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Grape facts
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Managing grapevine leafroll disease

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Key messages:

- **Avoid** – Do not use budwood or cuttings of unknown health status.
- **Exclude** – Plant virus-tested material from a reputable nursery.
- **Protect** – Apply dormant sprays to control overwintering mealybugs and scale insects.
- **Eradicate** – Remove all virus-infected vines.

Introduction

Grapevine leafroll disease is a major viticultural problem that can be found in every wine, juice and table grape-growing region in the world. Unfortunately, Michigan is no exception. There are several different viruses associated with this disease, all belonging to the same virus family, *Closteroviridae*. There is great diversity within this family; together they are all known as grapevine leafroll-associated viruses (GLRaV) and each discovered virus has been named with a consecutive number (see Table 1 on next page).

Vineyard surveys conducted in Michigan during 2010 and 2016 revealed the presence of viruses that cause grapevine leafroll disease. GLRaV-3 was most common, followed by GLRaV-2. This matches the pattern seen in other grape production regions, where GLRaV-3 is the most widespread grapevine virus. Although sources of grapevine leafroll disease resistance have not yet been identified, growers can make use of the management strategies presented here to reduce the impact of grapevine leafroll disease in their vineyards.

Grapevine leafroll disease symptoms

Symptoms and detrimental effects of grapevine leafroll disease vary widely with respect to grape cultivar, viruses involved and environmental stressors. However, the name given to the disease comes from the foliar symptoms observed in red-fruited European wine grapes (*Vitis vinifera*). These symptoms usually appear in older leaves and include red to purple, inward-curled (rolling) leaf blades with green main veins (Figure 1 foreground). Foliar symptoms in white-fruited cultivars are less pronounced and do not appear with reddish colors. Depending on the white grape cultivar, symptoms may show up as yellowing of the leaves (chlorosis) with green main veins and leaf rolling (Figure 1 background) or can be very atypical (Figure 2).

Marc Fuchs, Cornell University

Figure 1. Typical symptoms of grapevine leafroll disease in Pinot Noir (foreground) and Chardonnay (background) grapevines. Note the leaf curling and green coloration of main veins. Leaves turn red in the infected Pinot Noir vine whereas leaves appear chlorotic (yellowish) in the Chardonnay vine.

Timothy Miles, MSU

Figure 2. A Riesling vine that tested positive for *Grapevine leafroll-associated virus-3* and *Grapevine rupestris stem pitting-associated virus* (a widespread graft-transmissible virus). Symptom expression lacked the typical downward leaf curling and green main veins but exhibited a dramatic yellowing of the leaves. Co-infection of several viruses in the same vine are frequent.

Table 1. There are several viruses associated with grapevine leafroll disease. Each discovered virus has been named with a consecutive number. After further characterization, scientists had to discard some and rename a few species as strains, which are variants within a species. The known virus species associated with leafroll disease and their known vectors are listed below.

Virus name	Abbreviation and strains	Insect vector
Grapevine leafroll-associated virus 1	GLRaV-1	Mealybugs, soft scale insects
Grapevine leafroll-associated virus 2	GLRaV-2, including Red Globe strain	Unknown
Grapevine leafroll-associated virus 3	GLRaV-3	Mealybugs, soft scale insects, scale insects
Grapevine leafroll-associated virus 4	GLRaV-4, including strains 5, 6, 9, Pr, De and Car	Mealybugs
Grapevine leafroll-associated virus 7	GLRaV-7	Unknown
Grapevine leafroll-associated virus 13	GLRaV-13	Undetermined (possibly mealybugs and scale insects)

Prior to identification of the viruses associated with this disease, the symptoms were often blamed on inadequate cultural techniques and environmental conditions. When scouting, it is nearly impossible to diagnose a case of grapevine leafroll disease.

» Viruses cannot be seen with a hand lens and can only be observed with very powerful, expensive electron microscopes.

