FINAL REPORT

Washington State Grape and Wine Research Program

DUE 5:00 p.m. December 12th, 2016
by email to: ARCGrants@wsu.edu

Wine Research Advisory Committee Research Review – January 18-19, 2017

PROJECT TITLE: Evaluating the Impacts of Early Fruit-Zone Leaf Removal in Red Wine Grape Varieties

Project Duration: FY15, FY16, and FY17 (July 2014-June 2017)
WRAC Project No.:

PI Name:	**Michelle M. Moyer**
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Cooperator Name:	**Jim Harbertson**	**Cooperator Name:**	**Devon Newhouse**
Organization	WSU – Wine Science Center	Organization	Newhouse Farms Inc (Sunnyside, WA)
Description of participation:	Dr. Harbertson's lab performed most wine analyses and winemaking for the project.	Description of participation:	Mr. Newhouse donated the use of his land, labor in operating the mechanical leaf remover and harvest equipment, and the fruit for winemaking for the entire duration of the project.

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BUDGET AND OTHER FUNDING SOURCES

FINAL FINANCIAL REPORTING

BUDGETS*:* 3355-5789 and 3355-6789

	Year 1 FY15	Year 2 FY16	Year 3 FY17
	Jul 14 – Jun 15	Jul 15 – Jun 16	Jul 16-Jun 17
Item			
Salaries[1]	$32,854	$24,012	$23,697
Benefits[1]	$13,892	$9,845	$11,055
Wages[2]	$11,520	$12,000	$9,600
Benefits[2]	$8,271	$7,584	$7,325
Supplies[3]	$500	$2,000	$2,500
Travel[4]	$2,664	$1,680	$2,664
Total	$69,701	$57,121	$56,841

[*] Specific funding expenses for FY15 and FY16 are presented in their associated proposals. Those expenses are no longer presented in this footnote—FY17 is presented for example purposes.

[1] Funding for technician (Jensena Newhouse) for 75% of her time is: $2,633/mo *x* 12 mo *x* 0.75 = $23,697. Benefits at 46.7% are $11,055.

[2] Employment of hourly technical help working on all objectives. $24/hr *x* 20 hrs/week ($12.00/hr full time equiv) *x* 24 wks = $9,600 + Benefits (76.3%; $7,325).

[3] $1500 annual for vineyard supplies (Tyvek suits, water sensitive paper, flagging tape, sample bags), and $1000 to cover HPLC costs associated with color analyses. All additional associated winemaking costs are presented in Harbertson's concurrent proposal titled "Management of Phenolic Compounds in Vineyard and Winery: Investigation of mechanical pruning, and grape maturity."

[4] Research site travel: 3000 miles/year *x* $0.56/mile = $1,680. Attendance for technician to 2017 ASEV Meeting (estimated location, Bellevue, WA). Registration ($200), hotel ($140/night *x* 4 nights=$560), travel (400 miles RT *x* $0.56/mile = $224) = $984.

Total Project Funding: **$183,663**

Project Budget Status: Due to the nature of winemaking and sensory, a 1 year, no-cost extension of grant funding was requested and awarded, in order to complete sensory analysis of 2016 wine in the late fall / early winter of 2017 (since wines would be too young to evaluate prior to the end of the grant cycle in June 2017). Otherwise, all other expenditures and processes are progressing as expected, with sensory of 2015 wines scheduled for November/December of 2016, and additional fruit analysis (tannins, phenolics) scheduled for this winter, in addition to a final year of dormant pruning weight collection and cold hardiness evaluation.

OTHER FUNDING SOURCES/SUPPORT

Agency Name: Washington State University & Grower-Cooperator

Notes: Limited funds are given to Dr. Moyer to cover Extension-based travel and publication costs by Washington State University. The land use, machine labor, and fruit was donated by Newhouse Farms Inc for winemaking in 2014, 2015, and 2016.

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Project Summary: *A completed project report will be provided at the end of the funding period, as not all aspects of the project are complete at this time.*

- Properly managing a grapevine canopy is a true test in understanding grapevine development and response to inputs. While recent studies on *early* fruit-zone leaf removal (i.e., pre-bunch closure) are providing interesting and optimistic results, most of the work is being done in cooler climates (Palliotti et al. 2011, Tardaguila et al. 2010). Our past research has shown that early fruit-zone leaf removal is a viable option in white wine grapes in eastern Washington (Komm and Moyer 2015). Will we see similar beneficial results in red grape varieties, where the target goals of "quality" center on sugar, anthocyanins, and tannins? Early fruit-zone leaf removal has also been shown to reduce under-ripe flavors in red wine varietals (i.e., reduction of methoxypyrazines) (Scheiner et al. 2010). In addition, the nature of the canopy microclimate can influence the incidence and severity of many economically significant grape diseases, including powdery mildew (PM) and Botrytis bunch rot (BBR). In particular, fruit-zone leaf removal is a commonly recommended cultural practice for disease control in organic vineyards (i.e., vineyards with limited effective chemical options) as it alters canopy microclimate (temperature and moisture), which is a significant factor in the development of the fungi associated with PM and BBR (Carroll and Wilcox 2003, Delp 1954, Nair and Allen 1993, Thomas et al. 1987).

