females reach maximum size around early summer when they begin to lay eggs. The newly hatched scale called crawlers hatch and disperse during July and August to the undersides of leaves where they settle and feed until early fall, when they migrate to the current year=s wood and develop a hardened protective shell for the winter.

Both species of soft scale feed on the phloem of grapes and a large number of other woody plants, including many fruit trees and ornamentals. Scales are not usually abundant on grapes grown in British Columbia, and direct feeding damage from the removal of plant fluids is rarely a cause for concern. They appear to prefer weak vines, however, and the additional stress might be sufficient to hasten death. Of greater concern, they produce vast amounts of honeydew that can turn grape bunches into sticky, unmarketable messes. Additionally, honeydew supports the growth of sooty mold fungus which further disfigures the fruit.

Monitoring and Spray Thresholds

Because scale infestations often occur on only a single vine or a few vines in a small area, they can be difficult to detect. Partly-grown scales might be observed during pruning, or watch for honeydew on leaves and fruit during spring and early summer. Ants feed on the honeydew and will protect the scale from predators. They can often be seen in large numbers hurriedly running up and down posts or vine trunks to and from infested canes.

To detect when crawlers are active, remove the loose bark in an area near the infestation and encircle the vine with clear tape applied sticky side out or use double sided adhesive. Replace the tape weekly and check for the orange coloured crawlers. A good magnifying glass or dissecting microscope is useful for this purpose

There are no established thresholds for scale infestations. Small numbers of scale on a healthy vine are unlikely to cause damage; treatment is usually only required when the excretion from large infestations fouls table grapes.

Biological Control

Biological control of scale on grapes in British Columbia has not been investigated in any detail, but on other crops and in other regions of the world they are known to be heavily parasitized by several species of wasps and flies. They are preyed upon by lacewings, lady beetles, and other generalist predators. English sparrows and several species of warblers that feed on fully grown soft scale have been known to curtail infestations.

Cultural Control

Healthy vines of moderate vigour are less susceptible to scale infestations and are better able to withstand damage. Routine pruning removes many scales and a small infestation can be pruned out in spring or early summer.

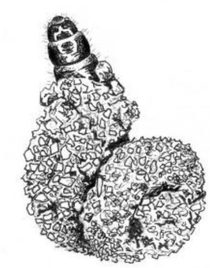
Chemical Control

Movento™ (spirotetramat) is registered for the suppression of lecanium scale. Malathion and insecticidal soap will also help control the active crawler stages in summer. Repeat applications might be required as long as crawlers are active.

Snailcase Bagworm

(*Apterona helix* Siebold)

Identification



This introduced moth (Family Psychidae) remains throughout most of its life within a snail-like case made from particles of soil and sand bound together with silken threads. When fully grown the coiled case is approximately 4 mm in diameter. There are no males and the wingless female moths remain inside the case to deposit their eggs without having mated (parthenogenetic reproduction). Large aggregations often form on posts, tree trunks, or vine trunks in late summer.

Life Cycle and Damage

Young caterpillars overwinter within the case formed by the mother. They drop to the ground in spring, form C-shaped cases, and begin to feed on a wide range of weeds, native plants and cultivated crops. Damage consists of small excavated holes on the leaf surface. As the larva grows it eventually expands its case into the typical snail-like, helical shape. In mid-summer the fully grown larvae will climb vines, posts or buildings, attach themselves firmly with silk, and pupate within the case. Several weeks later the females emerge, lay eggs, and then exit the case to die. The eggs hatch in late summer and the small first instar larvae spend the winter within the protective cases. There is only one generation per year.

Monitoring and Spray Thresholds

Larvae of the snailcase bagworm cause minimal feeding damage to leaves and they are not considered economic pests of wine grapes. The large aggregations are easily detected on buildings, posts, wires, and the trunks of vines. If contamination of table grapes is a concern, inspect vines and apply control measures before the overwintering aggregations form in late summer. The non-feeding overwintering stage, secure within the case, is not susceptible to insecticides.

Biological Control

Because it has not yet been adequately studied, natural enemies of this pest of grapes in British Columbia are unknown. The protective case would provide some protection from certain generalist predators, but predators, parasites and diseases undoubtedly take their toll.

Cultural Control

Snailcase bagworm prefer moist areas with thick vegetation. Avoid excessive irrigation and drain areas that puddle or remain damp. Proper drainage will also help reduce grapevine root diseases. Occasional discing or mowing of areas of the vineyard where bagworm are a problem can help reduce infestations.

Chemical Control

Dipel™ (*Bacillus thuringiensis*) is registered for snailcase bagworm control on grapes and sprays applied for the control of other insects will provide some protection. For this reason, they are more common in organic vineyards or conventional vineyards with low chemical inputs.

European Earwig

(*Forficula auricularia* L.)

The European earwig is both a beneficial insect and a pest of table grapes. All stages feed on small, soft-bodied insects such as small leafhopper nymphs and will scrape leafhopper eggs off of leaves. In fall they feed to some extent on damaged grapes and their presence in table grapes is not appreciated by some consumers. On grapes produced for wine, they should be considered important generalist predators.

Identification

Adult earwigs (Order Dermaptera) are dark brown, about 1.5 cm long, with a pair of forcep-like appendages (cerci) at the rear of their elongate bodies. The anal forceps of females are long and straight, while those of males are curved. Earwigs seldom fly and the membranous hind wings usually remain folded up under the short leathery forewings, exposing the abdomen. The four nymphal stages resemble the adults except that they are smaller and wingless. Earwigs are largely nocturnal and hide during the day, often in large aggregations, in cracks and crevices, or under bark. When disturbed they move quickly.

Life Cycle and Damage

Adults overwinter in the ground in earthen cells. Clutches of eggs laid in cells in the top 5 cm of soil in the fall and spring are opened by females in spring to release the young nymphs. Adults are semi-social and tend their young for a period of time after birth; nymphs later disperse to secure locations under rocks, in crevices, or under bark. Adults develop by midsummer and there is only a single generation per year. Earwigs are nocturnal and feed at night on damaged fruit, leaves, small soft bodied insects, and other foodstuffs. They rarely damage grape leaves.

