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Grapevine Leafroll – an Increasing Problem in the Finger Lakes, the US and the World

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Summary: *Out of 95 hybrid and V. vinifera blocks surveyed in the Finger Lakes in 2006 and 2007, 63 (that's two-thirds) had at least some grapevine leafroll-associated virus (GLRaV)-infected vines, with a third having high levels (>20% of samples) of infection. At harvest, reds with visible leafroll symptoms had brix levels from 1 - 4 degrees lower than adjacent, uninfected vines in the same blocks. Although grape mealybugs and soft scales– which transmit the virus from plant to plant – are present in low levels in many vineyards, the primary mode of spread is through infected propagation wood. Infected vines cannot be cured. The only way to eliminate the virus is to replace the vines with clean planting stock, certified to be free of viruses. Efforts are now underway to enhance availability and use of certified vines nationwide through the National Clean Plant Network, with funds appropriated under the Federal farm bill.*

Figure 1. Leafroll on red varieties. Red leaves with green veins are characteristic symptoms of infection.

Introduction. At the recent 2008 National Viticulture Research Conference, held in Davis, California, no fewer than 10 presentations addressed increasing problems with viral grapevine diseases. Over half concerned the complex of 10 viruses that are associated with grapevine leafroll disease. These presentations were based on studies in Napa Valley, Washington State, Missouri, and our survey from here in New York.

This (and other) viruses have been around for a long time – so why are researchers so concerned about the threat they pose? There are several reasons: 1) GLRaV delays maturity, lowers yield, and affects wine quality. 2) Infection is permanent. 3) New insect vectors and replacement of AXR1 by other rootstocks in California have led to the realization that GLRaV can spread more rapidly than previously thought possible (more on that later).

The prospect of having premium vineyards permanently compromised – and having your neighbor's 'dirty' vineyard affecting your adjacent (presumably better-managed) vineyards – has raised the stakes for growers. It's prompting a renewed emphasis on grapevine certification and the importance of planting virus-free stock throughout the world.

In this article, we'll describe why this is a problem worldwide, what we've found out about its prevalence in the Finger Lakes, how it impacts fruit quality, yield, and profitability, and why planting vines tested and certified to be free of the virus is by far the most practical way to reduce its impact.

Grapevine Leafroll Virus Biology. Briefly, the 10 grapevine leafroll-associated viruses (GLRaVs) are a group of viruses that cause similar symptoms in infected grapevines. They colonize and reproduce in the grapevine phloem tissue, which disrupts the flow of nutrients to shoots, leaves, and fruit pedicels. This disruption in vascular tissue stunts vines, reduces vigor, and impedes accumulation of sugars and other metabolites in the fruit. Infected vines often have fewer clusters, lower yield (up to 30-50%), and delayed fruit ripening. Red wines produced from GLRaV-infected vines have less color and lower levels of anthocyanin pigments. Red cultivars develop characteristic red leaves with green veins, starting at the base of the shoot (Figure 1), while white cultivars such as Chardonnay often exhibit leaf rolling and a yellowish color by late in the season (Figure 2). Leafroll is not limited to *V. vinifera* grapes, but also affects hybrids, rootstocks, and native grapes (Concords in NY often test positive for GLRaVs while showing no symptoms).

Figure 2. Leafroll on white varieties. Note cupped leaves and yellowish color.

Transmission. All viruses (denoted as GLRaV- followed by a number) are spread through infected budwood cuttings and graft unions (they are graft-transmissable). Until the mid 1980s, it was thought that this was the only means by which GLRaV was spread. European researchers, however, identified mealybugs and soft scale insects as vectors capable of spreading the infections to clean vines. Subsequent work in California in the early 90s revealed that 3 species of mealybugs (grape mealybug, obscure mealybug, and longtailed mealybug) were also capable of transmitting the virus – and the Foundation Plant Services found leafroll spreading to clean vines in their certified vineyard blocks at UC Davis.

(More complete information on leafroll biology and vectors is contained in the IPM Grape Disease Fact Sheet, posted at: http://www.nysipm.cornell.edu/factsheets/grapes/diseases/grape_leafroll.pdf)

California Situation. Several new developments in California have prompted increased concern about the potential for rapid spread of leafroll viruses in vineyards. First, a new mealybug species (vine mealybug) appeared in California in the '90s. It has fewer natural enemies, reproduces faster, and disperses farther than existing mealybugs. This means that the potential rate of spread of leafroll to clean vines is greater than previously thought possible.

