Keeping them fed and happy: Mitigating negative effects of Grapevine Red Blotch Disease (GRBD) through cultural practices

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Summary

Background and rationale. While entomological and viral research continues, wine grape growers desperately need more viticultural information on how to successfully farm GRBV-infected blocks in the interim period. The overall objective for this two-year project is to address vineyard management concerns by evaluating vine response to cultural practices in GRBD-afflicted vineyards. Specifically, project objectives are to (1) conduct on-farm field trials in collaboration with growers to determine best viticultural practices for the mitigation of GRBD in relation to wine grape production and fruit quality; and (2) determine the effects of mitigation practices on quality and sensory characteristics of wines made from GRBV-infected fruit. Accordingly, two field experiments were successfully established in majority GRBV-infected blocks at a commercial winery-vineyard operation located near Ashland, OR.

Disease testing and treatment imposition. After PCR testing, 95% of the vines resulted GRBV+ and only few GRBV- vines identified. Therefore, the treatments were imposed based on test results to only positive vines and the GRBV- treatment level was dropped from both experiments. To impose irrigation treatments, a second drip line was installed in those rows that were randomly selected to receive supplemental irrigation (in each experiment), and treatments were applied just after berry set. Control treatments received 259 L/vine, while supplemental treatments received 518 L/vine. Supplemental fertilization (applied through the drip system) treatments were imposed in specified plots by keeping drip line valves open (during application) for double the amount of time designated for the grower control fertilization treatments. Cumulative applied amounts of nitrogen (N), phosphorus (P), and potassium (K) in control treatments were 12.9, 1.24, and 11.1 kg/ha, respectively, and supplemental treatments received 2x the aforementioned amounts. Crop level was adjusted to one cluster per shoot just after berry set by thinning vines to one cluster per shoot.

Preliminary results. Disease severity at harvest was significantly reduced (10-19%) with supplemental irrigation in both experiments. In contrast, it was unaffected by supplemental fertilization or crop thinning, and there were no significant interactions among treatments. Notably, vines on both rootstocks responded similarly to irrigation and thinning treatments. There were no significant treatment effects on total soluble solids (TSS; °Brix) in either experiment, though in some cases, TSS trended lower with supplemental irrigation and higher with thinning. In contrast, juice pH was more strongly affected by treatments. Juice pH was significantly higher in vines receiving supplemental fertilization, and in thinned vines. Juice pH trended lower with supplemental irrigation, but this effect was not significant, nor consistent across experiments/treatments.

Unified Grant Management for Viticulture and Enology
ANNUAL REPORT 2018-2019 FUNDING CYCLE

OREGON WINE BOARD (OWB)

Project Title: Keeping them fed and happy: mitigating negative effects of Grapevine Red Blotch Disease (GRBD) through cultural practices

UGMVE proposal number: 2018-2223

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Objective(s) and Experiments Conducted to Meet Stated Objective(s):

1. Conduct two field experiments in majority GRBD-afflicted blocks at a commercial site to determine best viticultural practices for the mitigation of GRBD in relation to wine grape production and fruit quality. Experiments aim to:
   1.1. Manipulate vine water and nutrient status by providing supplemental irrigation and fertilization.
   1.2. Manipulate vine source-sink balance by reducing crop level.
2. Make wines from experimental plots and determine the effects of mitigation practices on wine quality and sensory characteristics.

Summary of Major Research Accomplishments and Results by Objective:

Objective 1: Conduct two field experiments in majority GRBD-afflicted blocks at a commercial site to determine best viticultural practices for the mitigation of GRBD in relation to wine grape production and fruit quality

Two field experiments were successfully established in majority GRBV-infected blocks at a commercial winery-vineyard operation located near Ashland, OR. However, due to vineyard design complexities and field-level limitations in the implementation of the treatments, a few characteristics in the experimental design were altered relative to the initial proposal. Plot maps of both experiments are shown in Figure 1.