- Various field-based methods were used to evaluate the objectives of this project. This included a replicated field trial at a commercial site with different timing of leaf removal implemented in two different varieties (Cabernet Sauvignon, Merlot). The fruit from this trial was then used to make associated wine and conduct wine sensory. In objectives relating to fungicide evaluation, a research block at WSU-IAREC was used to conduct the trial, where unsprayed controls were maintained to guarantee disease pressure.

- This project aimed to develop a better understanding of the impact of early fruit-zone leaf removal on red grape cultivars, how manual and mechanical leaf removal may differ in how these impacts are realized, and how leaf removal can interact with fungicide programs to enhance or detract from disease management. This project was also designed to see how early fruit-zone leaf removal influences components associated with high-quality red wine: anthocyanin and tannin accumulation.

Project Major Accomplishments:

***Project Objectives**:*

1. Evaluate the impact of the timing of manual and mechanical early fruit-zone leaf removal on fruit quality in red wine grape cultivars (FY15-17).
2. Evaluate the impact of the timing of manual and mechanical early fruit-zone leaf removal on wine quality (FY15-17).
3. Evaluate the relationship between fruit-zone leaf removal and the timing of specific fungicide programs in controlling powdery mildew and Botrytis bunch rot (FY15).

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Significant Results:

Objective 1: Results from 2014 and 2015 are presented in previous report. Leaf removal in Cabernet Sauvignon and Merlot occurred on 6 and 5 May (prebloom), 17 and 16 May (bloom), 15 and 13 June (postbloom), and 6 July (mechanical), respectively. Total leaf area removed in Cabernet Sauvignon at the time of treatment was 48.8%, 26.0%, 23.6%, and 27.0%, respectively, for prebloom, bloom, postbloom and mechanical. Total leaf area removed in Merlot at the time of treatment was 37.6%, 27.1%, 12.0%, and 23.5%, respectively, for prebloom, bloom, postbloom and mechanical. In Cabernet Sauvignon, fruit set was significantly reduced in the bloom (22%) and prebloom (22%) treatments relative to the mechanical treatment (35%), but not relative to other treatments (postbloom and control). The timing of leaf removal did not impact fruit set in Merlot, where fruit set average ranged between 25-27%. In Cabernet Sauvignon, the prebloom leaf removal treatment always resulted in significantly heavier berries ($P = 0.01$) and clusters ($P = 0.03$) than the bloom treatment. The larger berry size is likely why the prebloom leaf removal treatment did not have lighter clusters relative to other treatments, despite the significantly lower fruit set (relative to the mechanical treatment). The timing of leaf removal did not influence berry or cluster size in Merlot in 2016. There were no significant differences in sunburn in Cabernet Sauvignon between treatments on the east side of the canopy. On the west side, the postbloom leaf removal treatment had significantly more sunburn (11%) than the mechanical treatment (3.75%). The control (6%), prebloom (6.5%) and bloom (10%) treatments were not different from either the postbloom or mechanical treatments. In Merlot, there were significant differences in sunburn on fruit on both sides of the canopy. On the east side, postbloom (11%), bloom (10%), and mechanical (6.5%) had significantly more sunburn than the control (3.75%). The prebloom treatment was intermediate (6%). On the westside, the prebloom (11%), postbloom (10%) and bloom (6.5%) had significantly more sunburn than the mechanical (6%) and the control (3.75%) treatments.

In both varieties, the timing of fruit zone leaf removal did not influence IBMP (methoxypyrazine) concentration measured on 21 August 2016. In Cabernet Sauvignon, the bloom leaf removal treatment resulted in berries with higher anthocyanin concentration than the control treatment. The larger berry sizes that were seen in the prebloom leaf removal treatment did not appear to detrimentally impact total anthocyanin concentration. The timing of leaf removal did not influence berry anthocyanin concentration in Merlot. Skin and seed phenolics for 2016 are still being processed.

Objective 2: This objective is still currently underway, as 2016 wines have just been made. Sensory on 2014 wines have been completed. Sensory on 2015 wines were begun in November 2016 (evaluation and analysis not complete at the time of reporting). Sensory for 2016 wines will begin in November 2017. Basic wine analysis for 2016 and sensory for 2014 are presented below. Basic wine analysis from 2014 and 2015 are presented in past reports.

Wine analyses from 2016. Results from 2016 wine analyses are presented in Table 1. As seen, there were significant differences between treatments in both varieties for wine pH and alcohol. Just as in past years, while leaf removal treatments did impart different characteristics to the fruit and subsequent wine, those differences where never consistently in the direction of one extreme for the components analyzed.

Table 1 – Chemical analysis of 2016 wines made from grapes subjected to different leaf removal treatments. Different letters within a column represent significant differences using Tukey's HSD.