Second, many vineyards planted on the AXR1 rootstock in Northern California were replaced by vines grafted to other rootstocks when phylloxera devastated AXR1-grafted vines in the late 1980s. AXR1 – a vigorous rootstock – apparently masked symptoms in GLRaV-infected scion wood. When this budwood was grafted to other rootstocks, the apparently 'clean' budwood all of a sudden exhibited leafroll symptoms. The older vineyards on AXR1 weren't as clean as growers had thought.

A study in Napa valley from 2002-2008 documented rapid spread of GLRaV from a 'dirty' vineyard planted in 1970 across a dirt road to a 'clean' vineyard planted with certified vines. In five years, the percentage of infected vines increased from 5% to over 60%.

Similarly, studies in New Zealand, South Africa, and Australia have documented rapid spread by mealybugs – to the extent that even mealybugs hitchhiking on vineyard workers and equipment have spread GLRaV infections from one vineyard to another.

Figure 3 - Leafroll infected Lemberger vineyard in the Finger Lakes. Green vines in the background are a different variety.

Finger Lakes Survey

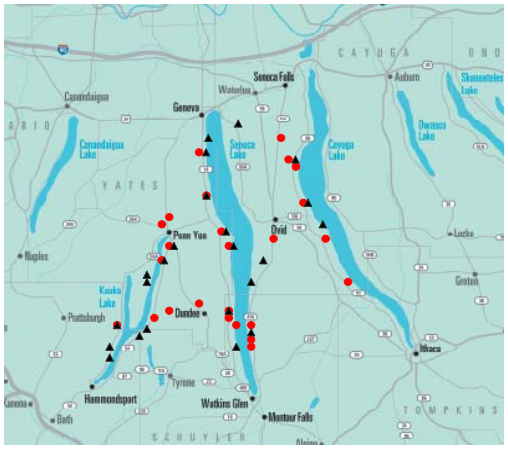

Figure 4. Survey locations in the Finger Lakes.

Our studies in New York. In the Finger Lakes, we started a survey in 2006 to look at how common GLRaV infections were in area vineyards. This survey was prompted by an observed infestation in a Lemberger vineyard, in which most of the vines showed visible symptoms of leafroll (See Figure 3). Testing revealed that this vineyard had two strains GLRaV-2 and GLRaV-3. Subsequent testing of other nearby blocks revealed – for the first time – GLRaV-1, the first report of this form of leafroll from New York.

Survey Methods. We surveyed 95 vineyard blocks in 25 different vineyards throughout the Finger Lakes (Fig. 4 for map of survey locations). At each vineyard block, up to 20 leaf samples (depending upon the size of the block) were collected in August 2006 from each vineyard to map incidence (% of positive samples) and also location within the vineyard. These samples (well over 1000) were then tested in Marc Fuch's laboratory for the presence of GLRaV 1, 2, and 3. Samples were collected from a wide range of 14 *V. vinifera* and hybrid vineyards. Because we had observed leaf symptoms in many Lemberger vineyards, we made a special effort to collect samples in all of the Lemberger blocks we are aware of in the Finger Lakes.

We also surveyed vineyards for grape mealybugs and soft scales. Samples were collected in 31 blocks at 25 different vineyards – some, but not all of which were the same vineyards from which leaf samples had been collected for virus testing. Some of the insects were retained and preserved to test them for the presence of GLRaV strains.

Results. Results of the survey were striking. (Table 1). Of the 95 blocks tested, 65 (68%) showed at least one positive GLRaV test, while 32 were clean. Although fewer hybrid blocks were tested, the percentage testing positive (57%) was in the same ballpark as the *V. vinifera* results (70%). About 32% of the blocks testing positive had no virus detected; 28% showed low to moderate (<20%) levels of vines infected, while the other 39% had high levels of 20 to 100% of samples testing positive for GLRaV infection (Table 2).

The bottom line: About one-third of the vineyards we tested had high levels of samples testing positive for at least one of the GLRaVs. About 15% of these had 2 viruses, and 3% had 3 GLRaVs. Leafroll is widely distributed and common in the Finger Lakes.