Monitoring and Spray Thresholds

Rolled up newspaper or cardboard, or flat boards placed on the ground, can be used to monitor earwigs. It might be possible to use these same refuges to enhance their numbers in wine grapes.

Biological Control

Birds, large spiders, wasps and ground beetles prey on earwigs. **Earwigs, in turn, feed on the eggs and small nymphs of leafhoppers and on other soft bodied insects.**

Cultural Control

Tillage in spring and fall will destroy some of the earthen cells. For table grapes, mowing, tillage, removal of loose bark from vine trunks, and sanitation will remove hiding places and help reduce earwig numbers. They can be kept out of small plantings of table grapes by applying sticky tape or commercial Stickum around trunks and posts. Washing table grapes after harvest will help dislodge many earwigs. Earwigs are less likely to seek refuge in table grape varieties with loose, open fruit bunches.

Chemical Control

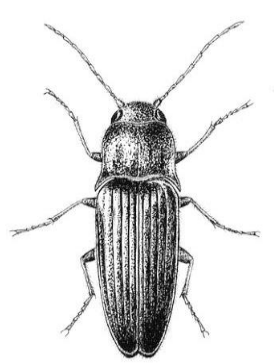
Earwigs are sensitive to most insecticides and sprays applied for the control of other grape pests will usually also provide control of earwigs. Commercial earwig baits are also available.

Click Beetle

(Coleoptera: Elateridae)

Click beetles where formerly considered to be important pests of grapes in British Columbia, but extensive study in Okanagan vineyards has shown that damage attributed to click beetle adults was in fact caused by half grown cutworm larvae. Several species will feed occasionally on buds of grapes, but control is usually not warranted. Click beetles are also not considered pests of grape in Washington State.

Identification



Click beetle larvae, called wireworms, have long, slender, hard bodies that are a light tan to a light orangey-brown in colour, and appear somewhat shiny and polished. Their short legs and cylindrical slender bodies allow them to burrow through the soil to feed on the roots of plants. Adult beetles have elongate, somewhat flattened bodies usually in shades of brown or black. The segment behind the head has small projections that point backward on each side of the body. Adults of most species are around 1 to 1.5 cm in length, but some are significantly larger. When adults are placed upside down in the palm of a hand or gently held between finger and thumb they will rapidly flex their bodies at both ends and attempt to right themselves or escape with a characteristic clicking action.

Life Cycle and Damage

Adults that have spent the winter under debris and leaves emerge with the arrival of warm weather in spring to feed on the tender buds and leaves of a wide range of plants, including occasionally grapes. They are often quite common on flowers where they feed on soft tissues and pollen. After feeding for a short time, females begin to deposit eggs into the soil. In two or three weeks the eggs hatch into small slender 'worms', the larvae, that develop in the soil throughout the summer. Click beetles can persist for a long time without feeding and they often require more than one year to complete development to the adult stage.

Larvae are not known to damage the roots of grapes to any extent, preferring to feed on the roots of weeds or grasses. As for cutworm larvae, feeding of adults on buds of grape causes the buds to die. Yields can be reduced and ripening of fruit can be uneven and delayed. Little damage occurs after bud break.

Monitoring and Spray Thresholds

Adult click beetles feed on buds so infrequently that monitoring for these pests is generally not warranted. **The presence of adult click beetles in a vineyard does not indicate feeding or correlate with damage.** There are no established thresholds in British Columbia relating click beetle numbers to bud damage. To determine if bud damage is due to click beetles or cutworm larvae, it is best to inspect vines with the aid of a flashlight soon after dark on warm spring nights.

Biological Control

Little information is available on the biological control of click beetles in British Columbia

Cultural Control

As for climbing cutworm, the presence of broadleaf weeds in spring helps reduce damage to grapes.

Chemical Control

Chemical control of click beetles is generally not warranted and none are registered specifically for adults on bearing vines. Sprays for cutworm larvae should help control adult click beetle.

Miscellaneous Insect Pests

In addition to the major and minor grape pests described in previous sections, a number of insects attack grapes only very rarely and are generally not of economic importance in British Columbia Following are brief descriptions of a few of these occasional pests.

Black Vine Weevil

(*Otiorhynchus sulcatus* F.)

Weevils spend the winter in the soil as pale, legless larvae feeding on the roots of a wide range of plants. The 1.5 cm long flightless black adult beetles have a long, broad >snout= typical of weevils (Coleoptera: Curculionidae). The thick, roughened front wings are fused together. Adults feed during summer on grape clusters and leaves and sometimes girdle fruit clusters. Weevils are active only at night and remain hidden under plant debris or loose bark during the day, making detection difficult. Look for leaves with deeply notched edges not associated with damage from other chewing pests. Traps can be made from cardboard loosely wrapped around vine trunks where the weevils will hide during the day. They are mainly a problem on older vines and in coastal production areas.

Wood-Boring Beetles

Two or three species of wood-boring beetles can occasionally infest older canes and vine trunks. Depending on the species, adults are brown to black, cylindrical in shape, and from 5-10 mm in length. They have hardened fore-wings typical of beetles and indistinct body sections. Adults burrow into the spurs and canes at the base of new shoots, causing them to wilt or break. The pale larvae or grubs bur-row through living or dead tissues. Damage usually occurs on older or diseased vines.

Grasshoppers

Adults and nymphs of several species of grass-hopper (Orthoptera: Acrididae) feed on grape leaves usually beginning in late summer when preferred hosts begin to dry up. Feeding by these well-known, long-legged jumping insects consists of chewing damage to leaf margins most often on lower leaves. Grasshoppers suffer from pathogenic diseases when popula-tions are high. Preying mantids, toads, and many species of birds feed on adults, while smaller nymphs are attacked by spiders and a number of predatory insects such as ground beetles.

