

Interim Progress Report for CDFA Agreement Number 2018-2158

GRAPEVINE VIRUS MANAGEMENT IN LODI: A COLLABORATIVE RESEARCH & INTEGRATED OUTREACH EFFORT TO HELP SOLVE A STATEWIDE CHALLENGE

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REPORTING PERIOD.

The results reported here are from work conducted October 2017 to March 2019.

INTRODUCTION.

Three main viruses – grapevine red blotch-associated virus (GRBaV), grapevine leafroll-associated viruses (GLRaVs), and grapevine fanleaf virus (GFLV) – are currently resulting in not only a great deal of confusion but

also significant economic losses for winegrowers throughout California. Each of these viruses can cause general vine decline, decreased yields, difficulty ripening, poor fruit quality, shortened vineyard life spans, and decreased ability of a vine to handle other stresses (Martelli 2014, Sudarshana 2015). Virus infections have resulted in the loss of grape contracts, the need to rogue infected vines, and the need to remove an entire vineyard (if the infection is greater than 26-30% of vines, depending on which economic model a grower chooses to follow) (Atallah 2012, Ricketts 2017). One recent study found that for red blotch disease alone, a high infection rate costs up to \$27,741 per acre (Ricketts 2017). For leafroll, a study in New York found the economic impact of ignoring the virus to be between \$10,117 to \$16,188 per acre (Atallah 2012). Vine mealybugs (*Planococcus ficus*) complicate the virus challenge as they are an extremely efficient vector of at least five leafroll-associated viruses (Engelbrecht and Kasdorf 1990, Tsai et al. 2010). It only takes one mealybug to infect a vine, and virus transmission can occur in as few as 1-24 hours (Golino et al. 2002, Tsai et al. 2008). Circumstantial evidence points towards a carryover effect with leafroll virus caused by mealybugs, where clean vines planted in the space where leafroll-infected vines existed previously can readily become infected (Pietersen 2016). It is imperative to combine outreach on vine mealybugs with management of leafroll-associated viruses via collaboration between Lodi's Mealybug Biocontrol Research Focus Group (funded by the American Vineyard Foundation and the Lodi Winegrape Commission) and the Virus Focus Group.

In fact, it will take a joint effort by all sectors of the industry to find a sustainable solution which will allow growers to continue profitably farming winegrapes. Growers need more education to make responsible virus management decisions. Even when responsible growers plan ahead and pay extra for CDFA-certified material, viruses and/or mealybug vectors are too often slipping through registered nursery doors. Preliminary case study collections are uncovering a lack in formal reporting procedures for when this scenario occurs, making it difficult for the industry to know there is need for improvement in virus prevention protocols. When 300-acre vineyards must be ripped out due to a virus infection after being in the ground for less than four years, there is a problem. The best way to learn is by doing, and Lodi growers are learning the hard way that ignoring grapevine viruses – either individually and as an industry – is one expensive mistake.

Despite many costly experiences with virus-infected grapevines, it has been surprising to discover that no one in Lodi has a working “virus best management protocol” in place. A true protocol would need to include nursery ordering, replanting following a leafroll infection, employee education, mealybug and ant control, scouting and rogueing procedures, economic thresholds, sampling and testing procedures, mapping, and a great deal of organized record-keeping. For a grower or even a large vineyard operation to have the depth of knowledge and time required to create such a management protocol for viruses would be nearly impossible. Luckily, the Virus Focus Group is investing the time and skills of an entire team to learn everything they can about viruses and their management, and then distribute this knowledge in the form of easily understandable, integrated outreach.

Growers need answers on how to manage viruses now, and they need to hear economically relevant stories to decide for themselves why they should care about viruses. Even many well-educated growers are left thinking, *“Is it worth it for me to worry about viruses if they are everywhere? Even if I knew how to manage for them, I couldn't afford it.”* Add in a general lack of knowledge about the different viruses – leafroll, red blotch, and fanleaf – and it is easy to see that an integrated, extensive virus outreach program is needed immediately. On the flip side, the California winegrape industry needs stronger communication between growers, nurseries, laboratories, researchers, and government programs to find a long-term strategy for lowering the state's inoculum and reducing the spread of viruses.

LIST OF OBJECTIVES.

The overall objective is to learn how to best manage and prevent grapevine virus disease in the 110,000 acres of Crush District 11, providing outreach tools and strategies to be shared with other regions across California.

This main objective will be accomplished by the following sub-objectives:

1. To investigate the current status of grapevine virus knowledge, both at the academic level and at the regional grower level. This ongoing investigation will include a grapevine virus literature search and the collection of case studies about grapevine viruses locally, state-wide, and internationally.
2. To learn how to best test and rogue infected grapevines for virus management, developing and incorporating economic thresholds into outreach materials.
3. To learn best practices for replacement of an existing leafroll-infected vineyard.
4. To formulate a long-term management plan for economically feasible and impactful virus control strategies in Lodi and California.
5. To develop and deliver timely, relevant educational materials and approachable outreach for best virus management practices for growers.
6. To establish priorities for further grapevine virus research projects.

RESULTS AND DISCUSSION BY OBJECTIVE.

Grapevine virus management has been established as a top outreach and research priority for Lodi, due to severe economic losses from region-wide virus infections and a general lack of knowledge about viruses. Lodi's winegrowing community is fully committed to learning more about viruses in general and to discovering sustainable, economically viable management options to allow for profitable grape growing.

Objective 1. To investigate the current status of grapevine virus knowledge, both at the academic level and at the regional grower level. This ongoing investigation will include a grapevine virus literature search and the collection of case studies about grapevine viruses locally, state-wide, and internationally.

Monthly meetings of the Virus Focus Group, monthly pest management network breakfast meetings, a large Mealybug & Virus Outreach meeting, as well as numerous personal conversations with local growers and other regional grower groups has revealed a great lack of knowledge about viruses in the California winegrape industry. Although the majority of growers are experiencing virus symptoms (red leaves or trouble ripening grapes), they have yet to understand the differences between the three main economically important viruses or to begin to manage for them. A significant amount of mis-information exists in all industry sectors from the nursery to the vineyard to the winery.