Table 1. Vineyards surveyed for Grapevine Leafroll Virus in the Finger Lakes Region of New York in 2006.

Class	Cultivar	No. Vineyards Surveyed	No. Vineyards with GLRV Present	%
V. vinifera	Cabernet franc	16	11	69%
	Cabernet sauvignon	3	2	67%
	Chardonnay	10	7	70%
	Gewurztraminer	1	1	100%
	Lemberger	10	6	60%
	Merlot	5	4	80%
	Pinot gris	2	2	100%
	Pinot noir	20	15	75%
	Riesling	9	5	56%
	Sangiovese	1	1	100%
	Sum	***76***	***53***	***70%***
Hybrid	Carmine	1	0	0%
	Chambourcin	1	0	0%
	Landot noir	1	1	100%
	Vignoles	6	3	50%
	Rougeon	1	1	100%
	Seyval blanc	4	3	75%
	Sum	***14***	***8***	***57%***

Table 2. Incidence of GLRaV-1, GLRaV-2 and GLRaV-3 in Finger Lakes vineyard blocks.

	Vineyard blocks	
Virus incidence (%)[a] (category)	No. infected	%
0 (none)	30	32
1-10 (low)	7	7
11-20 (moderate)	20	21
21-50 (high)	20	21
51-90 (very high)	14	15
91-100 (extremely high)	4	4
Total	97	100

[a]Data represent the number of quadrats per vineyard block in which samples infected by GLRaV-1, GLRaV-2 and/or GLRaV-3 were detected by DAS-ELISA over the number of quadrats tested.

Insect Survey. The mealybug and soft scale vectors capable of transmitting these viruses are rare, but present at low levels in many blocks. Of the 31 sites surveyed, 25 (81%) had either soft scales or mealybugs, and 6 had none. However, numbers were very low in 22 of the 25 blocks. Testing of mealybugs for virus was inconclusive in 2007, but virus was detected in a few soft scale insects. Mealybugs from multiple sites collected this season (2008), however, tested positive for GLRaV-1 or GLRaV-3, indicating for the first time the possibility that vine-to-vine spread by insects may be important in New York.

Leafroll and Fruit Quality. We also collected pre-harvest berry samples from 14 vineyards (Cabernet Franc, Lemberger, and Cabernet Sauvignon) where we could easily identify vines with and without leafroll symptoms at harvest. At one site, where 2 of the 14 rows of Cabernet Franc showed high levels of infection and the remaining 12 were 'green', we collected more detailed weekly samples for five weeks before harvest from groups of marked 'leafroll' and 'clean' vines in adjacent rows.

The detailed sampling (Figure 5) showed that fruit chemistry differed dramatically in leafroll-infected and clean vines. Most notably, brix accumulation in leafroll vines lagged behind that of clean vines. Brix was consistently 2 degrees lower throughout the five weeks of sampling. Juice pH was higher, while titratable acidity was lower in leafroll vines.