Whitefly

Several species of whitefly (Homoptera: Aleyrodidae) occasionally infest grapes. Over-wintering whitefly are relatively rare in B.C. Some sub-tropical and tropical species, such as the common greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood), infest outdoor plants each season from infested greenhouses, house plants, and vegetable and ornamental trans-plants. Adults are small, around 2 mm in length, with two pair of wings that are covered with a fine, white powder. They somewhat resemble small white moths. The minute crawlers are mobile for only a few hours until they settle and develop into nearly translucent, scale-like immobile nymphs. The >scales= have a fringe of waxy material projecting from the bottom edge; the distribution and numbers of the projections can assist in species identification. The pupal stage that develops inside the case on the undersides of leaves is somewhat bulbous and appears segmented. There are several generations per year. Whitefly feed by sucking juices from the leaves, much as scale insects do, and they also produce large amounts of sugary honeydew. Populations are controlled by para-sitic *Encarsia* wasps that turn the scales black, by several predatory insects, and by pathogenic fungi.

Western Grape Rootworm

The western grape rootworm, *Bromius obscurus* (L.), is a widespread pest of grapevines in Europe and California, but damage to grapes in British Columbia was not previously reported until recently when an outbreak occurred in the Kelowna area. Fully grown larvae are C-shaped white grubs about 7 mm long with yellowish brown heads and dark mouthparts. Adult beetles are about 4 mm long and somewhat hairy with nearly black heads and bodies. Adults, which are all females, start emerging in May and feed on the expanding leaves of grapes, causing long slit-like holes. Larvae initially feed on root hairs before tunneling into the roots of grapevines. Feeding by western grape rootworm larvae is known to cause the death of vines in California due to direct damage to the roots and entry of secondary pathogens. Additional information is available at www.al.gov.bc.ca/cropprot/bromius_obscurus.pdf.

Cicada

Adult minor cicada, *Platypedia minor* Uhler (Homoptea: Cicadidae), are about 20 mm long with 2 pair of large, transparent wings held roof-like over the body. The pale, wingless nymphs have enlarged front legs that they use to dig through soil. Cicadas are mostly known from the loud buzzing or clicking noises that males produce on hot summer days. They are difficult to locate and will move around to the opposite side of trees or posts when approached. Damage to individual shoots occurs occasionally when females deposit eggs into canes with their long, saw-toothed ovipositor. Deposition of several eggs into a cane can weaken it or cause it to break. The oviposition damage is recognizable by the slivers of wood protruding from a series of punctures. Newly hatched nymphs drop to the ground to spend two to three years feeding on the roots of plants. It is not known if they feed on the roots of grapes.

Three-Cornered Alfalfa Treehopper

Adult three-cornered alfalfa treehopper, *Spissistilus festinus* (Say) (Homoptera: Membracidae), are green in colour and about 6 mm in length. The pronotum is elongated to the sides and extends to the rear of the abdomen so that they look somewhat triangular when viewed from the front. Lacking the large side projections, the buffalo treehopper, *S. bisonia* Kopp & Yonke, which also reportedly feeds on grapevines, has the hump-backed appearance of the American Bison after which it is named. Mainly restricted to the south end of the Okanagan Valley, damage caused by the three-cornered alfalfa treehopper can resemble leafroll virus. In summer late instar nymphs will produce a series of feeding punctures around leaf petioles or stems, resulting in decreased flow of water and nutrients and eventual reddening of leaves beyond the feeding site. The initial feeding punctures coalesce into a darkened band of sunken tissue encircling the stem or leaf petiole. Although damage is often restricted to lateral shoots and generally not of economic concern, growth of newly planted vines could be stunted in areas with lots of alfalfa or other suitable host plants.

Additional Information

Other useful sources of information on pests of grapevines:

Grape pest Management, 2nd Edition. University of California, Agriculture and Natural Resources, Pub. No. 3343. 2008.

UC Integrated Viticulture Online. University of California website. Main Menu>Viticultural Information>Insects and Mites.

UC IPM Online. University of California website (www.ipm.ucdavis.edu). Main menu>agriculture>grape>insects and mites.

2009 Pest Management Guide for Grapes in Washington. WSU Extension Publications. Revised Jan 09.
(Free downloadable PDF version at: cru.cahe.wsu.edu/CEPublications/eb0762/eb0762.pdf).

Grapes: Factsheets and Publications.
BC Ministry of Agriculture and Lands website (www.al.gov.bc.ca/grape/factsheets.htm).

5.4 Weeds

Selection and management of appropriate ground cover vegetation will assist in managing weeds. For information on managing vineyard cover crops see section 4.5 Vineyard Floor Management.

The elimination of all vegetation around young grape vines is essential to eliminate competition and promote satisfactory growth that will result in early commercial yields. Newly planted grape vines are poor competitors for moisture and nutrients. Heavy sod will cause severe stunting of young vines. Effective chemical and mechanical weed control measures are available.

Non-Chemical Weed Control

Effective weed control is possible by plowing, disking, clean cultivation or by establishing a competitive cover crop a year before planting. Weeds that are difficult to control under the trellis can be eliminated with appropriate cultivation techniques such as a grape hoe. Excessive mechanical cultivation destroys soil organic matter and leads to a breakdown in soil structure.

Effective weed control under the trellis is possible with mulch and a hand or mechanical grape hoe. Hand weeding may be practical for small vineyards if perennial weeds are eliminated the year before planting. Hand weeding frequently leads to disaster if it is not done on a routine, daily basis. Effective weed control, using mechanical means, requires repeat operations that can be labour intensive, destroy organic matter, reduce water penetration and lead to trunk or root injury.

Mulches

Mulches consisting of a variety of materials can be used to control weeds and moisture. Sawdust or wood shavings can be used but avoid cedar products. Grass clippings or hay could also be used, but, these products contain seeds that may germinate. Fertilizer applications may have to compensate at a later date for the use of nitrogen by soil organisms to break down the organic matter in the mulch.

Organic materials must be at least 15 cm thick around the vine and in the area where weeds are to be controlled to be effective against annual weeds.

Control of perennial weeds should be done before planting since these are not easily controlled by organic mulches.

Chemical Weed Control

Be cautious and accurate when using herbicides. Use proper equipment maintained in good condition and calibrated accurately. Consult the section on Pesticide Application in this publication and the section on Pesticide safety.