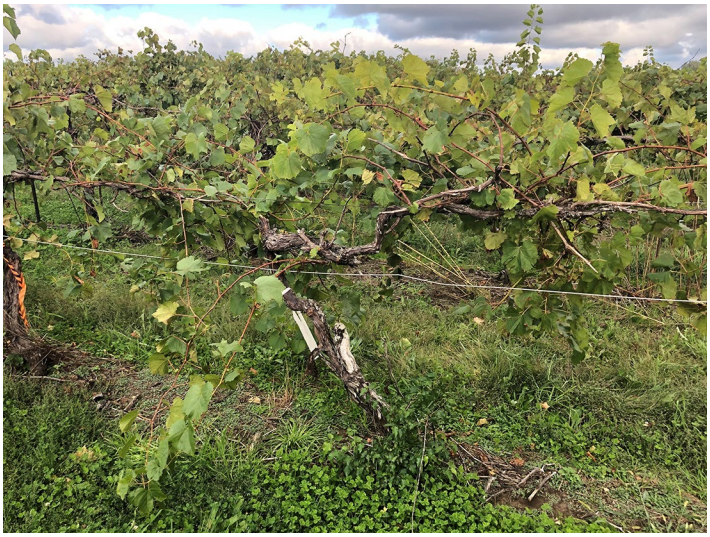
» GLRaV-infected rootstocks, juice grapes and grape hybrids do not usually display foliar symptoms (Figure 3). Seemingly healthy vines may be infected by these different viruses and serve as silent carriers of the disease.

» There are other diseases that also affect leaf appearance (other grape viruses, bacterial crown gall, root diseases, grapevine trunk disease, etc.).

» Nutrient deficiencies can also affect leaf characteristics and produce symptoms that look like grapevine leafroll disease. For example, vines deficient in phosphorus, potassium or magnesium tend to have discolored older leaves with green main veins (see Figure 4 examples).

Symptoms alone are not a reliable diagnostic feature of grapevine leafroll disease. If a leafroll virus infection is suspected, it can only be confirmed through laboratory testing. These tests target very specific components of the viral particles.

Wine grape cultivars such as Cabernet Sauvignon, Chardonnay, Merlot and Pinot Noir are highly susceptible and have been used to document the effects of grapevine leafroll disease. This research



Timothy Miles, MSU

Figure 3. Samples collected from this Vignoles hybrid grape consistently tested positive for *Grapevine leafroll-associated virus-3* and *Grapevine fleck virus* (the vector of this virus is unknown) at different dates during the 2019 growing season. The absence of visible symptoms in this cultivar emphasizes the importance of regular virus testing to assess the health status of grapevine nursery stock. Regular testing should continue in established vineyards.

Mark Longstroth, MSU and Eric Hanson, MSU

Figure 4. Some nutrient deficiencies can resemble grapevine leafroll disease symptoms. On the left, a magnesium-deficient Chardonnay vine displays yellow leaves with green veins. On the right, a potassium-deficient Concord vine with leaf-reddening and green veins. American grape varieties can carry leafroll-associated viruses and serve as point-sources of infection but do not show foliar symptoms.

shows that virus-infected vines grow less vigorously, have fewer clusters and poor fruit quality (berries with less sugar, higher titratable acidity and lower anthocyanin levels). Ultimately, the infection not only alters wine quality but leads to vine decline. In addition, graft incompatibility has also been associated with grapevine leafroll disease.

Grapevine leafroll viruses reside in the phloem portion of the vascular system, the specialized plant tissue responsible for transporting sugars throughout the plant. This internal network allows the spread of viruses from roots, trunk and cordons to the new expanding shoots. Virus infection is systemic, but the infection exhibits an uneven distribution in different parts of a single vine. As new shoots and leaves mature, these viruses interfere with the movement of sugars into the developing fruit and back to cordons, trunk and roots, disrupting the important roles that carbohydrates play in energy storage and cold acclimation.

Disease spread

The viruses associated with grapevine leafroll disease are usually introduced into vineyards through infected budwood or cutting material used for propagation, grafting or planting. Depending on the viruses involved, further spread within a vineyard is facilitated by insect movement and feeding (Figure 5). Mealybugs and scale insects spread certain leafroll viruses, specifically GLRaV-1, GLRaV-3 and GLRaV-4 (see Table 1). These insects insert their mouthpiece into the plant tissue to reach phloem sap, and if they feed on a virus-infected vine, they take in the virus as well. In the case of GLRaV-2 and -7, vectors have not yet been identified.

The speed of spread of grapevine leafroll disease in a vineyard depends on several biological and cultural factors, including the population levels of insect vectors, grafting practices and the health of newly planted material.