We've collected scientific articles, textbooks, online information, and a grower workbook on leafroll virus from sources in the USA and internationally. All information is shared within the Virus Focus Group and discussed at length during the monthly meeting, trying to understand how each piece of information applies locally in California. Information concerning leafroll from South Africa and New Zealand has been extremely useful and has allowed us to develop an overall virus strategy (Figure 1) at a faster pace. We've been able to share and discuss our findings and materials with other interested regional grower groups (including The Vineyard Team, the Monterey County Vintners & Growers Association, the Contra Costa Winegrowers Association, the California Association of Wine Growers, and the Washington Winegrowers Association) so that we all may learn and work together.

Case studies regarding the economics of virus management and individual virus-related situations are being collected and used in research and outreach. The financial losses experienced due to viruses are much greater than our local winegrowing community had realized. For example, one 70-acre block planted in 2012 was infected with leafroll virus and had to be removed in 2018, at a total loss (including revenues) of at least \$2.5

million. The collection and sharing of local case studies is helping influence growers towards learning more about viruses and how to manage them and will aide in bringing our industry towards the acceptance stage of thinking so that long-term solutions can be best realized.

Decrease vector populations.

Lower virus inoculum.

Why? The future of our industry depends on what we do today.

CALIFORNIA REPUBLIC

We can't beat these viruses alone.













 <p>Growers Education, vector management, and lowering the amount of virus inoculum on each farm.</p>	 <p>Nurseries Providing growers with reliably clean rootstock and scion material.</p>	 <p>FPS Providing nurseries with reliably clean propagation material.</p>
 <p>CDFA Administering an effective Grapevine Certification & Registration Program.</p>	 <p>Academia Scientific research to validate & improve management strategies and new technologies for virus detection & management.</p>	 <p>Virus Testing Labs Providing reliably accurate, efficient, and economical virus testing for plant material.</p>
 <p>Wineries Education and teamwork with growers to beat the virus challenge.</p>	 <p>Extension Virus education outreach and connection to resources needed.</p>	 <p>IPM Companies Vector control that keeps the natural enemies of vine mealybug doing their job.</p>
 <p>PCAs/Viticulturists Education, vector management, virus detection and management.</p>	 <p>County Ag Commissioners Education, vector management, regional organization and leadership.</p>	 <p>Regional Associations Education, vector management, regional organization and leadership.</p>

Figure 1. A visual representation of the overall virus strategy for California to guide the outreach initiatives of the Virus Focus Group. Created by Bolton for the 2018 Mealybug & Virus Outreach Meeting.

Through outreach and conversations, we’ve discovered that grower sentiments towards the California virus crisis are very similar to the stages of grief identified by the Modified Kubler-Ross Model – shock, denial, anger, bargaining, depression, testing, and finally acceptance. We’ve incorporated this grief model into our outreach presentations.

We’ve also uncovered numerous myths about grapevine viruses that are believed by all types of people, from an average farmer to the leaders of industry and county organizations. Here are a few examples of these myths:

- “Nurseries do not sell non-certified planting material.”
– Grower Association Leader
- “Certified vines are virus free.”
– Extension publication
- “Mealybugs won’t develop resistance to Movento.”
– A message told to growers by some pest control advisors
- “Rootstocks don’t get viruses.”
– A message told to growers by some nurseries
- “It is illegal to sell virus-infected vines.”
– A County Ag Commissioner’s office
- “Someone or some group is in charge of orchestrating a solution to the virus crisis.”
– Most people in the industry

At our upcoming Mealybug & Virus Outreach Meeting on April 4th, 2019, we will host an afternoon roundtable discussion for extension leaders and regional grower groups to discuss these myths and how we can use consistent messaging to overcome them.

Table 1. An overview of challenges uncovered through an in-depth look at the overall California grapevine virus situation.

Virus-Related Topic	Challenge(s)	Efforts to Help Solve the Issue
<p>CDFA Grapevine Registration & Certification Program</p>	<p>The current CDFA Grapevine Registration & Certification Program is not robust enough to prevent viruses and their vectors from passing through the system.</p>	<p>We’ve spent over a year drafting a letter to the CDFA from industry seeking specific improvements in the Grapevine Registration & Certification Program (with input from the CDFA) and are currently gathering support from other industry groups for these improvements.</p>
	<p>There was no list of nurseries registered under the CDFA Grapevine Registration & Certification Program.</p>	<p>We asked for a list of CDFA-registered nurseries, which is now posted online and is included in our outreach material so that growers know where to purchase CDFA-certified material.</p>

Virus-Related Topic	Challenge(s)	Efforts to Help Solve the Issue
Argentine Ants	Ants play a key role in the protection and movement of vine mealybugs, but there is currently no effective and economically viable method available for ant control.	We are working with several scientists and companies to express the need for ant control in the vineyard and to establish ant control trials in 2019.
Nursery Material	Vine mealybugs are being spread via nursery material, especially under the wax at the graft union.	We inform growers to inspect nursery material for mealybugs before planting and to ask for wax removal prior to shipment. We're writing a nursery-specific outreach chapter in our Mealybug Management Booklet.
	There is a lot of mis-information from extension and others stating that nurseries sell certified virus-free material, when in reality it should be called "CDFA-certified virus-tested" material.	We wrote a peer-reviewed educational booklet explaining what the CDFa certification means and how to improve your chances of getting cleaner wood. We politely correct speakers at industry meetings when they use the term "virus-free," asking them to instead use "virus-tested."
	Many growers do not know how to order CDFa-certified rootstock and scion material (there are very specific questions which need to be asked at some nurseries).	Our Nursery Ordering 101: Viruses Booklet includes the questions a grower needs to ask to be able to order CDFa-certified rootstock and scion material.
Virus Testing Labs	There is no third-party oversight for virus testing labs, and no system of checks and balances in place. Each lab is operating separately using their own proprietary protocols. There is no industry "standard" established for virus testing. Growers do not trust lab results.	We held a meeting on April 4, 2018, for the virus testing labs to speak with each other and our Virus Focus Group. At their suggestion, we organized a blind ring test in conjunction with Dr. Bob Martin of the USDA-ARS in Oregon, which was completed during winter 2018-2019. We are currently analyzing the results.

