Grape Powdery Mildew

December, 2015

Grape powdery mildew 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 B.C. Interior. Popular wine grape varieties vary in susceptibility to powdery mildew.

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. 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.

Vines severely affected with powdery mildew. Photo courtesy P. Sholberg, Agriculture & Agri-Food Canada.

Severe powdery mildew on Chancellor grape cluster. Photo courtesy P. Sholberg, Agriculture & Agri-Food Canada.

Powdery mildew on Reisling grape. Photo courtesy P. Sholberg, Agriculture & Agri-Food Canada.

Early powdery mildew symptoms on Chancellor grapes. Photo courtesy P. Sholberg, Agriculture & Agri-Food Canada.

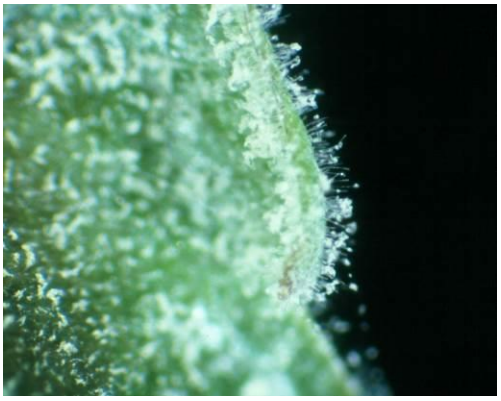
Life Cycle

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

Once primary infection has occurred the disease switches to its secondary phase. Patches of white powdery mildew develop in 7 to 10 days. These 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 1). 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.

Powdery mildew chasmothecia on grape shoot. Photo courtesy P. Sholberg, Agriculture & Agri-Food Canada.

Magnified view of a chasmothecia and ascus containing ascospores. Photo courtesy P. Sholberg, Agriculture & Agri-Food Canada.



Spore (condia) production of powdery mildew on a grape leaf. Photo courtesy P. Sholberg, Agriculture & Agri-Food Canada.

Powdery mildew infection on 'Pinot Noir' grape cane. Photo courtesy P. Sholberg, Agriculture & Agri-Food Canada.

TABLE 1. Effect of temperature on the development of grape powdery mildew

Temperature of leaf* (°C)	Days for spores to develop and 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

Disease Management

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 2);

TABLE 2. Level of resistance of grape cultivars to powdery mildew

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

Timing Fungicide Sprays:

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. Good spray coverage is important.

Apply fungicides at the following growth stages (see Table 3 for registered fungicides).

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 sulphur is used, shorten the spray interval to 7-10 days.

Contact your winery or packer 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. To prevent problematic sulphur residues it is suggested that a longer pre-harvest interval be followed than is shown on the label (see Table 3).

Disease Forecasting:

A grape 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 usually optimum for powdery mildew.

For more information on powdery mildew forecasting models, refer to the University of California website at:http://www.ipm.ucdavis.edu/DISEASE/DATABASE/grapepowderymildew.html.

Table 3. Fungicides registered for control of powdery mildew on grape

Fungicide	Chemical Group[1]	PHI[2] (days)	Notes
Kumulus DF or **Microthiol Disperss** (sulphur 80%)	M	30-wine 21-table See Notes*	Sulphur provides good powdery mildew control in both conventional and organic vineyards. Apply at 10-day intervals. Fruit and leaf "burning" may occur if sulphur is applied during slow drying conditions or when temperatures are above 27°C. Do not apply to Concord, Sheridan or Foch. *Sulphur pre-harvest interval (PHI): The legal (label) PHI for sulphur is 1 day on table grapes and 21 days on wine grapes. However we suggest using a PHI of 21 days for table grapes and 30 days for wine grapes. Excessive amounts of sulphur are detrimental to winery yeasts. For table grapes, sulphur odours may be detectable if sprayed close to harvest. Check with your winery or packer before application of sulphur within the last month.
PureSpray Green Spray Oil 13E (mineral oil)	NC	0-wine 14-table	Summer oil for suppression of powdery mildew. Apply on a 10-21 day interval. Use the shorter spray interval when disease conditions are severe. Do not apply within 14 days of sulphur or captan application. Provides protective, eradicant and antisporulant effects against grape powdery mildew. Do not apply in a spray volume of less than 1000 L water/ha (1% solution) or crop injury may result. Oil will remove the bloom on grapes, so a longer PHI is recommended for table grapes. It has been found in other areas that repeated sprays of oil can slightly reduce brix. It is suggested that the number of applications be limited to 3 per season, in early summer.
Vivando (metrafenone)	U8	14	Registered for control of powdery mildew. Not effective on botrytis . Apply at 14-21 day intervals; use shorter interval for high disease pressure or rapid growth phases. Rotate with fungicides from other chemical groups for resistance management, and do not use more than 2 times sequentially.
Quintec (quinoxyfen)	13	14	Protectant fungicide, best used before visible mildew is present. Use the higher label rate during high mildew pressure conditions. Apply on a 14 day interval. Do not exceed 5 applications/ season. Rotate with fungicides from other chemical groups for resistance management. Does not provide control of botrytis.
Flint (trifloxystrobin 50% WG)	11	14	Apply preventively using a 14-21 day interval, using the higher rate and longer interval under moderate to heavy disease pressure. Group 11 fungicides are at high risk for resistance. To help prevent the development of resistance, do not use Flint or other group 11 fungicides more than 2 times per season. Alternate with fungicides from other groups.
Sovran (kresoxim-methyl 50% WG)	11	14	Apply preventively using a 14-21 day interval, using the higher rate and longer interval under moderate to heavy disease pressure. Caution: Sovran drift may cause injury to certain cherry and Asian pear varieties. Group 11 fungicides are at high risk for resistance. To help prevent the development of resistance, do not use Sovran or other group 11 fungicides more than 2 times per season. Alternate with fungicides from other groups.
Pristine (pyraclostrobin + boscalid)	11 + 7	14	Wine grapes only. 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, do not use Pristine or other group 11 fungicides more than 2 times per season. Alternate with fungicides from other groups. Also provides suppression of botrytis.
Cantus (boscalid 70% WDG)	7	14	Registered for control of powdery mildew. May also provide suppression of bunch rot. Apply on a 10-14 day schedule. Use the shorter interval when disease pressure is high. Rotate with other fungicides for resistance management.
Sercadis (fluxapyroxad)	7	14	For powdery mildew control, begin applications as of bud break or prior to onset of disease on a 7 to 14 day interval. Also suppresses botrytis.

