FINAL PERFORMANCE REPORT

AWARD YEARS 2016 FORWARD

FINAL PROJECT REPORT TEMPLATE

PROJECT INFORMATION

Project Title	Sustainable management of grapevine red blotch disease in Oregon			
Recipient Organization Name:	Oregon State University			
Period of Performance:	**Start Date:**	10/16/2017	**End Date:**	12/31/2020
Recipient's Project Contact				
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PERFORMANCE NARRATIVE

PROJECT BACKGROUND

Wine grapes are the most valuable specialty crop in Oregon, and are produced throughout the state. Grapevine red blotch disease (GRBD), caused by Grapevine red blotch virus (GRBV), is an emerging problem for all winegrape producing regions in Oregon. Its effect on fruit and wine quality has been reported to reduce profit margins for both growers and wineries, and thus affects whole-industry sustainability. The three-cornered alfalfa treehopper (*Spissistilus festinus*, Say) is a known vector of this virus. Other treehoppers found in Oregon vineyards are potential vectors. This two-year project proposal aims to bridge knowledge gaps and develop new tools required to manage GRBV in Oregon vineyards. Project objectives include: (1) determine GRBV distribution and incidence, (2) determine presence and significance of S. festinus and other treehoppers, (3) develop cultural practices to mitigate the negative effects of GRBV on fruit and wine quality, (4) develop sustainable management strategies for the virus and its vectors, and (5) disseminate information developed in this project to stakeholders (growers, nurseries, wineries, and state regulatory agencies) through a collaborative extension program that will be advised by a stakeholder panel drawn from throughout the state. The research and extension activities will be conducted by a multidisciplinary team of 10 investigators across all major wine producing regions of Oregon that include pathologists, entomologists, horticulturists, enologists, analytical chemists, and extension specialists.

ACTIVITIES PERFORMED

OBJECTIVES

#	Objective	Completed?	
		Yes	No
1	Determine GRBV distribution and incidence	X	
2	Determine presence and significance of *S. festinus* and other treehoppers	X	
3	Develop cultural practices to mitigate the negative effects of GRBV on fruit and wine quality	X	
4	Develop sustainable management strategies for the virus and its vectors		X

5	Disseminate information developed in this project to stakeholders through a collaborative extetnsion program that will be advised by a stakeholder panel drawn from throughout the state	X	

ACCOMPLISHMENTS

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
1	**Disease incidence:** - Between 2017 and 2020, eight vineyards in southern Oregon were carefully surveyed for the distribution and incidence of GRBV symptoms. In each year, at least 10,000 vines across all sites were visually rated. - Incidence ranged from 0.5% to 71.9% in Southern Oregon - Grower self-reports from across the state showed acreage-weighted disease incidence in 2020 to range from 2% in Eastern Oregon to more than 13% in the Willamette Valley.	- Disease distribution and incidence is highly varied throughout the state, with current acreage-weighted estimates of approximately 12%. - The vineyards that are implementing the practice of vine roguing at earlier stages of GRBD incidence seem to minimize disease incidence over time. If the roguing is not implemented, the disease can progress significantly in subsequent years.
2	**Vectors and IPM:** - Showed spread of virus between years. - *S. festinus* was found mainly in S. Oregon. - Potential vector populations could be reduced by repellents (such as Surround) but the impact of clean cultivation was unclear	- Spread is likely caused by a vector, possibly treehoppers (Membracidae), but also other newly discovered species. - *S. festinus* is likely not a key vector in Willamette Valley vineyards - Clean cultivation may not be an appropriate method for reducing vector populations but repellents may be a sustainable management option
3	**Cultural practices:** - Showed that water deficits reduce fruit quality in GRBV+ vines, but supplemental irrigation mitigates negative disease symptoms somewhat. - Increasing soil-applied NPK fertilizer does not mitigate negative symptoms of viral infection if vines are already well-fertilized. However, foliar application of potassium fertilizer (at veraison) may help improve fruit ripening regardless of nutrient status. - Exogenous application of ABA to clusters (at veraison) does not improve fruit quality in GRBV-infected grapevines. - Showed that pre-bloom leaf removal may help to improve fruit ripening. **Grape compositional differences:** - Grapes from GRBV+ vines often had reduced Brix but the severity of the differences in Brix was seasonal. Differences in acid (pH and/or titratable acidity) were noted but not consistent between seasons. **Fermentation kinetics:** - No consistent impact on fermentation kinetics was noted. Grapes from GRBV+ vines fermented at a similar rate as grapes from GRBV- vines with no impact of irrigation treatment. **Wine compositional differences:**	- Keeping GRBV-infected grapevines well-watered helps to mitigate some of the negative symptoms of viral infection. - Foliar applications of potassium during ripening may improve fruit quality. - Plant growth regulators do not improve fruit quality (and are very expensive), thus are not recommended. - Timely canopy management practices can mitigate some negative symptoms - Cultural practices that improve grape and wine color should be considered while differences in Brix could be compensated for at the winery through sugar addition. However, the practical significance of the lower wine color is dependent on whether wines with lower color are deemed lower quality based on sensory analysis. GRBV did not impact fermentation kinetics and should not be a concern for winemakers