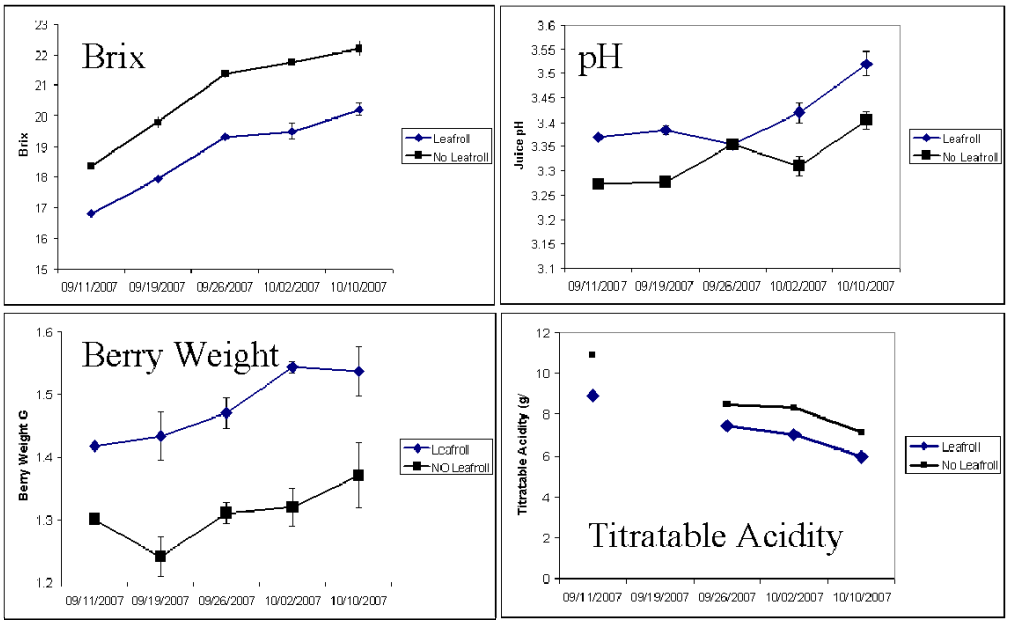

Figure 5. Fruit chemistry from GLRaV-infected and 'clean' vines in five weeks before harvest in a Cabernet Franc vineyard in the Finger Lakes.

Larger Survey. Similar patterns were evident in the 14 vineyards where samples were taken near harvest. Brix levels were consistently 1 to 3 degrees lower than in clean vines (Fig. 6), while juice pH was generally higher (Fig 7). Trends for titratable acidity (Fig. 8) and berry weight (Fig. 9) were inconsistent.

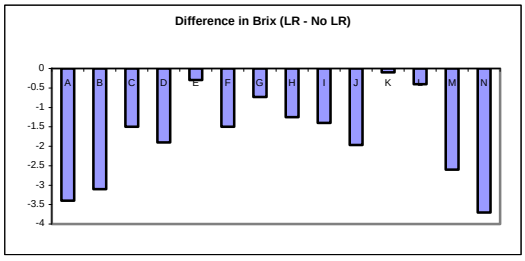

Fig. 6. Decrease in sugar content (in Brix°) in berries from vines with leafroll disease symptoms relative to healthy vines in 14 different vineyard blocks (A-N).

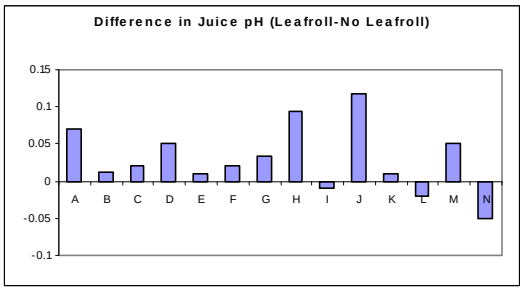

Fig. 7. Increase or decrease in pH in berry juice from vines with leafroll disease symptoms relative to healthy vines in 14 different vineyard blocks (A-N).

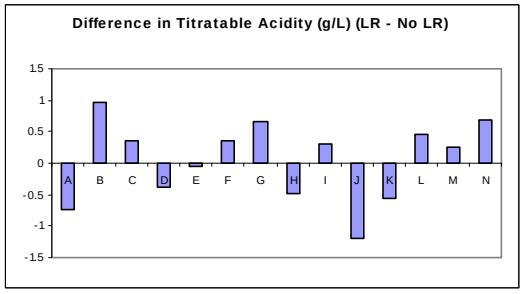

Fig. 8. Increase or decrease in titratable acidity in berry juice from vines with leafroll disease symptoms relative to healthy vines in 14 different vineyard blocks (A-N).

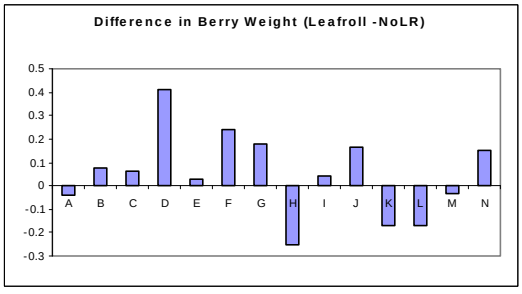

Fig. 9. Increase or decrease in berry weight in berries from vines with leafroll disease symptoms relative to healthy vines in 14 different vineyard blocks (A-N).

Implications. This survey has demonstrated that leafroll is more prevalent than we had thought, that (as noted in other areas worldwide) it has some very real implications for vine performance and fruit quality, and that mealybugs – though rare and hard to find in vineyards – are capable of spreading the disease to clean plants in vineyards.