Safe and effective chemical weed control measures are widely used. Successful chemical weed control always depends on the proper application of the correct amount of recommended herbicides. Pre emergence residual herbicides (diuron, dichlobenil, napropamide) require activation. They are most effective when applied to moist soil and followed by irrigation. In vineyards with drip irrigation systems, growers should take advantage of rainfall, applying just prior to or during rains when possible. Soil organic matter strongly influences the activity and safety of residual chemicals. Napropamide is the safest of the recommended chemicals on coarse, low organic matter soils. Dichlobenil can be used only at low rates on moderately coarse soils unless organic matter levels are sufficiently high (3%) to prevent leaching of the chemical. Diuron should be used only on heavier soils (silt, silt loam) with sufficient organic matter (>2%) or on loams and sandy loams with sufficient organic matter above 3%. Non-residual or foliar applied chemicals (glyphosate, paraquat) 8 are most effective on young, actively growing annual weeds. Perennial weeds are stage dependent for control. Weeds under moisture stress are clearly more tolerant to glyphosate.

Some weed species are tolerant of other herbicides. It is therefore useful to combine complementary herbicides to broaden the spectrum of weeds that can be controlled. The combination of a pre emergence residual herbicide with a post-emergence herbicide is useful when knock down action of a post-emergence herbicide is needed in order to place the pre-emergence herbicide on the soil. e.g. the use of glyphosate with dichlobinol, provides season-long control if applied in late spring when weed growth is at the right stage for control by glyphosate. Other pre-emergence herbicides such as diuron or napronomide also provide good control if used in this way. When using combinations of herbicides, do not exceed the rate specified for singly used herbicides. Always check the label for compatibility of a herbicide with another herbicide.

Apply all materials in water volumes recommended on the product label, using pressures not exceeding 300 kilopascals. Calibrate the weed sprayer carefully. Avoid application to vine leaves. For uniformity of application, use a boom-type sprayer. Do not use equipment that is used for regular vineyard insect or disease spraying.

Warning: Read the label instructions before handling. 2,4-D is very toxic to grape vines. Do not apply this chemical in vineyards. If 2,4-D must be used in areas close to vineyards it should be applied before grape buds reach the woolly stage.

Repeated yearly applications with residual herbicides may result in build-up of these chemicals in the soil and cause plant damage.

There is no antidote for paraquat ☠. Use extreme precautions with this herbicide as even small doses taken orally have been fatal to humans.

Do not apply herbicides to vineyards when the soil is frozen.

Prior to Planting a New Vineyard

Serious injury to grape vines can occur if the land that is to be planted to vineyard has been treated with residual herbicides such as diuron, simazine, dichlobenil or amitrole. Such land can be tested for herbicide residue the year before grapes are to be planted by growing cucumbers in a soil sample. Normal germination and growth of this indicates that the area is safe for grape growing.

Established perennial weeds such as quackgrass, orchard grass, field bindweed, etc., should be eliminated the season prior to planting. This can be accomplished by use of either glyphosate or amitrole applied at the appropriate stage of the problem vegetation followed by tillage approximately a week later. The rates of application for each chemical will depend on the vegetation present. Please consult labels for specific weeds. High rates are generally in order when attempting to obtain complete control of all vegetation present. However, excessive rates of amitrole can result in some residues in some situations. All vegetation is more easily controlled when growing actively; i.e. under good fertility and soil moisture conditions.

Young Non-Bearing Vines

FRONTIER (900 g/L dimethamid): Apply pre-emergence to weed growth. Activate with irrigation/rain within 10 days. Do not harvest within 2 years after application to newly planted or within 1 year after application to second year plants.

Established Vines

Pre-emergence for grass and broadleaf weed control (Soil applied)

CASORON 4G (4% dichlobenil): Apply to cool moist but unfrozen soil in late fall or spring before weeds emerge. Do not apply if air temperatures are 10 degrees Celsius or more. Apply to dormant vines established for at least 2 years. Use lower rates on coarse sandy soils.

DEVRINOL DF (50% napropamide): Apply in the fall through spring to unfrozen soil pre-emergence to weed growth. Activation with sufficient irrigation or rainfall (~10-15mm) is essential for good activity.

KARMEX DF (80% diuron): Apply before weeds emerge or tank mixed with GRAMOXONE after weed emergence. Use lower rates on sandy, coarse soils. Apply only to vineyards established for 3 years.

Post-Emergence for Grass and Broadleaf Weeds

Trade Name(s): AIM EC
Common Name: carfentrazone-ethyl

- Group: 14
- Registered On: Grapes
- Target Weeds: Very young broadleaf weeds
- Activity: Contact herbicide, not translocated in plant. No residual activity. Non mobile in soil.
- Use Suggestions: Alternative to other materials when rotating herbicides.
- Application: Post emergence to actively growing weeds. Less activity under dry conditions (drought or low humidity). Always add an adjuvant (e.g. Agral 90).
- Re-entry Interval: Not specified on label
- Days to Harvest: 3
- Nurseries & New Plantings: Safe on crop

Trade Name(s): CHATEAU
Common Name: flumioxazin

- Group: 14
- Registered On: Grapes
- Target Weeds: Selected grass & many broadleaf weeds. Controls common groundsel.
- Activity: Does not leach or volatilize from soil, but does breakdown with microbial activity, therefore residual control decreases under conditions of higher microbial activity (increased temperature, moisture, high organic matter etc.).
- Use Suggestions: Alternative to other residuals when rotating herbicides.
- Application: Pre-emergence. Most effective when applied to bare weed-free soil. Requires irrigation or rain to activate. Slow to degrade when soils are cold, so can be applied in the late fall for spring control. On apples protect spray boom with a hood or shield after bud break. Do not apply within a 100 meters of pears unless pears are between harvest and 2 months prior to bud break. Protect/shield the trunks of apples and pears less than one year old.
- Re-entry Interval: 12 hours
- Days to Harvest: 60
- Nurseries & New Plantings: Do not apply to vines less than 1 year old
- Do not apply to grapes established less than 2 years.
- Do not apply to grapes that are not trellised or staked unless they are free standing.
- Do not apply within 60 days of harvest.
- New plantings of "own-rooted varieties", such as *Concord*, should be planted so that all roots are a minimum of 20 cm below the soil surface to be treated. In some situations, this may require hilling soil around newly planted vines so that the settled depth of the hill will be 10-12.5 cm above the vineyard floor.