First, the number of replications in the supplemental inputs experiment was reduced from five to four. Second, blocks were replicated *across* rows in the rootstock/irrigation/thinning experiment as opposed to *down* the rows as previously proposed. This was done in part to satisfy the desires of the vineyard owner that we do not manipulate the existing drip line, but also in part to simplify sampling. Therefore, irrigation treatments were imposed in a different manner. While this reduced the number of replications from five to four, it ultimately simplified the field design and treatment imposition.

Finally, there was a lack of vines that tested as GRBV-, resulting in a highly unbalanced design. In fact, almost no GRBV- vines were identified in the block that was used for the supplemental inputs experiment. More GRBV- vines were identified in the rootstock/irrigation/crop level experiment (in the spring), but showed GRBD symptoms at harvest, and were subsequently tested as GRBV+. Therefore, the GRBV- treatment level was dropped from both experiments. While this reduces the power of the study to some degree – by not having a "true" control; i.e. not being able to compare with a healthy vine, it manages to further simplify sampling and narrows the research question such that the response of GRBV+ vines to management inputs can still be measured and evaluated.

Phenology and irrigation treatments. Mean dates of budbreak, bloom, and veraison at the study site were 23 April, 3 June, and 10 August, respectively. Crop level was experimentally adjusted just after berry set on 20 June 2018 by thinning vines to one cluster per shoot. The grower standard practice of thinning crop to reduce cluster bunching or stress on "short shoots" occurred just after veraison, and was applied equally to all treatments. Harvest occurred on 1 and 2 October for the supplemental inputs and crop level experiments, respectively.

In order to increase applied water amounts for all 2x irrigation treatments, a second drip line was installed in those rows that were randomly selected to receive supplemental irrigation (in each experiment). All irrigation treatments were imposed on 5 July. Control treatments received 259 L/vine, while supplemental treatments received 518 L/vine.

Fertilization timing and amounts. Fertilization was applied through the irrigation system. Supplemental fertilization treatments were imposed in specified plots (i.e. whole rows) by keeping drip line valves open (during application) for double the amount of time designated for the grower control fertilization treatments. Fertilizer applications conducted in three applications (instead of two), and were later (at berry set, one week before veraison, and two weeks post veraison) than anticipated (one month after budbreak and at berry set).

Fertilizer application rates and dates are given in Table 1. Control rates (and therefore supplemental rates) were determined by the grower-collaborator. Cumulative applied amounts of nitrogen (N), phosphorus (P), and potassium (K) in control treatments were 12.9, 1.24, and 11.1 kg/ha, respectively. Supplemental treatments received 25.8, 2.48, and 22.2 kg/ha for N, P, and K, respectively. Most of the N (76%) was applied prior to veraison, whereas most of the K (64%) was applied after veraison. In contrast, P was applied evenly across all applications.

Disease incidence and severity at harvest. Disease incidence was evaluated at harvest as number of vines with red blotch symptoms to the total number of vines in the entire treatment row. Disease severity was evaluated at harvest using a standard Horsfall- Barratt scale where percentage of red blotch symptomatic leaves per treatment vine was recorded. No significant differences among treatments on disease incidence was observed in both experiments. However, disease severity was significantly reduced (10-19%) with supplemental irrigation in both experiments (Figs. 2 and 3). In contrast, it was unaffected by supplemental fertilization or crop thinning, and there were no significant interactions among treatments. Notably, both rootstocks responded similarly to irrigation and thinning treatments (Fig. 3).

Crop yield and quality. In both experiments, supplemental irrigation significantly increased crop yield (Tables 2 and 4). Supplemental fertilization had no significant effect on yield (Table 2), while thinning significantly reduced yield for both rootstocks (Table 4). While there were no significant differences in various yield components among all experiments/treatments, this was expected given that yield formation in grapevines is a two-year process, and the treatments were only imposed for one year. Therefore, any treatment effects on yield components such as cluster number or berry number would be observed next year. Accordingly, the differences in yield due to irrigation treatments were primarily a result of larger clusters, which in turn were a result of larger berries. This effect was more pronounced in the thinning experiment.