Virus-Related Topic	Challenge(s)	Efforts to Help Solve the Issue
Freedom Rootstock	<p>Growers in Lodi and other parts of California have been planting thousands of acres of vines with Freedom rootstock, which researchers have known to be very susceptible/sensitive to leafroll virus since the 1990's. This information was unknown by many growers, who use it in high vine mealybug/leafroll risk areas. Large patches of vineyards on Freedom rootstock have been collapsing across the state.</p>	<p>We worked with several scientists to study collapsing vineyard patches, and organized case study collections where growers were interviewed to collect a large amount of data for each collapsing situation before testing these vines for viruses and other pathogens. We are now confident that Freedom rootstock (and possibly others) plays a role along with leafroll 3 virus in this mystery vine collapse disease complex, which also involves a third form of stress. We provide education on why growers may want to avoid Freedom rootstock following the removal of a vineyard with mealybugs and leafroll, or for vineyards in high risk areas.</p>
Vine Mealybug Control	<p>Many growers falsely believe that they do not have vine mealybugs, an incredibly efficient leafroll virus vector, in their vineyards.</p>	<p>We tell all growers that they either have vine mealybugs or are at risk for them and include vine mealybug identification in all virus outreach meetings. We are writing a "Vine Mealybug Management" booklet.</p>
	<p>Growers are heavily relying on only a few insecticide modes of action for mealybug control.</p>	<p>We include mealybug biocontrol in our outreach efforts and applied for a Western SARE grant to demonstrate effective mealybug biocontrol in Lodi.</p>
USDA Financial Assistance for Losses due to Viruses - TAP	<p>Leafroll virus is not currently an eligible disaster covered under the USDA TAP (Tree Assistance Program), but red blotch virus is covered.</p>	<p>Dr. Alan Wei pointed out to us that USDA TAP decide to cover leafroll virus in addition to red blotch virus if enough growers applied for assistance. After hearing one of our outreach presentations where this new information was discussed, a grower filed for assistance under TAP due to leafroll virus and has appealed the rejection. We are providing case studies and cost information to support this cause, in addition to spreading the word to other extension and grower groups.</p>

Perhaps because there is no one organization “in charge” of the complex California grapevine virus crisis, there hasn’t been adequate communication between all sectors of the industry (Figure 1). As the table above shows, we are having great success in helping to facilitate these communication channels to discover industry-driven working solutions which can be implemented in both the short- and long-term.

Objective 2. To learn how to best test and rogue infected grapevines for virus management, developing and incorporating economic thresholds into outreach materials.

Research into virus testing procedures revealed that there is no standard protocol for virus testing in California, nor is there a virus-specific accreditation available for laboratories. Virus testing is expensive (in the range of \$150-300 per sample or vine) and directions for sample collection need to be followed carefully for the most accurate results. On April 4th, 2018, the Lodi Winegrape Commission hosted the first meeting where all seven grapevine testing laboratories came together with growers, nurseries, and PCAs. At this meeting it was decided that a third-party ring test would help improve the accuracy and reliability of California virus testing. Dr. Bob Martin at the USDA-ARS in Oregon and PI Stephanie Bolton orchestrated the blind ring test during Winter 2018-2019 with positive samples donated by Dr. Maher Al Rwahnih from Foundation Plant Services (FPS). All seven commercial California laboratories, including FPS, and the new CDFA virus testing laboratory participated. The data is currently being analyzed and will be used to help laboratories improve their methodology, which has proven to be needed.

So far, the Virus Focus Group has toured one laboratory facility to learn about the virus testing process. Considering recent Foundation Plant Services studies and conversations with this laboratory, the current best practice for composite sampling appears to be including no more than ten individual samples per virus testing submission (which means five samples when testing nursery material, since both the rootstock and scion portion needed to be tested). During the same trip to the laboratory, we were able to visit two nurseries. This tour helped to develop a protocol for testing dormant vines at the nursery which will be shared in the Virus Workbook.

Efficient use of CDFA grant money awarded for regional virus testing will allow us to meet the following goals, all of which are in currently in progress:

1. To experience virus testing with all seven laboratories as a grower would for improved, real-world educational materials on “how to test.”
2. To determine if leafroll 3, red blotch, and/or fanleaf virus play a role in a regional mystery vine collapse disease.
3. To create Leafroll Virus Demonstration Vineyards with scouting and training opportunities.
4. To gather virus case studies and photographs from across the Lodi AVA which are verified by testing and can be used in educational materials.
5. To teach growers and PCAs how to sample and test for viruses (each sampling is an opportunity to teach the grower and/or his or her PCA how to test).
6. To show growers, especially those in virus denial, how widespread grapevine viruses are across the Lodi AVA.
7. To determine which leafroll 3 virus strains exist in the Lodi AVA (Dr. Maher Al Rwahnih has tested selected samples to the strain level).

Thus far, every sample submitted for virus testing has come back positive for at least one virus, with leafroll 3 being the most common virus found. It does appear that leafroll 3 virus plays a key role in a mystery vine collapse disease, which also involves Freedom rootstock. All mystery vine collapse samples (n=9) collected and tested have been positive for leafroll 3 virus, but not all of the samples have tested positive for vitiviruses. For the leafroll 3 positive samples tested to the strain level, we have observed Group I-V to dominate.

Samples for Virus Demonstration Vineyard #2 were submitted for testing to ensure that the new grapevines planted for a rootstock trial (funded privately by a Cooperator to see if there are any differences among rootstocks planted in a high leafroll and vine mealybug risk environment) in this vineyard were clean at the time of planting. All samples submitted for this testing came back negative and viruses will be monitored over time in this vineyard as part of the demonstration.

Significant virus testing is planned to continue throughout the duration of this project and is crucial to understanding the nuances of virus management.

Objective 3. To learn best practices for replacement of an existing leafroll-infected vineyard.

Grapevine root remnants remain alive for several years after the removal of a vineyard, and the results in Figure 2 on the following page show that these root pieces can test positive for leafroll virus. The Cooperators on this grant are continuously experimenting with management methods at their own expense and generously sharing the results of these trials. Cooperators are testing methods to kill grapevines, to remove as much root material as possible, and to best prepare the soil following the removal of a leafroll-infected vineyard. Methods used in New Zealand with imidacloprid drenches are being considered. We’ve also spoken with one nursery about the logistics of treating vines with imidacloprid in the nursery before shipment.