Juice, Raisin and Wine Grapes – Application Timing

- Do not apply during the period after bud-break through final harvest, unless using shielded application equipment and applicator can ensure spray drift will not come in contact with crop fruit or foliage.

UNACCEPTABLE CROP INJURY MAY OCCUR IF THIS PRODUCT COMES INTO CONTACT WITH NON-DORMANT STRUCTURES. Shielded applications during this time period should not be made with glyphosate, or products containing glyphosate.

Glyphosate products (ROUNDUP, TOUCHDOWN, CREDIT etc.): Apply as a directed spray avoiding leaves and green stems of grapevines. Repeat applications may be necessary since only emerged weeds will be controlled. Use on vines 3 years old or more.

- For annual weeds, use lower rates
- For quack grass and dandelions use higher rates
- For perennial broadleaf weeds (Canada thistle, field bindweed, etc.) use highest rates
- For spot treatments with handheld/backpack sprayers: Use 1 to 2 L/100L glyphosate products in directed application
- For more information on water volumes, rates on specific weed species, timing of application, time before harvest, removal of suckers etc. consult detailed label information included with each commercial glyphosate product

GRAMOXONE ☠ (200 g/l paraquat): Apply as a directed spray avoiding grape leaves, fruit and green bark. Use high water application volume (1100 L/ha). KARMEX or DEVRINOL, at the rates listed above, may be tank mixed with GRAMOXONE.

IGNITE (150 g/L GLUFOSINATE AMMONIUM): Apply as a directed spray to annual weeds before 30 cm. high, avoiding grape leaves, suckers and green bark.

Trade Name(s): IGNITE
Common Name: glufosinate

- Group: 10
- Registered On: Grapes.
- Target Weeds: Non-selective – affects all actively growing green plants; re-growth of perennial species may occur.
- Activity: Absorbed through foliage; minimal translocation. No residual activity.
- Use Suggestions: Alternative to glyphosate if there is low pressure from difficult to control or established perennials weeds.

IGNITE will knock back root suckers without harming vines.

- Application: Post emergence application. Avoid contact with leaves or green bark of crop, but suckers do not need to be removed. Thorough coverage of the plant tissue to be controlled is essential. Activity is influenced by environmental factors; at cool temperatures, poor moisture and low humidity speed of action may be reduced. Heavy dew at time of application may reduce control of certain weed species. Rainfast in 4 hours.
- Re-entry Interval: Not specified on label.
- Days to Harvest: 40

Table 5.7 Relative ratings for weed control with recommended herbicides in vineyards [a,b]

Weeds	Paraquat[c]	Glyphosate	Dichlobenil	Napropamide	Glufosinate	Dimethamid	Diuron
Annual broadleaved							
Buckwheat, wild	F	G	E	G	G	P	E
Chickweed, common	E	E	E	G	E	--	E
Groundsel, common	E	E	E	P	G	--	E
Lambs-quarters	E	E	E	G	E	G	E
Mallow, common	F	G	E	G	G	--	E
Nightshade, annual	E	E	E	P	E	G	E
Pigweed	E	E	E	G	E	G	E
Shepherd's-purse	E	E	E	P	G	P	E
Annual grasses							
Barnyard grass	G	E	E	E	G	E	G
Bluegrass, annual	E	E	E	E	E	--	--
Brome, downy	E	E	E	E	E	--	E
Foxtails	E	E	G	E	G	E	E
Perennial broadleaved							
Bindweed, field	P	G	G	P	G[c]	P	--
Cockle, white	F	E	E	P	G[c]	P	--
Dandelion	G	E	E	P	G[c]	P	--
Horsetail, field	P	P	G	P	P	P	--
Nightshade, climbing	P	G	G	P	P	P	P
Poison ivy	P	G	P	P	P	P	P
Vetches	P	F	G	P	G[c]	P	P
Perennial grasses							
Brome, mountain	G	G	G	P	P	P	P
Fescues	G	E	E	P	G	P	P
Quackgrass	G	E	E	P	G	P	P
Residual life (weeks)	0	0	10	8	0	8	10
Crop Safety Margin	E	E	E	E	E	E	G

a. Rate of application of the chemicals listed are those used in the preceding text: commercial names are capitalized, common names are not and may represent more than one commercial product with the same active ingredient.
b. These rates are given only to provide broad comparisons, and are subject to variations attributed to soil types, stage of vegetation at application, climatic conditions following application, different cultural practices, etc.
c. Top growth control only; regrowth can be expected.

Key: P = poor control (<50%); G = good control (90%); F = fair control (70%); E = excellent control (90 to 100%).

Invasive Alien Weeds

Invasive plants are a serious threat to British Columbia's agricultural industries and natural resources.

The Invasive Plant Council of BC defines the term "invasive plant" as any invasive alien plant species that has the potential to pose undesirable or detrimental impacts on humans, animals or ecosystems. Invasive plants have the capacity to establish quickly and easily on both disturbed and un-disturbed sites, and can cause widespread negative economic, social, and environmental impacts. Many invasive plants have been introduced to B.C. without their natural predators and pathogens that would otherwise keep their populations in check in their countries of origin.

Impacts associated with the introduction and spread of invasive plants affect all agricultural industries in B.C. These unwanted invaders can negatively impact: agriculture by reducing crop yield and quality and increasing management costs; rangelands by reducing forage quality and quantity; forestry operations by competing with seedlings for light, nutrients, and water; recreation opportunities by puncturing tires, obstructing trails, and reducing aesthetics; and water quality and quantity by increased erosion and sedimentation. They also threaten protected areas, wildlife, property values, public health and safety, and the ecological health and diversity of the province's natural environment.

Invasive species are the second largest threat to our biodiversity, after direct loss of habitat.

