Research News from Cornell's Viticulture and Enology Program Research Focus 2014-2

Research Focus

Grapevine Leafroll Disease Control: It Pays to Test Neighboring Vines

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Grapevine leafroll disease reduces yield and delays ripening. Removing and replacing infected vines can limit disease spread to healthy vines and provide economic benefits over the life of the vineyard.

Photo by Marc Fuchs

Once a vine is infected with one or more grapevine leafroll associated viruses (GLRaV), it remains infected and can serve as a source for infecting neighboring vines through transmission by insect vectors. Removing and replacing vines ("roguing") can limit the spread and provide economic benefits to growers over the life of the vineyard. In our study of the economics of grapevine leafroll disease control, we compared control strategies that involved roguing of either 1) visibly symptomatic vines or 2) symptomatic vines and their neighbors within and across rows. We found that spatial strategies testing and replacing immediate neighbors of symptomatic vines performed better than nonspatial strategies where only symptomatic vines were replaced, increasing the vineyard expected net present value by 18- 19% relative to the strategy of no disease control.

Key Concepts

- Grapevine leafroll disease is a viral disease.
- By reducing grape yields and quality, its economic impact can be $25,000-40,000 per hectare ($10,100-$16,200 per acre).
- The disease can be transmitted from vine to vine by mealybugs and soft-scale insects.
- Currently, the recommendation is to prevent the disease by ensuring that planting material comes from mother vines that have been tested for the virus.
- Control recommendations consist of removing and replacing infected vines with healthy, virus-tested vines.
- Using computational experiments, we found that it pays off to test the immediate neighboring vines (two or four) of symptomatic vines and remove them if they test positive.
- We also found that this strategy makes economic sense even if the costs of virus testing and vine removal and replacement were higher than what they are now.
- For more information, please consult the full research paper (Atallah et al. 2014) and associated references at http://ajae.oxfordjournals.org/content/early/2014/06/18/ajae.aau032.abstract

What is the grapevine leafroll disease and why is it an economic problem?

Grapevine leafroll disease (GLRD) is a vector-transmitted viral disease that presently threatens grape harvests in the United States and around the world. This disease reduces yield, delays fruit ripening, and negatively affects wine quality by lowering soluble solids and increasing fruit juice acidity.

Its economic impact was recently estimated at $25,000- $40,000 per hectare ($10,100 to $16,200 per acre) if the disease is left uncontrolled, which represents more than 75% of a vineyard's net present value (See box below) (Atallah et al. 2012).

GLRD is primarily introduced to vineyards through infected planting material. Once introduced, the disease can be transmitted from vine to vine by several species of mealybugs and soft-scale insects.

Mealybugs can transmit GLRD within and across vineyards in at least three ways. Insects crawling on wires and fruiting canes can cause disease transmission to neighboring vines. Vineyard management activities can facilitate mealybug dispersal to further neighboring vines within the same vineyard. Finally, disease spread between neighboring blocks or vineyards can take place through aerial dispersal of mealybugs.

Measuring Economic Impact:
What is Expected Net Present Value?

To estimate the economic impact of different management options, the model compares *Expected Net Present Value* in the presence or absence of the disease control practice.

The *Expected Net Present Value (*ENPV) is the difference between the expected present value of a vineyard's cash inflows and the expected present value of cash outflows. For each control strategy, we compute the 'economic improvement over not controlling the disease' using the following formula: (ENPV under that control strategy - ENPV under no disease control)/ ENPV under no disease control. This formula allows us to calculate the expected reduction in economic losses in percentage terms.

Figure 1. *A vine with GLRD symptoms that has been cut and scheduled for removal and replacement.*

Photo by Shady Atallah

What's being done about it?

Vineyard managers are currently advised to avoid introducing GLRD into their vineyards by planting certified vines derived from virus-tested mother plants. However, when GLRD is already present, disease management consists mainly of minimizing the source of infection by roguing symptomatic vines after harvest, especially the young ones and replacing them with virus-tested vines.

Young vines are especially important to remove because they might be able to transmit the disease sooner after infection than older vines. Vector management is recommended to reduce disease transmission. Although insecticide sprays can reduce mealybug densities, they have not been effective at controlling GLRD spread, mainly because of the exceptionally low insect density needed for disease transmission.

What more can be done?

This is exactly the question that we attempted to answer in our latest research on the economics of GLRD.

First we wanted to know if focusing on a certain *level of infection* (as proxied by the moderate vs. high level of symptoms) helps controlling the disease while minimizing disease control costs (as opposed to removing and replanting every single vine with symptoms).

