The Australian Wine Research Institute

Fact Sheet
VITICULTURE

Grapevine leafroll-associated virus 3

Figure 1. Symptoms of GLRaV-3 on red grapevine varieties

Introduction

Grapevine leafroll disease is one of the most widespread and economically damaging viral diseases of grapevines in the world. The disease is associated with up to twelve different virus species and strains known collectively as grapevine leafroll associated viruses (GLRaV). This factsheet focuses on GLRaV-3, one of the most severe of the leafroll viruses. Once established in a vineyard, GLRaV-3 spreads rapidly and takes years to eradicate. Many grapevines affected with GLRaV-3 have reduced yields, delayed or variable ripening and produce lower quality wine. GLRaV-3 infection can also reduce the quality of wood for propagation. Some GLRaV-3 infected vines may remain symptomless, acting as reservoirs for virus spread. Up to 10 sequence variants of GLRaV-3 with various symptom intensity have been identified. A mild variant of the virus, isolated from *Vitis vinifera* L. cv Crimson Seedless in Western Australia, has lost its ability to spread naturally.

Symptoms

Foliage

Expression of GLRaV-3 symptoms is influenced by grapevine cultivar, rootstock-scion combinations, virus combinations and environmental factors. In red varieties, symptomatic vines develop interveinal red or reddish-purple patches on mature leaves around veraison. Symptoms become more evident as the season progresses. By late autumn, the entire interveinal area of infected leaves turns reddish-purple, and the veins bright green. In severely infected vines, the entire canopy can turn red by the end of the season (Figures 1 and 2). Varieties such as Pinot Noir, Cabernet Franc and

Chardonnay show pronounced downward rolling of leaf margins while other varieties do not. In red varieties, other stresses such as magnesium or potassium deficiency or damage from machinery, pests, wind or girdling can cause discolorations that resemble leafroll symptoms (Figure 3). In white varieties, GLRaV-3 symptoms are far less distinct, ranging from none (latent) to mild interveinal yellowing with green veins. As with red varieties, foliar symptoms become more evident as the season progresses. In both red and white varieties, the leaf margins of symptomatic leaves start rolling downwards towards late autumn. In cases where symptom identification is uncertain, molecular testing can be used to identify GLRaV-3 infected vines.

Figure 2. Typical GLRaV-3 symptoms on a red variety, showing interveinal reddening, bright green veins and backward rolling of leaf margins

Figure 3. Symptoms of a physiological disorder on a Cabernet Sauvignon vine can be similar to GLRaV-3 symptoms

Fruit

Compared to healthy vines, GLRaV-3 infected vines have smaller bunches and berries, with yield losses between 14 and 40% reported (Naidu et. al. 2014). The magnitude of yield losses depends on cultivar-rootstock combinations, vine age, virus infection combinations, and environmental conditions. Berries from infected vines have reduced sugar, aroma and colour and increased titratable acidity compared to berries from healthy vines. Symptom severity increases over time, with ripening increasingly delayed each year, and yields lower. Asynchronised ripening of healthy and infected bunches reduces fruit quality over time, particularly in machine-picked blocks.

Vine growth

GLRaV-3 infection can reduce plant vigour, longevity and propagation wood quality. These effects are more pronounced in grafted vines. Affected plants show a low rate of grafting success.

Varietal susceptibility

European grapevine cultivars (*Vitis vinifera*) and an Asian *Vitis* species (*V. coignetiae*) exhibit GLRaV-3 symptoms, while rootstocks are asymptomatic hosts.

Biology/classification

GLRaV-3 is one of the twelve different virus species and strains belonging to the genus *Ampelovirus*, family Closteroviridae, which are associated with grapevine leafroll disease. *Ampelovirus* consists of two subgroups. Subgroup I has two species, GLRaV-1 and GLRaV-3, which are associated with severe leafroll disease. Subgroup II has one species, GLRaV-4, with up to 10 strains, which produce mild symptoms and may not affect vine yield and quality. GLRaV-2 and GLRaV-7 have their own genus.

Vineyard spread of GLRaV-3

Grapevine leafroll associated viruses can be transmitted through vegetative propagation and grafting or via sap-sucking vectors including mealybugs and scale. They are not transmitted by mechanical equipment or pruning.

Primary spread of GLRaV-3 occurs when it is introduced into a newly planted vineyard via virus-infected planting material or from vectors carrying the virus in from another vineyard. Vectors can be introduced into a vineyard via wind, ants, birds, machinery or vineyard workers' clothing and equipment. Primary spread usually results in the random distribution of virus infections within a vineyard.