There were no significant treatment effects on total soluble solids in either experiment (Tables 3 and 5), though in some cases, Brix trended lower with supplemental irrigation and higher with thinning. In contrast, juice pH was more strongly affected by treatments. Juice pH was significantly higher in vines receiving supplemental fertilization, and in thinned vines. Juice pH trended lower with supplemental irrigation, but this effect was not significant, nor consistent across experiments/treatments. As of this writing, analysis of various phenolic quality parameters in response to treatments is still ongoing.

Objective 2: Make wines from experimental plots and determine the effects of mitigation practices on wine quality and sensory characteristics.

The relative lateness of the harvest created logistical and winery fermentation capacity related challenges. The large number of plots in both experiments was such that the pilot winery in Corvallis did not have the capacity to conduct all winemaking operations given their heavy project load. However, non-replicated research wines from the irrigation and fertilization trial were made at the commercial scale (one barrel per treatment) by Rob Folin at Belle Fiore winery. These wines were produced under the same protocol, and were put into neutral barrels of the same age, cooperage, toast, etc. Wines are currently being stabilized and aged before bottling. It is anticipated that they will be evaluated at upcoming outreach events.

Outside Presentations of Research:

Growers and other stakeholders throughout the state have been abreast of this study since its inception on June 18th, 2018, a summary of this project and its objectives were shared with statewide stakeholders on the OWB website. In addition, the experimental field site was toured with regional growers as a part of the Rogue Valley Winegrowers Association (RVWA) annual vineyard tour in late-July 2018.

Thus far, the preliminary results of this work have been communicated to Oregon wine grape growers face-to-face at the annual Red Blotch workshop in Salem, OR on November 29th, 2018. They were also summarized in a follow-up OWRI Vine to Wine newsletter article distributed to statewide stakeholders in December 2018. A research summary will also be presented to the membership of the RVWA at their annual dinner in late January 2019. As of this writing, a popular press article is being edited for publication in Wines & Vines, and will be published in early 2019.

Results from this and other Red Blotch-related work will be presented to growers at the Oregon Wine Symposium in Portland on February 12th, 2019, and at the 5th Annual Southern Oregon Grape Symposium on March 12th, 2019. Abstracts and posters highlighting this work are being developed for OWRI Grape Day in Corvallis, OR on April 3rd, 2019, as well as for the 70th Annual American Society of Enology and Viticulture National Conference in Napa, CA in mid-June 2019. It is anticipated that final research results will be published in the American Journal of Enology and Viticulture upon completion of the study.

Research Success Statements:

Given the large amount of vineyard acreage that has been reported with GRBD, and the high cost of replanting vineyards, growers are desperate for any and all cultural tools they can employ to mitigate the disease. Accordingly, this research was established to test a suite of cultural practices aimed at *potentially* mitigating negative effects of GRBD. Field trials were established in 2018 in neighboring blocks of the same vineyard, planted on a uniform soil type. Helpful assistance from the vineyard management team allowed for the quick imposition of field treatments and subsequent data collection. Most importantly, a graduate student was recruited for this project in late-September 2018, and though he missed harvest activities – due to the misalignment of academic and agricultural calendars – he has since been intimately involved with laboratory work. It is anticipated that his addition to the team will allow for even more rigorous data collection and insight in this study.

At this point it is too early to determine whether the cultural practices tested herein could be used to successfully mitigate GRBD in vineyards. It appears that at the very least, increasing irrigation could reduce disease severity from a foliar symptom perspective. However, whether or not this makes a difference from a fruit quality perspective remains an open question – given that some 2018 data has yet to be analyzed and wines yet to be tasted. It is possible that the outcomes of this study reveal that negative symptoms of GRBD cannot be mitigated with cultural practices. While this would be a disappointing outcome, it would narrow the focus of future GRBD management strategies. At the same time, it is yet to be investigated the carry over effect of management practices on vine health (healthy canopy and less disease severity) and response to the GRBV and subsequent outcomes on fruit quality in following years.