Fungicide	Chemical Group[1]	PHI[2] (days)	Notes
Luna Tranquility (fluopyram + pyrimethanil)	7 + 9	7	Wine grapes only. Controls both botrytis and powdery mildew. Apply preventatively at 7-14 day intervals. Rotate with other groups and do not use more than 3 times per season.
Aprovia Top (benzovindiflupyr + difenoconazole)	7 + 3	21	Begin application at bud break; apply on a 11-21 day interval. Use the shorter interval under high disease pressure. Do not apply more than 2 consecutive sprays before switching to a fungicide from a different group.
Nova (myclobutanil 40%)	3	14	Apply at 21-day intervals. Limit group 3 fungicides to 1 or 2 sprays/season for resistance management, and alternate with fungicides from other groups. Do not apply Nova with copper fungicides.
Inspire (difenoconazole)	3	7	Apply at 11-21 day intervals. Limit group 3 fungicides to 1 or 2 sprays/season for resistance management, and alternate with fungicides from other groups.
Fullback (flutriafol)	3	14	Apple at 14-21 day intervals. Limit group 3 fungicides to 1 or 2 sprays/season for resistance management, and alternate with fungicides from other groups.
Mettle (tetraconazole)	3	15	Apply at 14-21 day intervals. Limit group 3 fungicides to 1 or 2 sprays/season for resistance management, and alternate with fungicides from other groups.
Milstop (potassium bicarbonate 85%)	NC	0	Contact fungicide; considered weaker than sulphur, but may provide a good alternative for sulphur-sensitive cultivars for powdery mildew. Apply at 7-14 day intervals. Ensure complete coverage of stems and foliage. Use the high rate and shorter application interval when conditions favour the development of powdery mildew. OMRI approved for organic production.
Serenade MAX (*Bacillus subtilis)*	NC	0	Biofungicide derived from a beneficial bacterium. It is registered for suppression of powdery mildew, and will also provide some suppression of bunch rot and sour rot. Use preventatively. Do not tank mix with other products or fertilizers. OMRI approved for organic production.
Regalia Maxx (*Reynoutria sachalinensis*)	P	0	Biofungicide derived from giant knotweed. It is registered for suppression of both powdery mildew and botrytis. Mode of action is by host plant defence induction. OMRI approved for organic production. Effectiveness on grape diseases is uncertain. Suggested use pattern: preventative application in rotation or tank mix with conventional fungicides. Avoid using as a solo product during periods of high susceptibility.
Actinovate SP (*Streptomyces lydicus*)	NC	0	Biofungicide. Disease suppression only. Use preventatively on a 7-14 day interval. Use the higher label rate when conditions are favorable for disease development. Rotate with other fungicides for improved performance.
Problad Plus Fungicide (BLAD polypeptide)	NC	0	Suppression of powdery mildew and botrytis. Apply in a preventive spray schedule beginning before bloom and at 7 to 10 day intervals. Use higher rates and shorter spray intervals under moderate to high disease pressure. Rotate with other fungicides for improved performance.
Double Nickel 55 WDG or LC (*Bacillus amyloliquefaciens*)	44	0	Biofungicide. Disease suppression only. Apply in a preventative schedule beginning when new shoots are 1-3 cm long, as per label. Use higher label rates and more frequent application when when disease pressure is moderate to high. Rotate with other fungicides for improved performance.
Cueva Copper Fungicide (copper octanoate)	M1	1	Liquid formulation of copper at a low concentration that is safer to plants. Apply at the start of flowering and continue every 7 to 10 days. Do not mix with lime. Certain *V. vinifera* and French hybrid varieties may be sensitive to copper sprays resulting in marginal leaf burn.
Lime sulphur (calcium polysulphide 22%)	M	120 (apply dormant)	Dormant spray for suppression of the overwintering population of powdery mildew. Apply once per season in late fall after leaf drop or early spring before bud break to dormant vines. Good spray coverage is important. Spray to point of runoff.

[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.* NC = not classified

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

Resistance Management:

Grape powdery mildew has developed resistance or reduced sensitivity to sterol-inhibiting fungicides (Nova, Inspire) and to strobilurin fungicides (Flint, Sovran, Pristine) in other areas such as Eastern North America. Avoid over-using 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, Inspire, Sovran, Flint, Pristine) to 2 per season per chemical group. Mildew fungicides with a low risk of resistance include Kumulus, sulphur, lime sulphur, PureSpray Oil, Milstop, Regalia, Actinovate, copper, and Serenade. Other products have a medium 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.