The B.C. Weed Control Act currently designates forty-eight plant species as noxious weeds. Currently, 21 weeds are listed as noxious weeds within all regions of the province. A further 27 are classified as noxious within the boundaries of specific regional districts. All of these species are non-native plants that create problems in agriculture and/or natural habitats. For information on identification of noxious weeds, refer to the BCMAL website at www.al.gov.bc.ca/cropprot/weedguid/

The following tables list recently introduced invasive alien plants, affecting or potentially affecting grapes in B.C. The majority of invasive plant species and about 2/3 of pests established in or threatening B.C. are species from outside North America.

Recently Established Invasive Alien Plant Species in BC

Plant	Distribution	Suspected Year of Introduction	Control Products Registered?
Puncturevine *(Tribulus terrestris)*	Predominately Penticton south into Okanagan Similkameen Valleys expanding north in valley	1970's	Yes
Leafy Spurge *(Euphorbia esula)*	North Okanagan with potential to move to South Okanagan	1970's	Yes
Rush Skeletonweed *(Chondrilla juncea)*	North Okanagan Valley with potential to move to South Okanagan	1990	Yes
Perennial Pepperweed *(Lepidium latifolium)*	West Thompson region near Walachin and Windermere Lake, East Kootenays	1992	Yes
Field Scabious *(Knautia arvensis)*	Boundary region and Thompson region	1990	Yes
Common Bugloss *(Anchusa officinale)*	Central Okanagan Valley, East Kelowna area and Rock Creek	1990	Yes
Longspine sandbur *(Cenchrus longispinus)*	South Okanagan Valley	1990's	Yes
Wild-Four O'clock *(Mirabilis nyctaginea)*	South Okanagan, Osoyoos area	1970's	Yes

5.5 Wildlife Management

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Grape growing will inevitably bring producers into contact with wildlife. Some species (birds, rodents, deer, bear, etc.) can cause serious crop losses in the absence of properly applied management practices, while other species use vineyards as habitat without causing damage. There are many options for dealing with wildlife in vineyards. A useful source of information is available through the Infobasket portal of the BC Ministry of Agriculture & Lands (BCMAL) home page. Click on the Grapes Community, then Production and Processing/ Production/Plant Health Management/ Other Pests to access a list of Internet sites with relevant information on wildlife control. Also refer to the fact sheet "*Farm Practices for Wildlife Control in the BC Interior*" posted at http://www.agf.gov.bc.ca/resmgmt/fppa/refguide/activity/870218-60_Wildlife_Damage_Interior_BC.pdf

Birds

Starlings, robins, house finches and other bird species attack grapes. The European Starling, which causes the most serious damage, resemble a blackbirds but with a stockier build, speckled appearance, yellow bill and shorter tail. Juvenile starlings are grey-brown with grey bills. Starlings are a major factor in the decline of native bird species and cause serious crop loss to small fruits such as grapes.

A combination of two or three control methods is usually better than a single method in reducing crop damage. Begin bird control efforts as soon as birds begin to attack crops. Control methods may not be very effective once birds have established a feeding pattern in a vineyard.

Permits are required to kill any birds except European Starlings, crows, magpies, House (English) Sparrows, and Rock Pigeons (domestic pigeons). Consult your local Conservation Officer (Ministry of Environment) for further information. Provincial and federal legislation protects all other migratory birds.

Scare Tactics

Stationary "scare crows" such as human figures or owl statues do not work. Flying hawk-shaped kites have more success.

Yellow plastic tapes or streamers, strung between poles above the vines, act as a visual repellent and may be effective in keeping birds out of vineyards. Twist the tapes or streamers every 3 m and attach to poles 12 m apart.

Noisemakers

Cracker or whistler shells, propane exploders and electronic Av-Alarm or Phoenix Wailer Systems are quite effective in deterring a variety of wildlife without harming them, including deer, raccoons, rabbits and birds. For maximum effectiveness, mount exploders or Av-Alarm speakers as high was possible to disperse the sound. It is usually best to alter the timing or location of these noisemakers periodically, or the pests may become accustomed to them.

Caution: Persons working within 50 m of an Av Alarm speaker should wear ear protection.

Starling Distress Calls

Recorded distress calls have proven highly effective in repelling starlings. Use a portable, automatic playback system to broadcast the distress calls. The components are a photocell, on/off switch, a duration and interval timer, and a cassette tape deck with one or more speakers.

Traps

A modified Australian crow trap can catch large numbers of starlings when supplied with appropriate bait. Trapping may significantly reduce local flocks of starlings in early summer. However, trapping may be less effective in reducing migratory flocks of starlings in late summer. Care must be taken to release any non-target bird species. For information on the Starling Control Program for the Okanagan/Similkameen and to contact a local professional trapper, visit the BC Grapegrowers Association website: http://www.grapegrowers.bc.ca/starling.shtml or contact the office 1-877-762-4652 toll free.

Nest box traps, which have been recently introduced, will trap any cavity nesting bird including bluebirds, swallows, small owls, woodpeckers and many other beneficial birds that control insect and rodent pests. It is very important to check nest box traps daily and release non-target birds. (Note that it is illegal to trap non-pest bird species. This applies to all land tenures.)

Nest removal: a less-labour intensive way of reducing the starling population is to erect nest boxes around your property, and simply remove the nest material every two weeks. Starlings will nest 2-3 times and produce as many as 15 young in a year. By repeatedly removing the material from the nest boxes you will prevent population increase. This also avoids the problem of trapping non-target species.

Netting

Netting is a very effective method of protecting grapes from birds.

Plastic netting, installed on a system of poles and wires above the vines, can provide a bird-proof enclosure. Netting is a noiseless, non-toxic and nonlethal form of bird control which requires little maintenance once installed. Make sure to choose netting with the correct gauge for birds. Too-large a gauge will trap starlings inside which attract hawks and owls which get trapped and do more damage. Ensure anti-bird nets are draped and pegged correctly so that there are no slack points and openings. Lastly, check netting regularly to ensure that non-target birds are not trapped.

