GRAPES

Cornell University

Integrated Pest Management

Grape leafroll disease

Grapevine leafroll-associated viruses

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Introduction

Leafroll is one of the most important virus diseases of grapevine. It occurs in every major grape-growing region of the world. Grapevine leafroll disease can affect all native and *Vitis vinifera* cultivars, hybrids, and rootstocks, although symptoms are not always expressed on infected vines. The disease was described as early as the 19th century in Europe, but its graft-transmissibility was not demonstrated until 1937. In 1979, a specific type of flexuous and filamentous virus was reported in a leafroll-affected vine. Shortly thereafter, in 1983, the capacity of mealybugs to transmit one of the viruses associated with this disease was shown.

Symptoms and impact

Leafroll-affected vines are less vigorous than healthy vines. Foliar symptoms on older leaves usually become visible in late summer and fall. Symptoms are usually most conspicuous in red-fruited cultivars of *Vitis vinifera,* with reddening of leaves in addition to cupping (Figure 1A, B) and primary leaf veins remaining green (Figure 1C). In white-fruited *V. vinifera* cultivars, symptoms are less pronounced, consisting of slight chlorosis and cupping (Figure 1D). Infected native cultivars, hybrids, and rootstocks usually remain symptomless but can contribute to virus spread by vectors.

Leafroll disease causes significant yield losses and delays fruit ripening (Figures 1E, F). Reduced soluble solids and increased titratable acidity are also often reported. Without any control measures, the estimated economic impact of leafroll disease in *V. vinifera* cv. Cabernet franc in New York can range from approximately $25,000 per hectare (for a 30% yield reduction and no grape quality penalty) to $40,000 per hectare (for a 50% yield reduction and a 10% penalty for poor fruit quality).

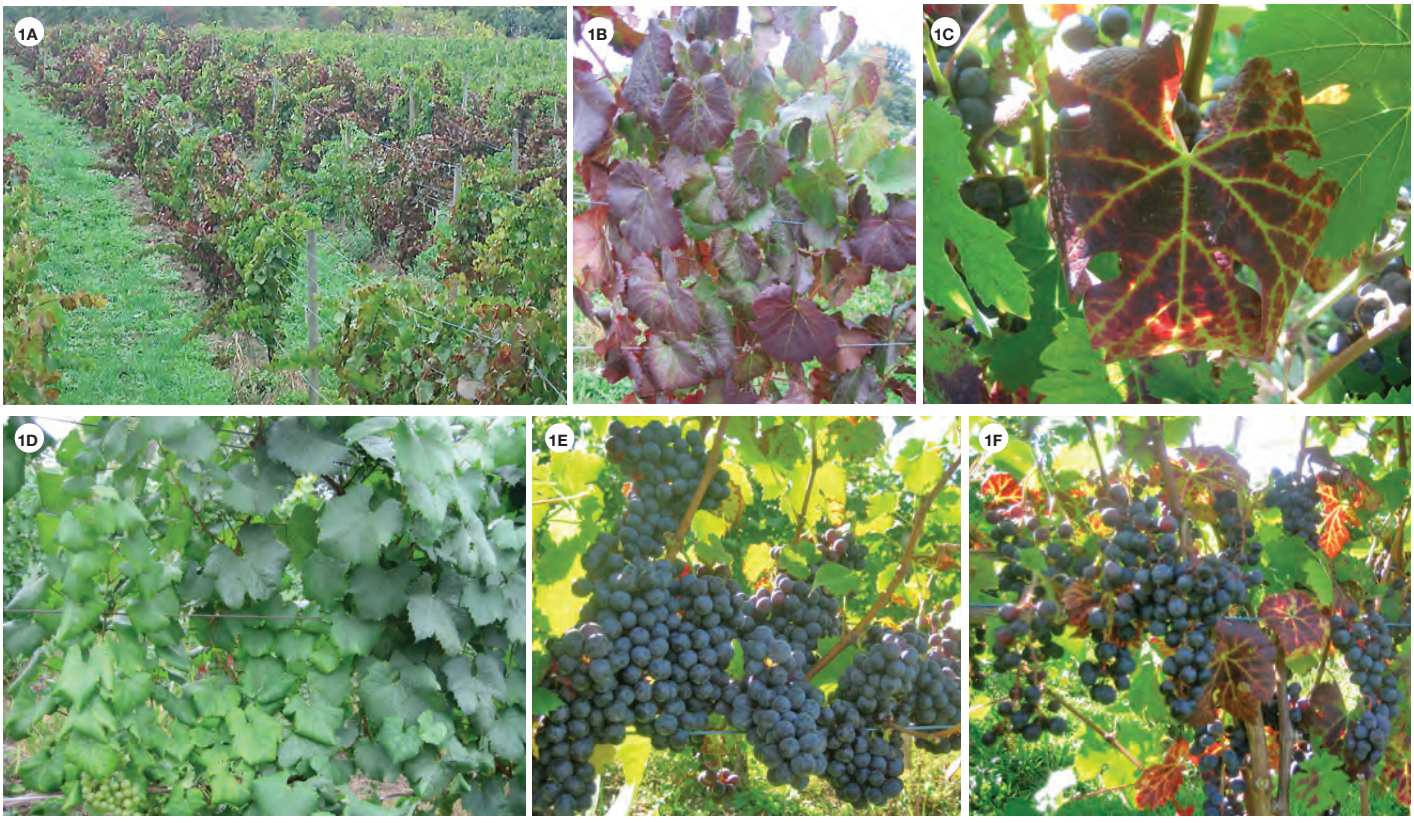

Figure 1. (A) High incidence of leafroll disease in a *Vitis vinifera* cv. Lemberger vineyard with conspicuous leaf reddening; (B) Close-ups of Lemberger and (C) Cabernet franc leaves with cupping and reddening while main veins remain green; (D) Leafroll symptoms (small, cupped, light green leaves) on a Chardonnay vine (left) compared to a healthy vine (right); and (E) Fruit yield and quality of a healthy and (F) leafroll-affected *Vitis vinifera* cv. Cabernet franc. Photos by Marc Fuchs.