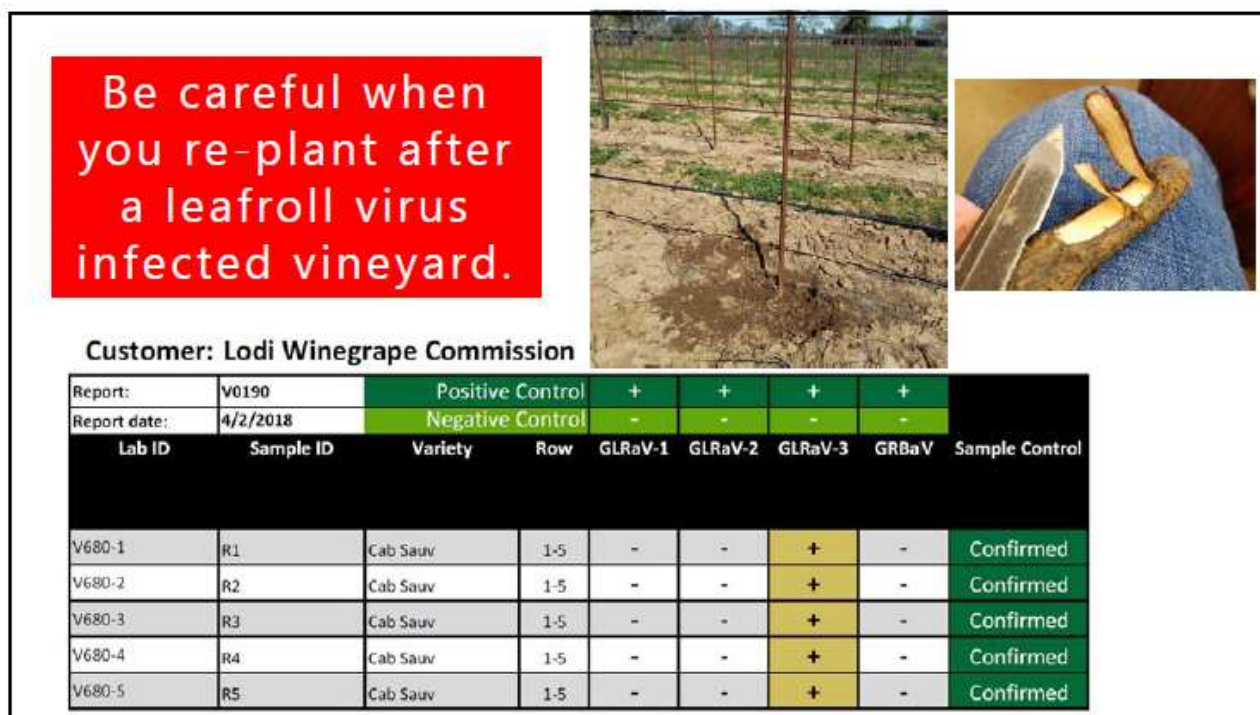


Figure 2. Wonderful Nurseries performed a complimentary virus test on root remnants to show growers that leftover root pieces can be an inconspicuous source of leafroll 3 virus inoculum. Slide created by Bolton for 2018 Mealybug & Virus Outreach Meeting.

As mentioned previously, there is a rootstock trial planted in a Cooperator vineyard (January 2019) to determine if there are commercially available rootstocks which may offer some tolerance to leafroll 3 virus and/or root mealybug vectoring. This trial includes nine replicates of ten rootstocks plus own-rooted vines (10 vines per replicate) as in Figure 3 on the following page. The vineyard, which serves as Demonstration Vineyard #2, is a block which was removed due to leafroll virus and mealybugs. It is surrounded by other vineyards with leafroll

virus and mealybugs, and there are root remnants underground which are likely harboring leafroll and mealybugs. We will work with University of California Cooperative Extension Agents to ensure that collection of data is consistent with rootstock trials in other regions of the state.



Figure 3. A rootstock trial planted by Cooperator Chris Storm in Demonstration Vineyard #2.

Objective 4. To formulate a long-term management plan for economically feasible and impactful virus control strategies in Lodi and California.

As viruses are costing everyone a good deal of money, people have been more than willing to work together to find long-term strategies for virus control statewide. The first step was to get all the entities (nurseries, laboratories, extension personnel, County Ag Commissioners, scientists, the National Clean Plant Network, and the CDFA) talking to each other, with informed growers as part of these conversations. The key part in these conversations is having average growers be part of the conversation – it makes future decisions more applicable to the real-world. Thus far, we have had discussions with every group listed. All entities are being invited and encouraged to work with the Virus Focus Group, and as mentioned earlier, teamwork with other grower groups has begun as well.

On April 3rd, 2019, the evening before the Mealybug & Virus Outreach Meeting, we are hosting selected “virus influencers” from these entities for a dinner to discuss long-term strategy planning and how we can overcome some of our largest hurdles. Also present will be Prof. Gerhard Pietersen, Dr. Marc Fuchs, and Dr. James Stamp, each of whom bring a unique perspective to the long-term strategizing. Prof. Pietersen has helped South Africa move from a crisis-status to an “under control” status when it comes to leafroll virus.

During the afternoon of April 4th, 2019, after the Mealybug & Virus Outreach Meeting, we are organizing special technical leadership sessions for industry leaders in the areas of grapevine virus testing, nurseries, and extension personnel/regional grower groups. Each session will include a roundtable discussion on specific topics, as noted in the following draft agendas:

GRAPEVINE VIRUS TESTING in CALIFORNIA

WHO: Lodi Grapevine Virus Research Focus Group, all California Virus Testing Laboratories, Dr. Maher Al Rwahnih (FPS)

1:30 – 1:45pm	Introductions
1:45 – 2:00pm	Ring Test
2:00 – 2:30pm	Complications in virus testing & ways to improve accuracy of sampling and results, Dr. Al Rwahnih
2:30 – 3:00pm	Open discussion led by Charlie Starr and Matt Frank

NURSERIES

WHO: Lodi Grapevine Virus Research Focus Group, Nurseries, Deborah Golino (confirmed), NCPN (invited), Gerhard Pietersen, Marc Fuchs, James Stamp, Judit Monis, and Larry Whitted (for his mediation skills)

1:30 – 1:45pm	Introductions
1:45 – 3:00pm	Suggestions for improvement in vector reduction, communication with growers about CDFA-certified vines and virus susceptibility (Freedom rootstock, etc.), and the CDFA Grapevine Registration & Certification Program

EXTENSION & REGIONAL GROUPS

WHO: Lodi Grapevine Virus Research Focus Group, Regional Group Leaders, Extension Personnel

1:30 – 1:45pm	Introductions
1:45 – 2:15pm	Myths about viruses and how we can overcome them
2:15 – 3:00pm	Sharing of information – Nation-wide consistent messaging

We had great success with a grapevine virus testing session at last year’s Mealybug & Virus Outreach Meeting and hope that the spirit of collaboration and collective improvement continues this year.