For additional information, refer to the fact sheets:

- "*Netting for Bird Control in Grapes – A Decision-making Guide*" posted at http://www.al.gov.bc.ca/cropprot/grapebirdnet.pdf
- *"Installation of Bird Proof netting for Horticultural Crops* " posted at http://www.al.gov.bc.ca/resmgmt/publist/300Series/336100-1.pdf
- *"Integrated Bird Management"* focuses on blueberries but has useful information for vineyard managers, posted at http://www.al.gov.bc.ca/cropprot/birdipmplan.pdf

Other Methods

Other methods of damage reduction include the use of scarecrows and predator models, e.g. hawk shaped kites. Move such devices frequently to maintain effectiveness.

For further information on bird control methods, refer to the fact sheet "*Suppliers of Bird Control Materials and Equipment for B.C. Growers*" posted at http://www.algov.bc.ca/berries/Publications/document/suppliers.pdf

Rodents

Information on the biology, damage and control of rodents that may cause problems in vineyards is published in the booklet *"Rodent Control on Agricultural Land in British Columbia – Central and Southern Districts"* available from the Kelowna BCMAL office.

Field mice (voles) prefer a habitat with abundant ground cover. They usually establish a system of surface runways and underground tunnels. Mice begin feeding on vines when cool weather reduces their summer food supply. Vine injury can begin in late summer and continue through fall and winter.

Damage to roots is often worse than visible damage above the ground.

Cultural Control

1. Mow the cover crop and remove tall weeds and grasses to discourage mice from breeding within the vineyards.
2. Remove brush piles and other trash adjacent to vineyards to discourage mice from migrating into the vineyards.
3. Destroy all vegetation at the base of vines with herbicides or by cultivation to discourage mice from feeding on the bark. However, retain vegetation where snow cover may be inadequate to protect vines from cold temperature change.
4. Place wire or plastic mouse guards around the base of vines, especially young vines, to exclude mice. Mouse guards should extend to at least 45 cm above soil level and 5 to 10 cm below.

Rodenticides

Rodenticides may be attractive to cats, dogs or wildlife. Covered bait stations are a safer method of application than broadcasting. Bait stations will also protect the contents from moisture deterioration; disappearance of bait will indicate the presence of mice. Bait stations can be constructed from old fluming, metal or plastic pipe, or pieces of wood. Place bait stations in areas where mice are likely to be found, e.g. near vines, fences and brush piles.

1. Chlorophacinone ☠ (many trade names for 0.005% baits) is a multiple dose anticoagulant rodenticide available in pellet bait formulations. Place in bait stations or broadcast evenly at label rates.
2. Zinc phosphide ☠ (many trade names for 2% bait) is a single-dose rodenticide available in cracked corn or pellet bait formulations. Place in bait stations or broadcast evenly at label rates.

Pocket Gophers

Pocket gophers live in underground burrows and push up small mounds of excavated soil. They can cause severe damage by feeding on roots below the surface. Apply recommended baits before birth of the young in early to mid-April before alternative green host plants are available, thus making the bait more attractive. Baiting after this time may increase costs since the presence of alternative foods may decrease bait consumption affecting the level of control.

Apply 0.4% strychnine bait☠ or 2% zinc phosphide bait☠ using a hand probe, mechanical burrow builders, or bait stations.

Hand-Probes

Use a hand-probe when infestation is light or as a clean-up operation between burrow-builder treatments. Probe opposite and about 30 cm from the V-shaped indentation on the side of the mound. The probe will drop about 5 to 10 cm when the burrow has been located. Leave the probed hole open after baiting.

For information on the design and use of hand probes, refer to the fact sheet "*Design and Use of Home-Made Hand Probe*" on the BCMAL website at http://www.al.gov.bc.ca/cropprot/handprobe.pdf.

In field trials, commercially prepared 2% zinc phosphide baits in pellet, whole grain or cracked corn formulations all gave excellent control of pocket gophers.

Burrow-Builders

To build a proper burrow the soil must be damp and the Burrow Builder must be clean before using. Use a broomstick or iron bar, probe gopher runways bar to determine depth of the gopher runway. Set machine to the same depth. Make artificial runways 7 m to 10 m apart encompassing the total infested area and then cross the ends. Apply 0.4% strychnine ready-to-use (R.T.U.) bait ☠ as per label instructions.

Bait Stations

Place the recommended amount of bait deep in each opened burrow in such a manner that the bait is not visible from the surface. Close the burrow without burying or covering the bait and repeat treatment of any opened burrows after one week.

For above-ground use, place bait in a tamper resistant bait station and replenish baits as necessary. Remove and bury any dead animals because they can present a significant poisoning hazard to predatory animals. Do not place bait above ground exposed to non-target species unless it is in a tamper resistant bait station.

Traps

Use pocket gopher traps (e.g. Guardian, Victor or Woodstream) where infestations are light or in areas where poisons cannot be used. Begin trapping in the spring when gophers are most active. It is important to correctly place the tunnel traps in main tunnels. Open the tunnel using a hand trowel or other small shovel and place two traps facing in opposite directions to intercept gophers in both directions. Use wire or light chain to secure the trap to a stake to allow safe and easy removal of the carcass or trap. Make sure the opening is sealed to prevent light or air currents entering the tunnel. Check the trap once or twice daily. If no gophers are trapped after 3-4 days, relocate to another main tunnel. Always be vigilant for gophers invading from bordering properties and act promptly to prevent establishment.

Deer

Deer and elk feed on grasses, shrubs, and vines. They chew buds, spurs, shoots and leaves of all varieties of grapes. Damaged vines may never develop into commercially productive plants. Antler rubbing may break branches and remove bark.

Damage Prevention

A properly built and maintained fencing is the most effective and the only permanent long term solution to deer exclusion from vineyards. Scare devices, repellents and shootings are short term, mainly ineffective deterrents to deer problems in vineyards.

Fencing

Woven wire fences, although more expensive to construct than electric fences, provide the most reliable protection from deer damage. These fences should be at least 2.4 m high with a 15 cm wire mesh. Secure the mesh close to the ground to prevent deer from crawling underneath. Avoid using barbed wire for the top of fencing which can injure both deer and non-target wildlife. The fact sheet "*Crop Protection and Wildlife Control Fences"* is posted on the BCMAL web site at http://www.al.gov.bc.ca/resmgmt/publist/300 Series/ 307250-1.pdf.