Regular vineyard activities can affect virus spread because these tiny insect vectors can be inadvertently moved to clean vines by machinery, people and even the wind. Effective grapevine leafroll disease management must include consideration of both insect vectors and production practices.

Disease management

Prevention

It is important to keep in mind that there is no cure for virus infection. An infected vine will carry the virus all its life and serve as a source of new infections if left in the vineyard. For that reason, the first and most important grapevine leafroll disease management strategy is prevention.

Any plant material destined for propagation, grafting or planting should be coming from virus-tested stock or certified nurseries. Please note that virus-tested does not mean virus-free, as only plant material coming straight out of clean plant centers is certified to be virus-free. Reach out to your supplier of nursery stock and ask for virus test results. Avoid using budwood or cuttings of unknown health status or from sites where grapevine leafroll disease has been detected. Remember, viruses can move from an infected scion to a healthy rootstock, and *vice versa* from infected rootstock to healthy scion.

Scout your vineyard

Familiarize yourself with grapevine leafroll disease (and look-alike) symptoms and keep track of those vines displaying abnormal growth patterns. Flag suspicious vines to check their health status and monitor disease spread.

Although not all grapevine leafroll-associated viruses are known to be spread by insects, it is highly recommended to carefully and very closely scout vines for mealybugs and scale insects or signs of their presence, such as sticky honeydew (secreted as a waste product), ants (protect mealybugs to collect honeydew) and sooty mold (fungi that grow on honeydew). These insect vectors are very small and seek shelter under the bark of trunk and cordons (see Figure 5).

Virus testing

Virus testing should be done not only when disease is suspected but also when the health status of a vineyard is unknown or routinely as part of the vineyard management budget.

The number of samples to test will depend on the purpose for testing (i.e., diagnosis or screening).

» When disease is suspected, samples are taken directly from the symptomatic vines.

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Figure 5. Mealybug monitoring and control can restrict virus spread. During scouting activities, bark sections of trunks and cordons must be stripped off to expose insects. This photo shows mealybugs feeding on a grape trunk; note the different stages of development as well as honeydew droplets excreted by these insects.

» When testing is part of an integrated disease management plan, the recommendation is to create a composite sample from five vines for every 1,000 vines in a vineyard block. Before you collect samples, make sure to check with the testing laboratories for specific sampling guidelines and testing fees.

When foliar symptoms are evident, ruling out other conditions first can be very helpful at reducing testing and management cost.

» Carefully inspect trunk and cordons for galls and cankers. During pruning activities, examine the wood for discolorations. Crown gall and trunk diseases also induce leaf color changes.

» Have tissue tested for nutritional disorders.

There are several out-of-state commercial laboratories that offer comprehensive virus testing services, which can be very useful if the material under evaluation will be used for propagation. When working with a laboratory, results should include either serological (e.g., ELISA) or molecular methods of detection (e.g., PCR). In Michigan, MSU Plant & Pest Diagnostics can test tissue from symptomatic vines for some of the most common grapevine leafroll infections, which include GLRaV-1, -2 and -3. Visit their website at www.pestid.msu.edu for a more complete list of services.

Eradication

A test result that confirms the presence of a leafroll virus in a submitted sample can leave growers with a head full of questions. Before you give up on your vineyard block, consider the following questions when making a final decision:

» How widespread is the disease?

» What viruses are involved?

» Are virus vectors in the vineyard?

Rogueing of infected vines is an expensive and difficult task, as living roots that remain in the soil can still harbor pathogens and pests. Recommended practices to minimize these point-sources of infection include the careful application of an herbicide to kill the grapevine prior to removal, followed by fallow periods.

Chemical control

Viruses cannot be controlled by applying pesticides. However, in cases where an insect vector is involved, chemical control can be used to control insect populations. Delayed dormant sprays of oil or insecticides can reduce overwintering mealybugs and scale insects. Later in the season, insecticide applications targeting mealybugs should ensure spray penetration into the canopy and bark crevices. Systemic insecticides are more likely to be effective against insects in these difficult-to-reach locations.

Scales and mealybugs both have mobile crawler stages in their annual life cycles, and these can be targeted with contact insecticides to prevent their establishment on the canopy. For up-to-date recommendations on insecticides, consult your local MSU Extension educator and the E0154 Fruit Pest Management Guide published by MSU Extension.

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