

# Grapevine leafroll-associated viruses

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## Summary

Leafroll is a serious disease of grapevines that is of major importance to viticulture world-wide. It is named for the distinct foliar symptoms that can be observed on sensitive grapevine varieties from late summer and through autumn. The disease is associated with all species of Grapevine leafroll associated viruses (GLRaV). Many grapevine cultivars affected by leafroll disease can have reduced quality and yield of fruit and/or reduced quality and production of wood for propagation. The disease and infection by GLRaVs can also be associated with graft incompatibilities. Symptomless infections can occur and these infected grapevines may act as a reservoir of virus for other sensitive varieties.

## Symptoms

### Foliage

Leafroll symptoms include downward rolling of leaves and reddening (red varieties; Figure 1, 3-6) or yellowing (white varieties, Figure 2) of the leaf tissue between the main veins. The discolouration may be less obvious in white varieties. The main veins may remain green, although in some varieties the discolouration affects all of the leaf tissue.



Figure 1: Reddening and downward rolling of leaves on the variety Marzemino infected with GLRaV-1.

### Vine growth

Leafroll-affected grapevines may have reduced growth resulting in smaller canopies. This may also result in a reduction in cane pruning weight associated with a reduction in the circumference and/or the length of the canes. This will affect the quality of wood collected for propagation. Leafroll disease may result in a decline of grapevines over time and reduce the lifespan of affected vineyards.



Figure 2: Yellowing, green veins and downward rolling of leaves from the variety Pinot Gris infected with GLRaV-1.



Figure 3: Reddening, green veins and downward rolling of leaves on the variety Pinot Noir infected with GLRaV-1 and GLRaV-4 strain 9.

### Fruit

Effects on fruit quality can include reduced colour in red varieties, reduced aromas, reduced sugars and increases in titratable acidity. The ripening of fruit may be delayed, which is significant for grapevines grown in climates where fruit maturity can be delayed due to lower temperatures and a shorter growing season. In a few GLRaV infected cultivars early ripening has occasionally been observed. Up to 50% yield losses have been reported.

### Graft compatibility

Graft incompatibilities associated with leafroll disease and infection by GRLaVs, particularly GLRaV-2, can result in decline and death of the grafted scion.

### Varietal susceptibility

Differences in symptom severity are observed between varieties and may be attributed to variation in susceptibility, resistance and tolerance to GLRaV infection. *Vitis vinifera* varieties and clones are often more susceptible than other *Vitis* species and hybrids, including rootstocks, which can remain symptomless.

Differences in symptom severity may also be associated with a specific GLRaV species and strain variation within a GLRaV species. Leafroll disease expression may be affected by environmental factors, such as temperature. After an infection event it can take more than 12 months for grapevines to display leafroll symptoms associated with GLRaV.

## Biology

### Grapevine leafroll virus species found world-wide

GLRaVs are differentiated into different genera of the family *Closteroviridae* based on molecular characteristics and biology, such as insect vector transmission. The genus *Ampleovirus* includes three recognised species, (GLRaV-1,-3, and -4). GLRaV-7 is a tentative member of the proposed *Velarivirus*. For each distinct GLRaV species there are often many strains. The previously reported *Ampleovirus* species GLRaV -5, -6, -9, -De,-Pr, and -Car are now recognised as strains of GLRaV-4, based on biological and genetic similarities.

GLRaV-1, -2, -3, -4, -5 and -9 are known to occur in Australia. In a survey of 218 grapevines from grape growing districts of mainland Australia (NSW, SA, QLD, WA and VIC), GLRaV-1, -3, and -4 were more frequently detected (13-22%) than GLRaV-2 (6%). Mixed infections of more than one GLRaV and also with other grapevine virus species can occur.

### Transmission

GLRaVs are phloem restricted. They are not known to be mechanically transmitted on pruning equipment or harvesters, nor are they known to be transmitted by touch. Seed transmission has not been reported.