Electrified deer fences, although cheaper to build than woven wire fences, have higher maintenance costs, and in general are less cost-effective than woven wire fences. Vertical fences are more effective than slanted designs. Electric fences should be 1.5 to 2.1 m high with 7 to 9 strands of high-tensile smooth wire at 20 to 30 cm spacing. It is important to use a high-voltage energizer with this type of fence.

For further information on electric fencing, refer to the fact sheet Crop Protection and Wildlife Control Fences - Non-Electric and Electric Fence Designs posted at http://www.al.gov.bc.ca/resmgmt/

publist/300Series/307250-1.pdf. Another useful publication, Electric Fencing Manual, is available from the Kelowna BC Ministry of Agriculture & Lands (BCMAL) office.

The brochure Protecting Orchards from Deer will help growers to estimate the benefits and costs of fencing. It is also available from the Kelowna BCMAL office. A complete listing of downloadable publications on fencing is found on the BCMAL web site http://www.al.gov.bc.ca/resmgmt/publist/Farm_Structures.htm#fencing.

Bears

Bears can be a nuisance or cause extensive crop damage. In years when their native berry hosts have low production, orchards and vineyards become a favourite target of bears in the fall. Depending on the intensity of bear attack, vineyard managers have tried many different methods to keep bears out of their orchards such as nightly patrols to scare off bears using bird flares and bangers, rubber bullets, or other scare tactics. Managers must weigh this approach against staff costs and safety. Properly constructed electric fencing is the only proven effective method for protecting vineyards from bears. Information on the construction of electric bear fencing is available from the fact sheet fact sheet "Crop Protection and Wildlife Control Fences" posted on the BCMAL web site at http://www.al.gov.bc.ca/resmgmt/publist/300Series/307250-1.pdf. Also see "Shocking Solutions to Bear Conflicts – a primer on electric fences at www.bearaware.bc.ca/electric-fencing.htm

Contact the Ministry of Environment Conservation Officer Service – Problem Animal Hotline (1-877-952-7277) for information on shooting or trapping nuisance bears.

Snakes

Snakes are not a pest but are sometimes perceived as a threat to vineyard worker safety. Snakes are actually beneficial to grape growers because they prey on mice and pocket gophers. Snakes often forage at night and hide during the day. By providing cover areas (rock piles, shrubs or plywood) well away from work areas and being aware of potential snake hiding spots, you can reduce encounters. Use a stick to probe irrigation valve boxes and lumber piles before reaching into a hidden spot. Lastly, educate vineyard workers to identify rattlesnakes and non-poisonous snakes. Snakes are protected by law. **Provincial and federal laws make it an offence to harass or kill a snake.** Snake identification posters and best management practices are available at http://www.osca.org/index.php/ecomanagement/

5.6 Urban Issues

As population increases farmers must become good communicators. Understanding and complying with local bylaws is important as well as discussions with non-farming neighbours. Explaining normal farm procedures along with reasons for the practice and giving neighbours a chance to voice concerns may eliminate or minimize many misunderstandings.

Farm Practices Protection (Right To Farm) Act

This act protects agricultural producers from legal action as a consequence of nuisance complaints surrounding agricultural operations and farming activities. Protection against such complaints depends upon the farm being operated in a 'reasonable manner or in accordance with generally accepted farm practices." The farm must be located within the ALR, and the operation must comply with other relevant local, provincial, and federal legislation relating to the farm practice being challenged. (Also see Section 9.3, Farm Practices Protection Act)

Noise

Humming tapes, cracker or whistler shells, propane exploders, Wyvern Walers (Phoenix Walers) and electronic AV alarm systems, are effective in frightening birds out of orchards or vineyards. Before deciding to use this equipment, be aware of the restrictions that may apply under municipal bylaws. Some local districts in B.C. have banned the use of noisemakers entirely.

The use of these devices may result in complaints from neighbours, particularly where farms are located adjacent to residential areas. The Municipality of Surrey, for example, has already banned the use of noisemakers, and other municipalities have placed restrictions on their use. Check the bylaws of your local municipality before using any noisemaker. To minimize noise disturbance to neighbours, adhere to the following guidelines for the use of propane exploders:

- Do not establish more than one noisemaker per two hectares of crops.
- Do not set off any noisemaker more than once every three minutes.
- Take measures to reduce the noise impact if a noisemaker is located less than 100 meters from an occupied dwelling or a place inhabited by domestic animals on an adjoining property.

  These should include directing the sound away from the dwelling and using sound buffers (such as hay bales). Do not use rotating noisemakers within 100 meters of an occupied dwelling.
- Do not use noisemakers prior to the onset of bird damage to crops (i.e., when birds are not a threat). Remove noisemakers after the harvest is complete.
- Do not use noisemakers before 6:00 a.m. or after 8:00 p.m. Pacific daylight saving time.

Pesticides

Pesticide application may concern people living or pursuing activities near farms. Most pesticide complaints are about spray drift. Others may be about improper pesticide storage, improper pesticide container disposal, or noise from sprayers.

- Abide by provincial and federal legislation when using, transporting, storing and disposing of pesticides.
- Identify areas where drift could be a concern. For example, property lines backing onto schools, care facilities, residential buildings, walkways, etc.
- Develop a drift reduction plan. Share the plan with concerned neighbours.
- Use buffer zones to prevent spray drift into sensitive areas.
- Adjust, maintain and calibrate your sprayer at least once a year.
- Apply pesticides when weather conditions minimize the possibility of drift.
- For more tips on reducing spray drift, please refer to the publication Orchard Spray Drift Management (http://www.al.gov.bc.ca/resmgmt/publist/200series/234006-2.pdf).
- Also see: Neighbour Relations and Pesticides http://www.al.gov.bc.ca/pesticides/a_8.htm Empathy by all concerned along with continued communication and valid farming activities will help minimize complaints as well as the production of local by-laws to control farming practice.