#	Accomplishment or Impact	Relevance to Objective, Outcome, and/or Indicator
	- As expected, differences in ethanol reflected differences in Brix between treatments. 2018 and 2019 wines made from grapes harvested from GRBV+ vines had reduced color density and polymeric pigment compared to wines made from grapes harvested from GRBV- vines.	
4	- Updated GRBD Information is available online through OSU Extension and OWRI websites. - Annual workshops held in 2018 and 2019, and online webinar series took place in 2020 (due to COVID-19 restrictions)	- With increased outreach during project period, industry has become well informed about the disease, are testing vines to confirm disease presence, and making management changes in the vineyard to ameliorate potential shortcomings in wine quality.

CHALLENGES AND DEVELOPMENTS

#	Challenge or Development	Corrective Action or Project Change
1	- We surveyed five vineyards in 2017. Two of the vineyard block was removed due to disease severity in 2019. We could not continue to report the disease progress in all vineyards that we started.	- We added three new vineyard blocks in 2020. Now the project is self-sustainable through other funding sources, these vineyards will be regularly monitored for disease progress over time.
2	- It is not clear if spread is because of virus latency, or actual transmission in the field. - Current known vectors have not been positively determined - Management options were difficult to evaluate due to lack of positively identified vectors and the desire of growers to treat for potential vectors in vineyards where red blotch was present and spreading	- More effective sampling and monitoring and diagnosis of the virus is needed. - Additional transmission biology experiments are needed. - Studies on vector transmission and control were moved to more controlled environments. Research vineyards in southern Oregon (at SOREC) are being used to study vector transmission and the effect of groundcover on potential vector populations.
3	- Colloborating grower harvested plots without notice resulting in lost data.	- Trial was being replicated in another site, so some those data were still salvageable.
4	- Covid restriction limited in person meetings during 2020.	- The use of online tools to meet with growers was increased and proved an effective means of outreach.

LESSONS LEARNED

Provide recommendations or advice that others may use to improve their performance in implementing similar projects.

Though our project outcomes benefitted greatly from the diversity and expertise of our team in the various fields of research and extension, it is important to highlight several lessons that were learned. Marketing the project and its goals to the industry is of utmost importance to get buy-in from stakeholders. This will help to get meaningful and robust survey data, but also positive collaborations in field work. Communication with collaborating growers in the field is key, and we experienced some data loss due to some mixed up messaging. Redundancy in trials is also important to mitigate against this data loss (e.g. don't put all eggs in one basket when doing field work). With respect to outreach, the project team needs to have a cohesive, unified message to stakeholders, and the outreach program must be highly coordinated.