Objective 5. To develop and deliver timely, relevant educational materials and approachable outreach for best virus management practices for growers.

The Lodi Winegrape Commission has multiple established channels for communicating with growers and the industry. The 750 growers and 200 supporting members of the winegrowing community (as well as the additional LODI RULES community, reaching twelve other Crush Districts, and a network of Lodi wineries) receive information about virus educational workshops via mailings (postcards advertising events and biannual newsletters), email (a list-serve of over 800 people), twitter (@LodiGrower), a website (www.lodigrowers.com), and a blog (www.lodigrowers.com). Each method of communication listed provides an opportunity not only for educational outreach, but also for a conversation to begin between the recipient and the Virus Focus Group.

We have also created a virus-specific email list-serve for anyone interested in virus outreach who does not want to be on our regular Lodi grower email list.

Our integrated outreach strategy progress:

OPEN COMMUNICATION VIRUS MEETINGS FOR GROWERS

The Lodi Winegrape Commission continues to host monthly pest management network breakfast meetings where anyone in the Commission network (growers, PCAs, winemakers, etc.) can stop in and ask questions about grapevine pests and diseases. Beginning in April 2018, we devoted a portion of these roundtable meetings to viruses and their vectors so that the community has a consistent, approachable place to come with virus questions. We purchased a microscope set-up to bring to these meetings so that everyone also has an opportunity to get help identifying vine mealybugs in traps. At least three members of the Virus Focus Group are always in attendance. Attendees at the April 2nd, 2019, meeting will get a pleasant surprise because Prof. Gerhard Pietersen will be present!

(impact: 1000+ industry members invited to meetings; free and open to the public)

VIRUS MANAGEMENT DEMONSTRATION VINEYARDS

Two Virus Management Demonstration Vineyards have been established in Lodi, where growers can observe virus management in practice, learn symptom identification, and learn how to mark, test, and rogue vines during annual tailgate talks. The financials of the vineyards in terms of virus management, along with successes and failures, will be discussed openly. Demonstration Vineyard #1 is an example of <25% leafroll infection managed with roguing and was the site of a Leafroll Virus Tailgate Talk in October 2018. Extensive mapping and testing by Cooperator Charlie Starr have provided a view of the virus infection over time, which will be shared at the April 4th, 2019, outreach meeting. Demonstration Vineyard #2, planted in January 2019, will provide an example of moving from >60% leafroll infection to effective leafroll control. Virus testing is conducted in both vineyards to show results over time and to aide in hands-on virus symptom identification workshops.

Every fall, there is a tailgate talk at one of the vineyards to discuss virus management. The October 2018 Leafroll Virus Tailgate Talk was hosted at Demonstration Vineyard #1 (Figure 4). Even during harvest, about 75 people showed up to learn about virus management. Stephanie Bolton, Charlie Starr, Aaron Lange, and Chris Storm spoke with attendees about managing leafroll and mealybugs. Dr. Cindy Preto also spoke about the presumed red blotch vector, the threecornered alfalfa hopper. Four hands-on learning stations were set up in the vines and the surrounding area as follows and were led by members of the Virus Focus Group and invited educators: mealybug biocontrol/beneficial insects (Chris Storm and Larry Whitted), virus scouting (Charlie Starr and Tia Russell), virus sampling and testing (Matt Frank), and the threecornered alfalfa hopper (Cindy Preto and Kamyar Aram). Large posters emphasizing the potential for mealybug population explosions were distributed to attendees. Attendees were also given a ten-page handout which included: regional photos of red leaves and the stories behind why the leaves were actually red, a flow chart to determine the cause of red leaves, a list of grape varieties whose leaves naturally turn red in the fall, a threecornered alfalfa hopper identification sheet, a list of commercial virus testing lab contact information, a virus comparison chart, and more. See Figure 4 on the following page for page one of the handout. As with every outreach meeting, the main handouts are crafted for the specific event and then posted online at [lodigrowers.com](https://www.lodigrowers.com/leafroll-virus-tailgate-talk/) to share with those who were unable to attend.


Other educational materials available at the Tailgate Talk included a beneficial insect risk chart (so that growers are not accidentally killing the beetles and wasps which help with vine mealybugs) and a New Jersey extension article which describes abiotic and biotic causes of red leaves in the vineyard.

Growers really enjoyed the hands-on format of the meeting and learned a lot – the meeting lasted an extra hour! One grower and industry leader from Napa (who travelled to Lodi for this meeting specifically) commented that it was the best outreach meeting he’s ever been to, and we are now in close contact with him about virus management.

(impact: 1000+ industry members invited to annual tailgate talks; free and open to the public)

LODI WINEGRAPE COMMISSION
 LEAFROLL VIRUS TAILGATE TALK
 October 17th, 2018

A special thanks to our host, LangeTwins Winery & Vineyards, and both the American Vineyard Foundation and the CDFA PD/GWSS Board for funding Grapevine Virus educational outreach in Lodi! Today’s meeting is the culmination of months of dedicated research by the Lodi Winegrape Commission’s Research, Education, & Communication Committee’s Grapevine Virus & Mealybug Biocontrol Research Focus Groups.