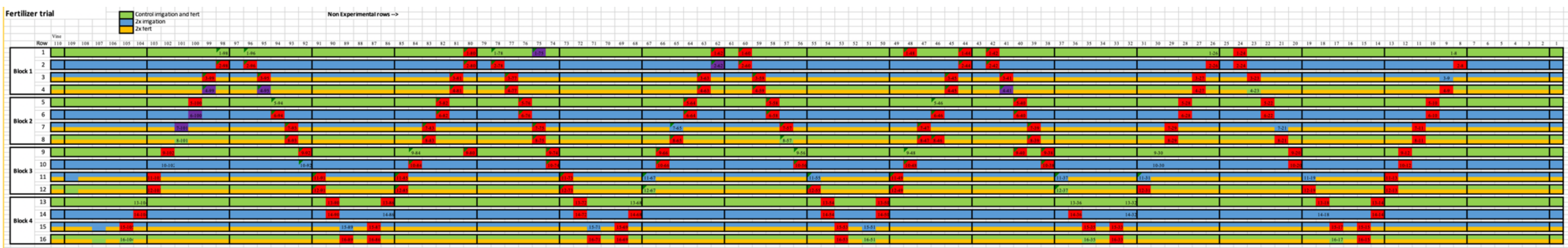
Funds Status:

A total of $14,897 has been used as of the date of this report. The majority of the spent funds were used to pay the salary and OPE of the graduate student (GRA). The remaining funds were spent on laboratory supplies/expenses and travel. The remaining money will be used to support our graduate student during the winter and spring terms on the Corvallis campus, as well as during the summer term at SOREC. In addition, a portion of the remaining funds will be used to support Dr. Levin's summer salary and benefits. It is also anticipated that there will be some additional supplies needed to finish up analyses of 2018 samples. Finally, remaining funds from the 2018-2019 funding cycle will be used for travel expenses associated with PI and GRA travel between campus and SOREC, as well as to the ASEV national conference in Napa, CA.

Appendix 1: Figures

Figure 1

Plot maps of the supplemental inputs (top) and rootstock/irrigation/thinning (bottom) experiments. Combinations of green, blue, yellow, and orange colors indicate various treatment combinations, while red or purple cells indicate individual vines that tested positive or negative, respectively.



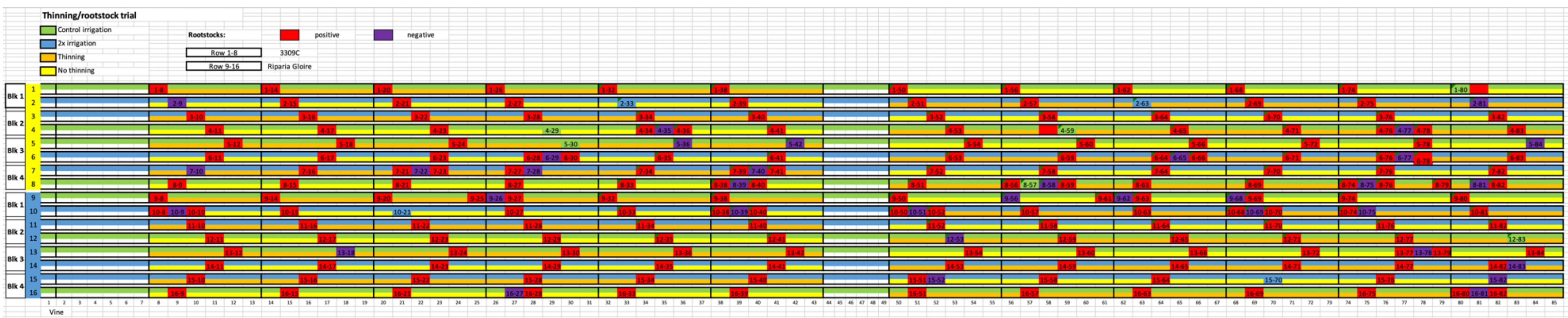


Figure 2
Disease severity ratings of GRBV+ vines subjected to either grower control or supplemental (2x grower control) fertilization or irrigation. Ratings were conducted just prior to harvest. Data are treatment means (n = 4). Error bars are one standard error. '***', '**', or '*' indicate statistically significant differences between treatments at $P < 0.001$, 0.01, or 0.05, respectively.