All GLRaV species are transmitted through vegetative propagation and grafting. Graft transmission can occur from rootstock to scion and vice versa.

Field spread of leafroll disease associated with GLRaV-1, -3, and -4 has been observed in Australia. GLRaV-1, -3, and -4 can be transmitted by mealybugs and some are also transmitted by scale insects. Some of the vectors



**Figure 4:** Reddening and subtle rolling of leaves symptoms on the sensitive indicator Cabernet Franc inoculated with GLRaV-2 from the variety Chardonnay Pen 58. Symptoms were observed in autumn 2008 at Loxton. Note the variation in symptom severity between leaves and vines.

are common in Australian vineyards and include long soft scale (*Coccus longulus*), citrophilous mealybug (*Pseudococcus calceolariae*), longtailed mealybug (*P. longispinus*, Figure 7), obscure mealybug (*P. viburni*) Grapevine scale (*Parthenolecanium persicae*, Figure 8, 9), Nigra scale (*Parasaissetia nigra*), and a *Saissetia* sp. (black scale).

Field spread of GLRaV-2, and -7 has not been reported and a vector is unknown.



**Figure 5:** Reddening and rolling of leaves symptoms on the sensitive indicator Cabernet Franc inoculated with GLRaV-3 from the variety Graciano WA6V6. Symptoms were observed in autumn 2008 at the Yarra Valley.



**Figure 6:** Reddening and subtle rolling of leaves symptoms on the sensitive indicator Cabernet Franc inoculated with GLRaV-1 from the variety Shiraz RVC14. Symptoms were observed in autumn 2008 at the Yarra Valley.

### Virus movement within a grapevine and disease development

Virus concentration (titre) may be low and distribution can be uneven in grapevines at certain times of the year, particularly in the first season after an infection event. It can take more than 12 months for viruses to move from the point of infection to shoots and cordons of the grapevine. This can have important implications for virus detection and disease expression.

### Alternative hosts

No naturally occurring alternative hosts have been reported for any GLRaV species.

### Disease management

Certification schemes have been established in Australia that aim to reduce the risk of spread of serious grapevine diseases by providing industry with high-quality, pathogen-tested planting material. High-health grapevine material is routinely screened for the presence of virus-associated diseases through visual inspection and active diagnostic testing for viruses. These schemes contribute to the improved productivity and sustainability of the viticulture industry and the use of high-health material is encouraged for vineyard establishment and vine replacement.

Field spread of leafroll disease occurs in Australia and vineyards should be routinely monitored for the presence of leafroll disease. If the disease is suspected, diagnostic testing can be done to confirm the presence of GLRaVs. Removal of infected vines may reduce the risk of virus spread in a vineyard. Vineyards should also



**Figure 7:** Longtailed mealybug *Pseudococcus longispinus* (Targioni Tozzetti) (David Cappaert, Michigan State University, Bugwood.org).

be monitored and treated for mealybug and scale that may transmit GLRaVs and other viruses.

Because grapevines may be symptomless, active virus testing of grapevines is recommended prior to top working to a new variety. If the new variety has not been obtained from an accredited certification scheme then it is recommended that it also be actively tested for virus. Symptomless infected grapevines may act as a reservoir of virus for other sensitive varieties.

Other factors such as magnesium and phosphorous deficiencies may induce symptoms similar to leafroll disease and result in a misdiagnosis of disease. Consequently, visual inspection alone cannot be relied upon for disease diagnosis and pathogen detection.



**Figure 8:** Immature grapevine scales on a dormant cane during winter (A. Rakimov © Department Primary Industries, Victoria).

Active diagnostic testing is required to confirm the presence of viruses.

A few studies suggest that there may be benefits from virus infection in grapevines, infection being associated with more desirable characteristics in the table grape cultivars Crimson seedless and Emperor such as improved colour, crispness and berry weight.



**Figure 9:** Mature female grapevine scales on a dormant cane (A. Rakimov, © Department Primary Industries, Victoria).

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