How important the insects are in vectoring the disease remains to be seen. Follow-up surveys in vineyards with moderate levels are underway (this is the 3rd year), and will provide additional information on in-vineyard spread. Insecticides aimed at these rare insects are not likely to be a practical means of insuring that the virus doesn't spread in vineyards. But given the possibility of insect-vectored spread, this is a disease that growers can't afford to ignore anymore. Having vines that consistently produce fruit with lower brix and higher pH – particularly with late-ripening reds that can be a challenge in our climate – is likely to limit wine quality.

Clean Stock. Preventing the spread and propagation of leafroll virus in NY vineyards will involve the ability of growers to source virus-free vines for establishing new vineyards and for replants. Currently, availability of certified vines is limited. Maintaining clean vines involves continuous testing and verification - and there are many ways that virus infections can be unintentionally propagated. In particular, suppliers throughout the US and Canada will need to examine how and from where they collect the propagation material, and maintain a testing program to insure that transmission through budwood and rootstock is limited to the extent possible.

Figure 10. Leafroll-infected Cabernet Franc replant in 2007. Vine (from California nursery) was planted into 15 year-old vineyard in 2005.

An example from a local vineyard (Figure 10) illustrates this point. In this Cabernet Franc vineyard with many replants following the 2004 winter injury episode, we found that about half of the 3 year-old replants in this block showed leaf symptoms of leafroll infection. The nursery supplying the vines was not a local one. But the consequences for the grower are long-term and economically significant. Essentially, after having a vineyard with many skips (and loss of income for 4 years following the '04 freeze), this grower has a new portion of his vineyard in which the fruit will ripen later and yield less, and have less intense color. He is now faced with the possibility of again replacing these vines (and losing another 4 years production) or permanently having a portion of the vineyard perform differently than the older, uninfected vines.

Management. Once vines acquire the virus, infection is permanent, so preventing infection and spread is key.

1. Plant Certified Vines. Use planting material derived from certified virus-tested stock for new vineyards and replants. Many certified *V. vinifera* cultivars and clones are available; certified hybrids are generally not, but some nurseries have tested vines for viruses.

2. Recognize symptoms. Leafroll becomes visible in vineyards in mid to late August. Symptoms are easiest to spot in red varieties, with characteristic 'red leaves with green veins', spreading from the base of the shoot towards the tip (Fig.1). In white varieties, look for rolled leaves and general yellowing (Fig. 2). It may be harder to spot symptoms in whites. It's important to note that infected vines may not exhibit any symptoms.

3. Mark and replace infected vines when possible. Infected vines may be a source for infecting healthy vines. We're not certain how important mealybug transmission from vine to vine is in New York, but we can't ignore the possibility of spread. Removal of infected vines will limit the possibility of further spread in your vineyard.

4. *Insecticides for mealybugs are not recommended.* Mealybugs are rare in vineyards, and don't directly impact vine performance. This makes it difficult to scout for them and decide when control is warranted. In other regions, insecticides have not proven to be the answer for limiting spread of the viruses. We don't recommend them in New York.

5. *Selective harvest.* Red *V. vinifera* (Lemberger, Cabernet franc, Pinot noir) show the most consistently visible leaf symptoms – so selectively harvesting around leafroll-infected vines to improve wine quality is possible. Fruit from vines with leafroll will have lower brix and less color than fruit from clean vines. Separating it from harvest of healthy vines without leafroll symptoms will reduce green, unripe flavors.

Clean Plant Initiative. Discussions are underway with federal officials and universities to establish a National 'Clean Plant' network to increase the availability of certified virus-free planting stock for the benefit of growers and nurseries. Congress included in the Farm Bill an appropriation of $20 million, spread over 4 years, to fund a program under the direction of Federal agencies APHIS, CSREES, and ARS. Not all of this funding will be directed at grapes, but grapes are listed as an important priority area in the appropriation. For the first time, a portion of this federal effort will be directed at the specific

needs of Eastern viticulture – and the effort will include and serve growers from Texas, Missouri and Minnesota to Virginia, Pennsylvania, Maryland, New York, Michigan and beyond. As this program gets underway, results are likely to be increased availability of virus-tested and certified vines to serve the expanding grape industry in the US. Also under discussion is the possibility of limiting other non-viral diseases propagated through planting stock such as crown gall.

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