CONTINUATION AND DISSEMINATION OF RESULTS (IF APPLICABLE)

We were funded through USDA-SCRI to continue work on Red Blotch virus for the next few years. The USDA-SCRI project continues and greatly expands on the research and extension activities that our group has been conducting on a national scale and will last until 2024. From a virology perspective, the additional funding will allow us to continue work on disease surveys and fine-tuning testing and diagnostic techniques. From an entomology perspective, the additional funding will allow us to continue work on insect vectors and help us determine the relative importance of potential vector insects commonly found in vineyards. We are also developing traps that are species-specific. These traps will enable more effective and targeted monitoring of insects that are often cryptic in nature. Additional data gathering using these traps will create more detailed biological and ecological information that can possibly help to understand the timing of virus transfer. Finally, from a viticulture and enology perspective, the additional funding will allow us to continue work on understanding virus effects on plant physiology so that cultural practices may be tailored to virus-infected vineyards to maximize productivity and wine quality. We will continue extension and outreach efforts to stakeholders throughout the state. Two journal articles related to objectives 2 and 3 have been published in scientific journals (one in entomology and one in viticulture; see below). We expect to publish results from Objective 1 in one of the plant disease/virology journals. Two graduate students have graduated, and one more is expected in 2021 (see below).

BENEFICIARIES

Number of project beneficiaries:.....80% of Oregon wine grape growers

OUTCOME(S) AND INDICTATOR(S)/SUB-INDICATOR(S)

OUTCOME MEASURE(S)

Outcome 4: Enhance the competitiveness of specialty crops though greater capacity of sustainable practices of specialty crop production resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources

Outcome 5: Enhance the competitiveness of specialty crops through more sustainable, diverse, and resilient specialty crop systems

OUTCOME INDICATOR(S)

#	Outcome and Indicator	Quantifiable Results
1	Outcome 4, Indicator 2a: Seventy percent of the wine grape growers that have GRBaV will adopt the pest management practices developed from the results of this study.	At project end, 97% of surveyed growers were trying to manage GRBD in the vineyard compared to not managing it at all. In the vineyard, most of the changed management practices reflected the results from our research trials. The most common management practice (25% of all responses) was removal of infected vines and replanting with clean stock. Growers reported increased cluster zone leaf removal, and foliar fertilization applications, both of which were shown to be moderately effective in mitigating the most notable fruit symptoms (delayed ripening).
2	Outcome 4, Indicator 2b: Of the wine grape growers that participate in this study, 50% will report increased dollar returns per acre or reduced costs per acre	By project end, only 71% reported that GRBD had not had a negative impact on their business or were unsure (n = 41).

	because of implementation of the pest management practices developed herein.	
3	Outcome 5, Indicator 6: Of the wine grape growers that participate in this study, 80% will be trained to identify Red Blotch disease symptoms and/or insect feeding damage, and be prepared to respond quickly such that the negative effects of the disease are minimized.	At the end of the project, 81% of surveyed wine grape growers reported that they were confident to extremely confident in visual symptom indentification of GRBD (n = 41). The data also show that a higher percentage of growers were confirming their visual symptom ID with lab testing – 62% of growers (n = 76) reported confirming visual symptoms with testing at the end of the study compared to only 54% of growers (n = 48) at the beginning. We also documented a higher percentage of growers sending green tissue samples to labs for testing compared to woody tissue samples.
4	Outcome 5, Indicator 8: Of the wine grape growers in Oregon 60% will learn of best management practices for GRBD through online webinars, technical bulletins, and extension field days.	By project end, 77% of growers reported being knowledgeable to extremely knowledgeable (n = 90). More importantly, there was a huge improvement in the percentage of growers that reported being aware of of GRBD management options by project end – from only 37% (n = 41) in the beginning, to 90% (n = 42) at the end.

DATA COLLECTION

Explain what data was collected, how it was collected, the evaluation methods used, and how the data was analyzed to derive the quantifiable indicator.

Qualtics surveys were sent out at project start (early 2018) and project end (late 2020) to wine producers statewide using Oregon Wine Research Institute email lists that have ~2500 recipients. Surveys were short, but specifically polled participants about their familiarity with GRBD, its symptoms, its management, economic consequences, and overall affected acreage. Since project activities were conducted mostly in between two surveys, change in response was interpreted as due to the research and extension efforts of the project PIs.