Secondary spread occurs when vectors move the virus from the primary source of infection to other vines within the vineyard. Vectors generally move along the rows from one vine to the next, spreading the virus in a clustered pattern. The rate of secondary spread is correlated with vector abundance.

Vectors

Several species of mealybugs (Pseudococcidae) and scale (Coccidae) have been identified as vectors for GLRaV-1, -3, and -4, while there are no known insect vectors for GLRaV-2 and -7. There is no evidence of GLRaV transmission by aphids.

In Australia, three mealybug species, all effective GLRaV-3 vectors, are frequently found in the vineyards: *Pseudococcus calceolariae* (citrophilus mealybug), *Ps. longispinus* (long-tailed mealybug) and *Ps. viburni* (obscure mealybug). Mealybug nymphs overwinter under vine bark and in crevices (Figure 4a), and in the case of the citrophilus mealybug, in the rootzone below ground. In spring, they move out onto vines. Female mealybugs lay a large number of eggs, which quickly hatch into crawlers (first instar nymphs). The nymphs are highly mobile and effective GLRaV-3 vectors. Mealybugs can have three to four generations per year. When conditions are favourable (25°C and humid) mealybug populations increase rapidly. Mealybugs can survive on remnant vine roots and spread GLRaV-3 to newly established vineyards, even after a four-year fallow period.

Parthenolecanium persicae is the most common species of scale found in Australian vineyards (Figure 4b). This species is capable of spreading GLRaV-3 and grapevine virus A simultaneously. Scale insects have one generation per year. Second or third instar nymphs overwinter under vine bark and in crevices. They emerge in spring and begin to grow rapidly. The female lays between 100 and 2,000 eggs depending on the species. The crawlers (first instar nymphs) emerge in late October (mid-spring). Crawlers are highly mobile and effective GLRaV-3 vectors.

*Figure 4a (left). A cluster of obscure mealybugs (*Pseudococcus viburni*) under the bark of a Shiraz cane. Figure 4b (right). Grapevine scale (*Parthenolecanium. persicae*) on a Shiraz cane. Crawlers are visible on the top of the shell as small white dots.*

Management strategy for leafroll disease

Management of the spread of GLRaV-3 in vineyards requires roguing of GLRaV-3 infected vines, control of insect vectors and planting virus-tested propagating material. This integrated approach has been used effectively in vineyards in South Africa, New Zealand and California (Bell et al. 2021). In these countries, the recommendation is to completely remove vineyards if infection rates reach 20% (Bell et al. 2020). Beyond 20% infection, it becomes economically unfeasible to rogue symptomatic vines. Depending on the region, in Australia most growers still find vineyards with 20% infection to provide an economical return. In the Riverland region of South Australia, a Shiraz vineyard on Ramsey rootstock established in 1994 shows over 50% GLRaV-3 infection but it is still producing 11 tonnes per hectare. This might either be due to the presence of a milder strain of GLRaV-3 or to the vigorous growth occurring on Ramsey in a hot climate with sufficient irrigation.

1. Monitoring and testing

The process for identifying GLRaV-3 vines differs for red and white varieties. In white varieties, visual identification of GLRaV-3 vines is difficult and suspected GLRaV-3-infected vineyards should be screened before winter using composite vine sampling and molecular testing. In red varieties, visual symptoms are sufficient to identify GLRaV-3-infected vines. In white varieties molecular diagnostics should be conducted each year since GLRaV-3 symptoms in these varieties are difficult to identify visually.

Mapping the pattern of spread of GLRaV-3 can help to identify the source of the virus, and the direction and speed of the spread. Remote sensing technology can speed up the mapping process; however, 'ground-truthing' the data is important.

2. Roguing of infected vines

Once identified, GLRaV-3 positive vines should be removed immediately, making sure that all remnant roots down to 30 cm are completely removed. The vines on either side of the rogued vine should be monitored closely before harvest each year to detect and remove new infections. Treating infected vines with herbicide prior to roguing does not reduce virus spread (as shown in New Zealand).

3. Vector control

It is very difficult, if not impossible, to entirely eradicate mealybugs and scale from vineyards due to their cryptic nature and protective coatings/shells. Predators such as lacewings, lady beetles, parasitic wasps and mites provide good biological control, while the use of pheromones for mating disruption has also proven effective. Opening up the vine canopy may provide some level of control by creating a less favourable environment for the vectors and by improving spray penetration if chemical control is required. Various chemical control options are registered for mealybug and/or scale control in Australia. It is important to get the spray coverage and timing right with most of the chemicals available.

References and further reading

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Rootstock remnants, viruses and re-planting challenges (AWRI webinar 29 October 2020)

Scale – factors influencing their prevalence and control (AWRI fact sheet)

Virus elimination (AWRI fact sheet)

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