Second, we wanted to know if focusing on a certain *age category* (young vs mature vs old vines) does better than targeting all vines of all ages.

The idea here is that one might want to be strategic by focusing on the younger vines given they might spread the disease sooner after infection than older vines. On the other hand, one might want to wait until vines are older and produce more grapes before removing them and replacing them.

Third, we wanted to know if it pays to perform a virus test for those healthy-looking vines that are situated next to infected vines with symptoms. In other terms, is it worth considering the *location* of vines and paying for virus tests when controlling the disease? Finally, should we maybe take all three factors (infection level, age, and location) into consideration?

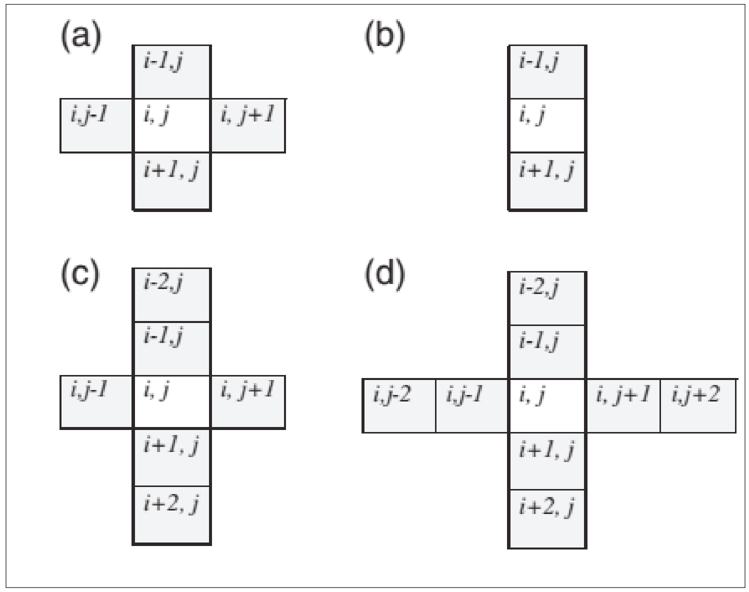

Figure 2. *Diagrams representing the strategies of testing four (a), two (b), six (c), or eight (d) neighbors.*

How did you answer these questions?

We developed a model that simulates the spread of GLRD over space and time. Think of it as a computer game, with the difference that the rules of the game are the result of previous research and scientific knowledge.

The model starts with the disease being introduced through infected vines and then the disease spreads from vine to vine through mealybugs, scale insects, or workers. As observed in experimental settings, the disease spreads in the model more within vineyard rows than from row to row.

Which disease control strategies did you test using this computer model?

We compared a strategy of doing nothing to control the disease with different disease management strategies. We tested eighteen strategies. Strategies either focused only on vines with visual symptoms (call them nonspatial strategies) or included the neighboring vines as well (call them spatial strategies).

Nonspatial strategies differed by whether they removed and replanted (1) all vines with symptoms; (2) only those with a certain level of symptoms (for example, only vines with moderate reddening and leaf rolling); (3) only those of a particular age category (for example, only vines five years old or younger); (4) vines of a certain infection level and age category (example, only young vines with moderate level of symptoms).

Spatial strategies **(Figure 2)** involve not only removing and replanting symptomatic vines, but also testing neighboring vines and then removing and replacing those that test positive for leafroll. Spatial strategies differed by whether they tested two, four, six, or eight neighboring vines.

What did you learn?

(1) Among *nonspatial strategies*, controlling earlier (when infected vines are young and their symptoms are moderate) is more cost-effective than controlling later (when vines are mature or old and their symptoms are advanced);

(2) Among *spatial strategies*, testing the immediate neighboring vines (two or four) gives you a good return on your investment. The economic improvement over not controlling the disease is 18-19% (statistically significant at the 1% level). Testing in a wider neighborhood (six or eight vines) does not pay off.

(3) By providing the benefit of early detection, spatial strategies are better at controlling the disease than nonspatial strategies. They are also more cost-effective.

Figure 3. A Finger Lakes vineyard manager has marked (red circles) the immediate two neighbors of an infected vine to monitor vine-to-vine disease spread.

Photo by Shadi Atallah

2. *Your recommendation depends on the testing cost, doesn't it?*

That's true, but we found that the cost of the test would need to increase five times (!) from its current value ($2.6/vine) before the spatial strategies become too expensive for the early detection benefit they provide ***(Figure 4)***.