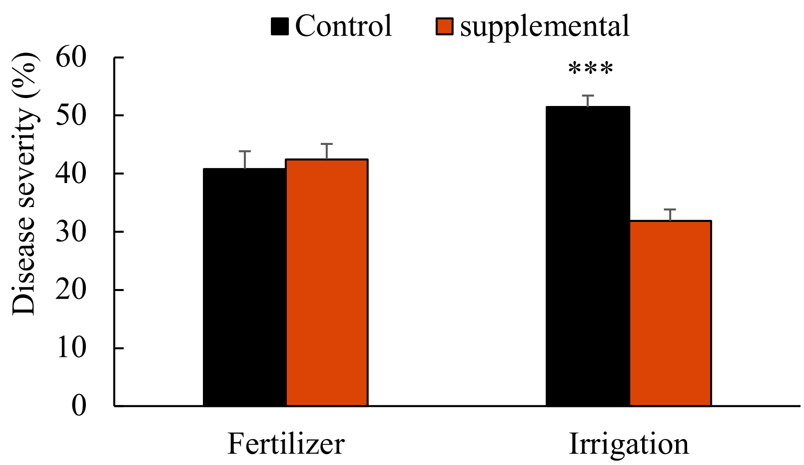
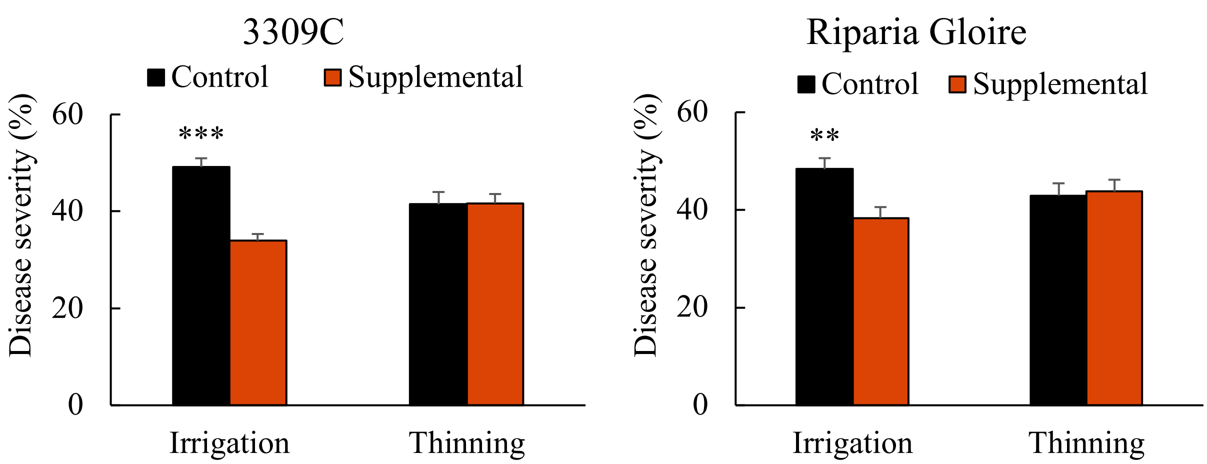


Figure 3
Disease severity ratings of GRBV+ vines across two rootstocks (3309C and Riparia Gloire) subjected to grower control or supplemental (2x grower control) irrigation, or grower control or supplemental thinning (one cluster/shoot). All other information is as in Figure 2.



Appendix 2: Tables

Table 1
Date and control rates of nitrogen (N), phosphorus (P), and potassium (K) applied in 2018 for the Supplemental Inputs experiment. Supplemental vines received 2x the rates given below for all applications.

Date	N	P	K
		------- *kg/ha* ------	
27 Jun	4.37	0.34	1.79
2 Aug	5.49	0.45	2.24
28 Aug	3.03	0.45	7.06
Total	**12.9**	**1.24**	**11.1**

Table 2
Crop yield and yield components in response to supplemental irrigation and fertilization. Control treatments (Cont.) were grower control and supplemental treatments (Supp.) were 2x grower control. Data are treatment means ± one standard error (n = 4). Values followed by different letters for each parameter are significantly different at $P < 0.05$.