AGENDA

Welcome by Stephanie Bolton, Lodi Winegrape Commission

Intro. to the Lodi Grapevine Virus & Mealybug Biocontrol Research Focus Groups

Summary of South Africa & New Zealand Leafroll Virus Management Strategies

Leafroll Virus Management Strategies by LangeTwins team & Charlie Starr

Presumed Red Blotch Vector by Cindy Preto, USDA-Parlier

Virus Workshop Stations in the Vines:
VIRUS SCOUTING, VIRUS TESTING, MEALYBUGS & BENEFICIALS,
 and **ALFALFA HOPPERS** with experts

Virus Workshop Stations: This is an interactive tailgate talk, where you are welcomed into the Cabernet Sauvignon vineyard (Clone 7, planted in 2013, Freedom rootstock, 10x7 spacing) to learn how to identify possible virus symptoms, to identify vine mealybugs & evidence of beneficial insects, to take a proper virus testing sample, and to scout for threecornered alfalfa hoppers with a sweep net. Enter any marked row and find someone there to lead an interactive lesson. Check out the microscope table for an up-close look at virus vectors!

We hope that you will take what you learn today into your own vineyards and those that you manage! Sweep nets are available to check out from Julie Sasak, our new VITICULTURE OUTREACH ASSISTANT, at the sign-in table.

When you see a mealybug, think “leafroll virus”!
Leafroll virus is known as the most economically devastating virus because it is the hardest to manage.

LEAFROLL VIRUS & VINE MEALYBUG FACTS
(aka why we keep talking about them)

- vine mealybugs can infect a grapevine with LEAFROLL VIRUS in just one hour
- it only takes one vine mealybug to cause a leafroll virus infection
- each female vine mealybug can produce HUNDREDS of eggs (300 on average)
- vine mealybugs have SEVERAL generations each growing season (5-7 in Lodi)
- vine mealybug mating in the late summer – fall determines the population for the next growing season
- vine mealybugs move into the lower trunk and roots during the Winter, then move up the vine in the Spring when the weather warms up
- grapevines infected with leafroll virus *may* experience lower yields, inefficient photosynthesis, higher acidity levels, decreased quality, poor color, and delayed/inhibited ripening




Figure 4. Page one of a ten-page handout given to attendees at the October 2018 Leafroll Virus Tailgate Talk hosted by the Virus Focus Group.

ANNUAL VIRUS WORKSHOP (in Spring of every year)

Every year, the Lodi Winegrape Commission hosts a virus workshop (called the Mealybug & Virus Outreach Meeting) with updated information and case studies from growers. This workshop provides timely, relevant information on nursery ordering, the CDFA Grapevine Registration & Certification Program, red blotch virus, leafroll virus, fanleaf virus, virus management, mealybugs, ants, and replanting after a virus infection. The first Workshop hosted by the Virus Focus Group (along with a similar team, the Mealybug Focus Group) was held on April 4th, 2018 and over 150 people from all over California attended the half-day meeting (Figure 5). Attendees received two complimentary mealybug traps (courtesy of Suterra) along with instructions on how to use them. Several attendees also received a draft version of the “Nursery Ordering 101: Viruses” booklet (see GRAPEVINE VIRUS WORKBOOK section). A follow-up workshop with Suterra helped people learn how to identify the male mealybugs in their traps, and the Lodi Winegrape Commission has since served as a resource for male mealybug identification. All seven virus testing labs in California attended the outreach meeting and six stayed in the afternoon for a break-out session on how to improve virus testing. This was the first time that all virus testing laboratories came together. Another afternoon break-out session discussed mealybug biocontrol trials.



Figure 5. The 2018 Mealybug & Virus Outreach Meeting in Stockton, CA.

In 2019, the Mealybug & Virus Outreach Meeting will include roundtable meetings for nurseries, laboratories, and regional grower associations along with extension personnel to discuss short- and long-term strategies to reduce virus vectors and inoculum in California. Also in 2019, South African Prof. Gerhard Pietersen (leafroll

expert) and Cornell University’s Dr. Marc Fuchs (red blotch expert) will be attending as keynote speakers and to consult with growers throughout the week. Dr. James Stamp (nursery material expert) and Dr. Kent Daane (mealybug expert) will also be speaking. We’re expecting growers, pest control advisors, nurseries, beneficial insect companies (including a drone company which releases the beetles), pheromone mating disruption companies (Suterra is providing free mealybug traps to attendees), our County Ag Commissioner’s office, a local USDA Tree Assistance Program representative, virus testing laboratories, Dr. Deborah Golino and Dr. Maher Al Rwahnih (FPS), Wine Institute, UC Farm Advisors, a North Carolina viticulturist, and many other people with the power to help reduce vectors and inoculum. The meeting will be held on April 4th, 2019, at the Stockton Cabral Ag Center and if you are reading this report we hope you will join us. The draft agenda is on the following page. *(impact: 1200+ industry members invited to annual workshops; free and open to the public)*

2019 MEALYBUG & VIRUS OUTREACH MEETING draft agenda

- | | |
|------------------------|--|
| 8:45 – 9:00am | CONTINUING EDUCATION CREDITS SIGN-IN.
3.5 hours of DPR CE (other) and 3.5 hours of CCA CE (IPM) |
| 9:00 – 9:15am | WELCOME & VIRUS OUTREACH PROJECT.
Stephanie Bolton, PhD, Lodi Winegrape Commission |
| 9:15 – 9:45am | VINE MEALYBUGS.
Kent Daane, PhD, UCCE |
| 9:45 – 10:20am | VIRUSES.
Marc Fuchs, PhD, Cornell University |
| 10:20 – 10:30am | COFFEE & NETWORKING BREAK. |
| 10:30 – 11:20am | LEAFROLL VIRUS MANAGEMENT.
Prof. Gerhard Pietersen, University of Stellenbosch, South Africa |
| 11:20 – 11:45am | PLANTING MATERIAL.
James Stamp, PhD, Stamp Associates |
| 11:45 – 12:05pm | OPEN Q&A SESSION.
Marc Fuchs, Gerhard Pietersen, James Stamp, Chris Storm |
| 12:05 – 12:10pm | CLOSING REMARKS & TAKE-HOME MESSAGES.
Stephanie Bolton, PhD, Lodi Winegrape Commission |
| 12:10 – 12:30pm | BREAK OUT SESSIONS with the pros: <ul style="list-style-type: none"> • Mealybug biocontrol insects • Pheromone mating disruption for vine mealybugs • Virus testing laboratories • Nursery ordering • CDFA Clean Grapevine Program/FPS • USDA Tree Assistance Program • Ant control |
| 12:15 – 1:15pm | CATERED LUNCH & DESSERT |

GRAPEVINE VIRUS GROWER WORKBOOK

We're in the process of writing a Grapevine Virus Grower Workbook which teaches growers why they need to care about viruses (using financial examples and case studies), where to start if their vineyard is sparsely or completely infected, how to identify/sample/test vines, how to rogue, the differences between red blotch, leafroll, and fanleaf viruses, how to manage for vine mealybugs, and how to order certified virus tested rootstock and scion (protocol 2010) from a nursery – plus why that is financially & socially important. The educational material includes plentiful, recent photographs (verified by testing), case studies, myth-busters, question & answer sections, industry interviews, and very importantly sections where the grower can record pertinent virus and vector management information for each vineyard.