FEDERAL PROJECT EXPENDITURES

EXPENDITURES

Cost Category	Amount Approved in Budget	Amount Approved in 2020 Re-budget	Actual Federal Expenditures (Federal Funds ONLY)
Personnel	$80,811	$93,991	$100,272
Fringe Benefits	$29,513	$37,312	$26,433
Travel	$6,084	$6,033	$1,281
Equipment	$0	$0	$0
Supplies	$56,028	$37,600	$35,410
Contractual	$0	$0	$0
Other	$2,500	$0	$0
Direct Costs Sub-Total	$174,936	$174,936	$163,396
Indirect Costs	$0	$0	$0
Total Federal Costs	$174,936	$174,936	$163,396

ADDITIONAL INFORMATION

Publications and Intellectual Contributions – Peer Reviewed

Journal Articles:

- Levin, A., & KC, A. N. (2020). Water deficits do not improve fruit quality in Grapevine Red Blotch Virus-infected grapevines. *Frontiers in Plant Science*. DOI: 10.3389/fpls.2020.01292
- Dalton, D. T., Hilton, R. J., Kaiser, C., Daane, K. M., Sudarshana, M. R., Vo, J., Zalom, F. G., Buser, J. Z., Walton, V. M. (2019). Spatial Associations of Vines Infected With Grapevine Red Blotch Virus in Oregon Vineyards. *Plant Disease.* DOI: 10.1094/PDIS-08-18-1306-RE

Theses:

- Copp, C. (expected June 2021). Efficacy of Cultural Practices For Mitigating the Negative Impacts of Grapevine Red Blotch Virus on Vine Physiology and Fruit Composition. Master's Thesis. *Oregon State University.*
- Dalton, D. (2020). Evaluation of grapevine red blotch virus epidemiology with reference to potential insect vectors. PhD Dissertation. *Oregon State University.*
- Litwin, J. (2020). Assessment of Grapevine Red Blotch Virus Impacts on Physiology, Productivity, and Fruit Composition of 'Pinot noir' Grown in Oregon's Willamette Valley. Master's Thesis. *Oregon State University.*

Abstracts:

- Copp, C., KC, A. N., & Levin, A. (2020). Efficacy of Cultural Practices for Mitigating Negative Effects of Grapevine Red Blotch Disease in Oregon Pinot Noir. *2020 ASHS Annual Conference*.
- Levin, A., & KC, A. N. (2019). Deficit Irrigation Reduces Fruit Quality in Grapevine Red Blotch Virus-Infected Pinot noir Grapevines. *70th ASEV National Conference*.
- Litwin, J., Martin, R., & Skinkis, P. (2019). Effects of Red Blotch Disease on Pinot noir under Oregon's Cool Climate Conditions. *70th ASEV National Conference.*
- Levin, A., Dalton, D. T., Walton, V. M., & KC, A. N. (2018). Exogenous Application of Abscisic Acid (s-ABA) Does Not Influence Fruit Ripening in Red Blotch-Infected Grapevines. *69th ASEV National Conference*.
- Levin, A., & KC, A. N. (2018). Interaction of Deficit Irrigation and Grapevine Red Blotch Virus (GRBV) on Disease Development and Grapevine Physiology. *69th ASEV National Conference*.
- KC, A. N., Rasmussen, A. L., & Levin, A. (2018). Red blotch disease severity in relation to deficit irrigation. *Phytopathology*.

Publications and Intellectual Contributions – Other

Magazine/Trade Publications:

- Levin, A. (2019). Can the Effects of Grapevine Red Blotch Disease be Mitigated with Cultural Practices?. *Wine Business Monthly*, (July 2019).

Newsletter:

- Copp, C., KC, A. N., & Levin, A. (2020). Effects of Grapevine Red Blotch Disease (GRBD) on vine physiology and potential vineyard management strategies for symptom mitigation. *OWRI Technical Newsletter*.
- Levin, A., & KC, A. N. (2018). How do deficit irrigation and grapevine red blotch virus influence disease severity, water status, yield, and fruit composition?. *OWRI Technical Newsletter*.

Research Report:

- Qian, M. C., & Levin, A. (2019). Effects of Grapevine Red Blotch Disease on Flavor and Flavor Precursor Formation in the Grape and on Wine Quality. In *Research Progress Reports: Pierce's Disease and Other Designated Pests and Diseases of Winegrapes*. https://www.cdfa.ca.gov/pdcp/Documents/Proceedings/2019ResearchProgressReports.pdf