Lower vigor associated with virus infection increases vine susceptibility to adverse environmental factors, such as cold winter temperatures, resulting in a higher level of mortality in virus-infected vines. Consequently, the cost of vineyard maintenance increases due to more frequent vine replacements.

Causal agents

To date, five distinct filamentous viruses (Figure 2) identified as Grapevine leafroll-associated viruses (GLRaVs) have been isolated and characterized from leafroll-affected grapevines. They include GLRaV-1, -2, -3, -4, and -7. These viruses are serologically unrelated and their particle length ranges from 1,400 to 2,200 nanometers. Other than *Vitis* species, no wild or cultivated plant species are known to serve as alternate hosts for leafroll-associated viruses.

Most of these viruses can be detected by indexing samples from suspect vines through wood or green grafting onto indicator vines of *V. vinifera* cv. Pinot noir, cv. Cabernet franc or cv. Gamay. Lab assays such as antiserum-based ELISA or nucleic acid-based RT-PCR can also be used to detect GLRaVs in grapevine tissue. These assays are faster and more reliable than indexing to diagnose leafroll viruses.

Among the five viruses associated with leafroll disease, GLRaV-1, GLRaV-2, and GLRaV-3 usually prevail in leafroll-affected grapevines. Additionally, GLRaV-2 also incites severe graft-incompatibility syndrome and a decline of scions grafted on certain rootstocks, including Kober 5BB, 3309C, 5C, 1103P, Harmony and Freedom.

Figure 2. Electron micrograph of a GLRaV particle isolated from a leafroll-diseased vine. Note scale bar for particle size (1 nanometer - nm - equals 1/1,000,000 millimeter). Photo by Marc Fuchs.

Conditions for infection

The most efficient means of spreading leafroll-associated viruses is through vegetative propagation and grafting. GLRaVs can be moved across long distances in planting and propagation materials. In addition, insect vectors in two homopteran insect families (mealybugs, *Pseudococcidae*, and soft scales, *Coccidae*) can also transmit GLRaV-1, GLRaV-3, and GLRaV-4. Mealybugs and soft scales feed on a wide range of host plants and can be serious pests of woody plants, including *Vitis*. Most species overwinter as eggs and young instar nymphs beneath the bark of the trunk. Only a few species can overwinter underground on the roots. Females are wingless but can exhibit limited mobility, while adult males, which lack mouthparts, and hence, cannot feed and transmit the viruses, are winged. Because of their small size, crawlers and adults can be readily wind-blown.

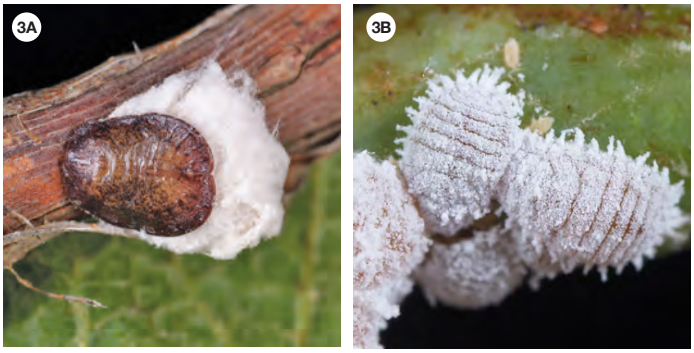

Figure 3. (A) A soft scale female with white egg sac collected in a vineyard near Seneca Lake, and (B) Mealybugs, potential vector of GLRaVs. Photos by Joe Ogrodnick.

Several vectors are known from New York and other states in the eastern US: brown apricot scale *(Parthenolecanium corni), grapevine scale (P. persicae), woolly vine scale (Pulvinaria vitis), cottony maple scale (Neopulvinaria innumerabilis),* and grape mealybug *(Pseudococcus maritimus).* Another pest of grapes and a known vector of GLRaV, vine mealybug *(Planococcus ficus),* has not been reported from the eastern US but is a potential invader. A census of mealybugs and soft scale insects in New York vineyards suggests that populations tend to be low, except in a few isolated cases where outbreaks have occurred.

Management

To manage grapevine leafroll disease and secure a healthy and high quality crop, ensure that the planting material originates from virus-tested, clean vine stocks. The importance of establishing new blocks with clean planting material and selecting clean replants cannot be over-emphasized because there is no cure for infected vines in the vineyard.

Routine scouting for diseased vines and roguing - the elimination of infected vines - can reduce the economic impact of leafroll disease ($3,000 to $23,000 per hectare) when disease prevalence is moderate (1% to 25%). With disease prevalence levels greater than 25%, replacing the entire vineyard is justified economically.

In foundation blocks and nurseries, the use of virus-tested material followed by regular and routine monitoring for disease symptoms, causal viruses, and insect vectors is paramount for providinwg planting material of high phytosanitary standards. Stocks in foundation and increase blocks should be tested regularly for GLRaVs and such blocks should be isolated from commercial vineyards to avoid further infection through vector transmission. Appropriate insecticides should also be applied in nurseries and increase blocks to eliminate the vector threat.

No sources of resistance against any of the GLRaVs have been identified in wild or cultivated grapes. Therefore, conventional breeding is not a viable option to develop GLRaV-resistant material. Research is ongoing to develop resistant material through genetic engineering.

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