Irrigation	Fertilization	Yield (kg vine^{-1})	Clusters vine^{-1}	Cluster FW (g cluster^{-1})	Berries cluster^{-1}	Berry FW (g berry^{-1})
Cont.	Cont.	3.2 ± 0.2 ab	23 ± 1 a	141 ± 8 a	122 ± 7 a	1.17 ± 0.05 a
	Supp.	2.8 ± 0.2 a	21 ± 1 a	136 ± 8 a	118 ± 7 a	1.16 ± 0.05 a
Supp.	Cont.	3.9 ± 0.2 b	26 ± 1 a	155 ± 8 a	122 ± 7 a	1.27 ± 0.05 a
	Supp.	3.7 ± 0.2 b	25 ± 1 a	150 ± 8 a	119 ± 7 a	1.26 ± 0.05 a

Table 3
Juice composition in response to supplemental irrigation and fertilization. All other information is as in Table 2.

Irrigation	Fertilization	Total soluble solids (°Brix)	pH
Cont.	Cont.	21.0 ± 0.7 a	3.53 ± 0.03 ab
	Supp.	21.2 ± 0.7 a	3.61 ± 0.03 c
Supp.	Cont.	20.3 ± 0.7 a	3.49 ± 0.03 a
	Supp.	20.4 ± 0.7 a	3.56 ± 0.03 bc

Table 4
Crop yield and yield components in response to supplemental irrigation and crop thinning across two rootstocks. Control treatments (Cont.) were grower control. Supplemental irrigation treatments (Supp.) were 2x grower control, while supplemental thinning treatments were thinned to one cluster/shoot at berry set. Data are treatment means ± one standard error (n = 4). Values followed by different letters for each parameter for a given rootstock are significantly different at $P < 0.05$.

Rootstock	Irrigation	Thinning	Yield (kg vine^{-1})	Clusters vine^{-1}	Cluster FW (g cluster^{-1})	Berries cluster^{-1}	Berry FW (g berry^{-1})
3309C	Cont.	Cont.	3.7 ± 0.2 bc	23 ± 1 b	160 ± 9 a	124 ± 5 a	1.29 ± 0.04 ab
		Supp.	2.3 ± 0.2 a	14 ± 1 a	165 ± 9 a	124 ± 5 a	1.32 ± 0.04 ac
	Supp.	Cont.	4.3 ± 0.2 c	24 ± 1 b	182 ± 9 a	128 ± 5 a	1.42 ± 0.04 cd
		Supp.	2.9 ± 0.2 ab	15 ± 1 a	186 ± 9 a	128 ± 5 a	1.45 ± 0.04 bd
Riparia Gloire	Cont.	Cont.	3.0 ± 0.2 b	19 ± 2 ab	153 ± 14 a	145 ± 9 a	1.01 ± 0.06 a
		Supp.	2.4 ± 0.2 a	14 ± 2 a	178 ± 14 a	146 ± 9 a	1.27 ± 0.06 b
	Supp.	Cont.	3.8 ± 0.2 c	23 ± 2 b	169 ± 14 a	140 ± 9 a	1.26 ± 0.06 ab
		Supp.	3.2 ± 0.2 b	17 ± 2 ab	194 ± 14 a	141 ± 9 a	1.30 ± 0.06 ab

Table 5
Juice composition in response to supplemental irrigation and crop thinning across two rootstocks All other information is as in Table 4.

Rootstock	Irrigation	Thinning	Total soluble solids (°Brix)	pH
3309C	Cont.	Cont.	24.4 ± 0.4 a	3.80 ± 0.04 b
		Supp.	24.6 ± 0.4 a	3.94 ± 0.04 c
	Supp.	Cont.	24.9 ± 0.4 a	3.65 ± 0.04 a
		Supp.	25.1 ± 0.4 a	3.79 ± 0.04 b
Riparia Gloire	Cont.	Cont.	23.1 ± 0.5 a	3.73 ± 0.04 a
		Supp.	24.4 ± 0.5 a	3.88 ± 0.04 b
	Supp.	Cont.	22.9 ± 0.5 a	3.72 ± 0.04 ab
		Supp.	23.2 ± 0.5 a	3.79 ± 0.04 ab