Instead of waiting until the entire Workbook is ready for publishing (which will be too late), we have been distributing small “draft” booklets on selected topics as the information is verified and available, starting with a nursery ordering instructional booklet (“Nursery Ordering 101: Viruses,” first distributed in April 2018 after a peer review and included as Appendix A). A second booklet on “Vine Mealybug Management” is being created and reviewed for a targeted distribution at the April 4th, 2019, Mealybug & Virus Outreach Meeting. Approximately 4-5 small booklets will each undergo a peer review process and a grower test run in Lodi before they are improved and published altogether as a robust Virus Grower Workbook, projected to be completed in Spring 2020. Each booklet is being freely shared with any interested parties – we have received several requests for the first booklet. Additionally, booklets are shared with other winegrowing organizations with the hopes that they will customize the photos, information, and case study examples to their regional needs and grower audience.

(impact: distributed through Lodi Winegrape Commission to 800+ community members; available to the public and to other winegrowing regions)

Objective 6. To establish priorities for further grapevine virus research projects.

Thus far, it appears that research on the following topics is much needed:

1. An effective and efficient ant bait for use on large (50+) acre blocks to control ants which tend mealybugs.
2. The depth that mealybugs can be found on vine roots during the overwintering period (research is planned with Dr. Kent Daane).
3. A prevention strategy for leafroll replants (both individual vines and entire vineyard blocks).
4. The role of viruses in complexes with other biotic and abiotic stresses.
5. Rootstock and scion combinations which are more or less prone to virus disease symptoms.
6. How to determine the percent of a vineyard which is infected with virus in a cost-effective manner.
7. Cost-effective methods of virus testing.

When new researchers are looking for grower-relevant virus-related projects, we have been able to provide them with this list of priorities, invite them to our monthly meetings and outreach events, and provide input or access to vineyards and information as needed.

PRESENTATIONS & PUBLICATIONS RELATED TO THE FUNDED PROJECT.

(in addition to our own outreach meetings)

The Lodi Winegrape Commission is well-known in the industry and the PI is frequently requested to provide presentations and articles for various grower groups and media outlets. Even when the presentation is on a different topic (sustainability, etc.), we are always mentioning the virus outreach efforts and inviting growers from outside the area to join us. Additionally, a new grapevine virus email list-serve has been created to ensure that audiences outside of Lodi are adequately notified about virus outreach events and news. We believe in freely sharing information about viruses as it comes along and have been very proactive in leading conversations

with anyone interested in the format of their choosing. In fact, our virus outreach is getting mentioned for its leadership at nearly every industry virus presentation.



Pictured above: An email advertisement for the Turlock Tree & Vine Expo featuring a presentation on our outreach project.

Presentations:

“Grapevine Virus Management Strategies and an Update on Local Viruses.” Stephanie Bolton. March 1, 2019. Grow West 2019 Grape Grower Meeting. Lodi, California.

“Grapevine Virus Management in Lodi: A Collaborative Research & Integrated Outreach Effort to Help Solve a Statewide Challenge.” Stephanie Bolton. February 27, 2019. UC Davis Current Wine & Winegrape Research. Davis, California.

“Updates on LODI RULES and Virus Outreach.” Stephanie Bolton. February 7, 2019. California Sustainable Winegrowing Alliance Board Meeting. Lodi, California.

“Lodi Winegrape Commission Annual Meeting.” Stephanie Bolton. January 23, 2019. Lodi, California.

“Grapevine Virus Management in Lodi: A Collaborative Research & Integrated Outreach Effort to Help Solve a Statewide Challenge.” Stephanie Bolton. December 19, 2018. Pierce’s Disease Research Symposium. San Diego, California. (poster and talk)

“Grapevine Virus Management: What to Do Right Now.” Stephanie Bolton. November 6, 2018. Tree & Vine Expo. Turlock, California.

Written Articles:

“Ants: the secret weapon of the virus-vectoring vine mealybug.” Stephanie Bolton. Winter 2018-2019. CDFA PD/GWSS Newsletter. https://pdgwss.net/wp-content/uploads/2019/02/PD_Newsletter_Winter-2019.pdf

Adams, C. 2019. Where are they now? UGA Graduate School Magazine. Winter 2019. <http://gradmag.uga.edu/where-are-they-now-2/>

“Grapevine Virus Management in Lodi: A Collaborative Research & Integrated Outreach Effort to Help Solve a Statewide Challenge.” Stephanie Bolton. December 2018. Proceedings of the 2018 Pierce’s Disease Research Symposium. California Department of Food and Agriculture, Sacramento, CA.

“Grapevine Virus Research Focus Group.” Stephanie Bolton. Winter 2018. Lodi Grower Newsletter.
<https://www.lodigrowers.com/wp-content/uploads/2018/12/Winter-2018-Lodi-Grower-Newsletter.pdf>

“Lodi Grapevine Virus Field Workshop Provides Practical Advice: Grower Groups Developing Virus Best Management Practices and Outreach.” Ted Rieger. October 23, 2018.
<https://www.winebusiness.com/news/?go=getArticle&dataid=204938>

“Beneficial Insect Drones!” Stephanie Bolton. August 6, 2018. Online Viticulture Blog.
<https://www.lodigrowers.com/beneficial-insect-drones/>

“Lodi Grapevine Virus Research Focus Group.” Stephanie Bolton. Spring 2018. Lodi Grower Newsletter.
<https://www.lodigrowers.com/wp-content/uploads/2018/05/LODI-Grower-Spring-2018-Newsletter-FINAL-for-website.pdf>

RELEVANCE STATEMENT.