3. *Does this recommendation depend on the cost or removing and replanting vines?*

It does. But the recommendation remains valid as long as the cost of removing and replanting vines does not increase more than four times (!) from its current value ($7.25/vine).

4. *That's all fine if my neighbor and I control the disease similarly. Does the model account for situations where my neighbor might not be controlling for leafroll in his vineyard?*

That's an excellent point. This model does not account for such cases. But we recently developed a model that incorporates disease spread between neighboring vineyards ***(Figure 5)***. We will be disseminating the results as soon as our research is peer-reviewed. Stay tuned.

Frequently Asked Questions:

1. *I don't understand why the improvement is not higher? Why is the disease not eradicated?*

The tests might not detect the virus in the vine right after infection occurs. Some infected vines will go undetected, even if you test for the virus and the disease might not be eradicated (unless scientists develop a test that can detect the virus right after infection, with no error).

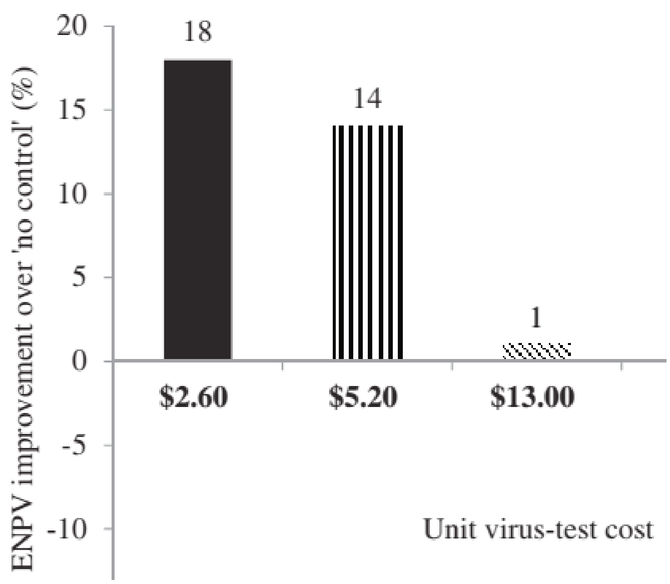

Figure 4. The economic improvement under the strategy involving testing two immediate neighboring vines remains positive even with a five-fold increase in testing costs.

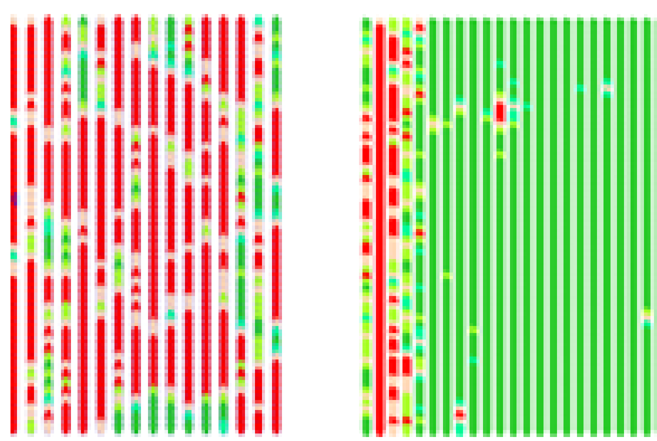

Figure 5. Screen shot of the model that accounts for disease spread between two neighboring vineyards (green=healthy vines; red=GLRD-affected vines)

References:

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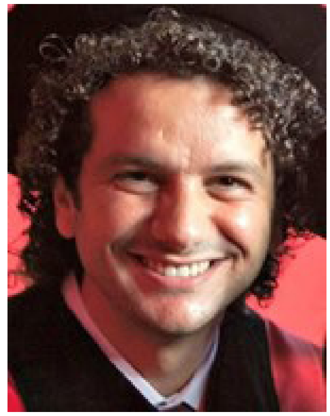

Shady Atallah (l) and **Miguel Gomez (r)**

As a Ph D student in Miguel Gomez' program, Shady Atallah completed his thesis in 2014, specializing in the bioeconomics of plant diseases. His economic modeling aims to identify novel, profit-maximizing disease control strategies for vineyard managers. His current responsibilities as assistant professor at Purdue are in the field of natural resource economics with a focus on sustainable forest ecosystems and associated ecosystem services.

Miguel Gómez specializes in marketing, price analysis, and industrial organization. Since his arrival at Cornell in 2008, he has initiated several projects with New York's grape and wine industry as part of a broader program to enhance the market opportunities for horticultural products and benefit producers, processors, distributors, and consumers.

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