Establishing the Virus Focus Group and developing an agreed-upon outreach strategy has brought new energy and momentum towards solving the virus challenge and has opened communication between all sectors of the industry to transparently discuss successes and failures in virus management. The collaborative nature of this community, along with the immense experience of the Cooperators and generosity of expert consultants Gerhard Pietersen and Marc Fuchs, has set the stage for quickly discovering and implementing both short- and long-term virus management strategies first in Lodi and then statewide. There is a common recognition now that viruses are not just a nursery problem or one neighbor’s bad luck. Grapevine viruses are everywhere and are thus everyone’s problem – creating a unifying goal of finding real-world solutions so that everyone can stay in business. We are moving past the phase of blaming others, and into a new phase where every entity is taking responsibility, doing the best they can, communicating, and working together against the common enemy (vine mealybugs!).

The Virus Focus Group is seen as a leader in terms of providing grapevine virus outreach that is practical, relevant, and reaching not only the average grower but also laboratories, nurseries, and other states. We’ve started compiling binders full of virus information for other regions and extension personnel, and they are seeing great value in attending our outreach meetings.

It’s extremely important for virus extension to distribute a unified message which is based on science and real-world experience, and we are leading that charge while also filling in the gaps in virus communications between all sectors of our industry.

These coordinated efforts directed by the Lodi Winegrape Commission, a trusted source for real-world grower education, are reaching over one thousand winegrape growers and PCAs to quickly and effectively implement virus management initiatives while establishing priorities for future research. Cooperators are willing to invest their time and money into discovering virus management strategies for the greater good, and they are very capable of comparing management techniques due to the large number of acres they cover. Outreach materials created, workshops and meetings hosted, and the communication channels which are opening between industry sectors will be of utmost importance for the winegrape industry across the state of California, as we collectively develop a long-term strategy for lowering the state’s inoculum and reducing the spread of viruses.

LAYPERSON SUMMARY OF PROJECT ACCOMPLISHMENTS.

Principal Investigator Stephanie Bolton successfully led an outreach project entitled “Grapevine Virus Management in Lodi: A Collaborative Research & Integrated Outreach Effort to Help Solve a Statewide Challenge” during the 2018-2019 grant funding cycle. The overall objective of this continuing project is to learn how to best manage and prevent grapevine virus disease in the 110,000 acres of Crush District 11, providing outreach tools and strategies to be shared with other regions across California. Grapevine viruses pose a severe threat to the sustainability of California viticulture by decreasing yields, lowering fruit quality, and decreasing vineyard lifespans. Traditional extension is unable to meet the outreach needs of this crisis alone because decades of scientific research are still needed. The good news is that there are virus management strategies that growers can implement in the short-term while we wait for science to catch up, which can be taught through real-world, hands-on integrated outreach from a team of growers, extension personnel, pest control advisors, and scientists established as the Lodi Grapevine Virus Research Focus Group. Our team meets monthly to conduct a thorough review of regional perceptions of viruses, virus management in the literature, current virus research projects, and management of viruses locally and internationally, which we use to produce practical advice for growers.

We hosted a Mealybug & Virus Outreach Meeting (April 2018), a Mealybug ID Workshop (May 2018), a *Cryptolaemus* Beetle Drone Demo (July 2018), a Leafroll Virus Tailgate Talk (October 2018), and several breakfast meetings where viruses and their vectors were discussed. We produced a “Nursery Ordering 101: Viruses” booklet, draft versions of two additional virus management booklets, a red leaf handout, a mealybug poster, lists of grapevine virus resources, a threecornered alfalfa hopper handout, and a virus comparison chart. Presentations on the outreach project were given at the Tree & Vine Expo (Turlock), the Pierce’s Disease Research Symposium, the UC Davis Current Wine & Winegrape Research Event, the Grow West 2019 Grape Grower Meeting, and elsewhere. Outreach articles were written for the Lodi Grower Newsletter, the Pierce’s Disease Board Newsletter, online as blogs, and by the press. The first blind ring test for all virus testing labs in California was orchestrated by the Virus Focus Group during winter 2018-2019. Two Demonstration Vineyards were established – one managing leafroll virus through rogueing and another which is a full replant situation with rootstock trials in place. Virus testing across the region is documenting case studies and has elucidated the role of leafroll virus and Freedom rootstock in a mystery vine collapse. On April 4th, 2019, we will host a second Mealybug & Virus Outreach Meeting with invited speakers Gerhard Pietersen (South Africa), Marc Fuchs (Cornell University), Kent Daane (UCCE), and James Stamp (Consultant). This event will include outreach presentations, leadership sessions, and a grapevine virus influencer dinner for long-term strategizing. Outreach materials created, workshops and meetings hosted, and the communication channels which are opening between industry sectors are of utmost importance for the winegrape industry across the state of California, as we collectively lower virus inoculum and vector populations.

STATUS OF FUNDS.

Grant funds from the American Vineyard Foundation and the PD/GWSS Board, along with contributions made by the Lodi Winegrape Commission and Collaborators, have been used for monthly meetings of the PI and Collaborators, grapevine virus testing, outreach material printing, outreach meetings, and educational field trips. The project is performing well within the anticipated budget and at this point in the project it appears that all funding is appropriately allocated for specific, budgeted needs.

Additional funding is being requested during the 2019-2020 cycle for further grapevine virus testing, two outreach meetings, monthly meetings of the Virus Focus Group, and the culmination of outreach booklets into a Grapevine Virus Grower Workbook to be distributed across California and beyond.

INTELLECTUAL PROPERTY.

As per Lodi Winegrape Commission policy, educational materials are created for the greater good of viticulture and there is no restriction on the sharing of materials. The Workbook and a future candid virus video will be copyright protected through the Commission, but all outreach created during this project will be publicly available and with proper funding, outreach materials such as the Virus Grower Workbook can be distributed free of charge which will allow for wider distribution to the target audience of growers, extension personnel, and the California winegrape industry.

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American Vineyard Foundation
Cooperators and their employers
The Lodi Winegrape Commission

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