Cabernet Sauvignon 2016				**Merlot 2016**			
Treatment	pH	TA (g/L)	Ethanol % (v/v)	Treatment	pH	TA (g/L)	Ethanol % (v/v)
Control	3.76a	6.14	13.37b	Control	3.84a	5.20	13.39cd
Prebloom	3.75ab	6.28	13.69a	Prebloom	3.85a	5.34	14.52a
Bloom	3.76a	6.15	13.5ab	Bloom	3.83a	5.23	13.99b
Postbloom	3.69b	6.17	12.97c	Postbloom	3.77ab	5.40	13.58bc
Mech	3.74ab	6.07	12.86c	Mech	3.71b	5.27	13.09d
P-value	0.01	0.24	<0.0001	P-value	0.004	0.60	<0.0001

Sensory analysis from 2014. Wines were evaluated by a trained panel (n=11) consisting of industry members (viticulturists and winemakers). Panelists were trained on color, bitterness, and astringency, as well as general fruit and herbal aroma and flavors. After three training sessions, panelists evaluated wines made from grapes from the experiment described above. There were significant differences in perceived color, saturation, and astringency between the Cabernet Sauvignon treatments. Wines made from grapes subject to postbloom leaf removal was perceived as more purple than wines made from grapes subject to prebloom leaf removal; prebloom was perceived as more red and brown. Interestingly, though, these two treatments had less saturation than the bloom treatment, and prebloom was the least saturated of all of the different wines. Wines made from grapes subjected to bloom leaf removal were more astringent than wine made from grapes subjected to late mechanical leaf removal. The other treatments were not different from either astringency extreme. Differences were seen in saturation, astringency, and fruit flavor in the Merlot wines. Wines made from grapes subjected to postbloom leaf removal were more saturated than wines from the control and mechanical treatments. Postbloom and bloom wines were also more astringent, and had more perceived fruit flavor than control wines. Wines from the control treatment also had a higher perceived herbal aroma, but was not statistically significant (P = 0.06) relative to other treatments. Sensory panelists were also asked to rank their preference of the different wines. There was no consistent preference response in Merlot, but there was in Cabernet Sauvignon. Panelists ranked wines on a 1-5 scale (1 = preferred, 5 = least preferred)), and the results indicate that overall panelists preferred a wine made from grapes with some form of hand leaf removal. Bloom was ranked 2, 36% of the time. Postbloom was split between a 1 and a 5, with 21% of the responses in each category. Prebloom was also ranked 2, 25% of the time. The control and the mechanical treatments were each ranked 3 and 5, respectively, 32% of the time.

Objective 3: Overall, more sunburn was noted in later leaf removal stages in this portion of the trial (conducted on Chardonnay). Both fungicide treatment and leaf removal significantly influenced powdery mildew severity, but they did not interact with each other. Treatment 5 (FRAC 13 at the near end of ontogenic resistance), 7, 8, and 9 (U6 and U8 during the latter part of the critical window) performed the best. Treatments 2, 3, 4 and 6 had intermediate performance. Leaf removal at bloom resulted in significantly less disease than the control; prebloom and postbloom were intermediate in disease management. Leaf removal also significantly improved spray penetration as expected. Leaf removal was conducted on 30 May (prebloom), 16 June (bloom), and 11 July (postbloom). As such, the prebloom treatment had significantly higher spray coverage (P = 0.0098) on 10 June relative to the other treatments, both the prebloom and bloom treatments had significantly more coverage (P < 0.0001) than the control and postbloom treatments on 19 June, and all three leaf removal treatments had significantly more coverage (P = 0.0025) than the control on the 17 July. Interestingly, when spray coverage was assessed on 31 July, the prebloom treatment had reduced coverage similar to the no-leaf removal control, and both were significantly lower (P < 0.0001) than the other two treatments that had more recent leaf removal indicating the degree of fruit-zone canopy refill that occurred during the season. Neither fungicide treatment, leaf removal treatment, nor their interaction influenced cluster weights. Fungicide treatments, but not leaf removal, influenced final berry size. The control (no spray) treatment had significantly smaller berries relative to treatments 3, 4, 7, and 8. Interestingly, those fungicide treatments where those that had either FRAC 13 or FRAC U6 applied during the immediate post bloom to the end of the critical window of susceptibility, indicating potential increase in berry size with improved disease control. The same was true for juice pH, TA, and Brix. This was in slight contrast to previous years, but was likely related to the warmer-than-average vintage.

Key Outcomes:

Objective 1: Early leaf removal (prebloom) did not always detrimentally effect fruit set. It also minimized sunburn relative to other removal treatments.

Objective 2: Leaf removal did appear to impart both chemical and sensorial differences in subsequent wines, however, while these differences were statistically significant, they were practically subtle. Leaf removal may be of value in imparting attributes in the wines that are tailored to the tastes preferences of a particular winery's target clientele.

Objective 3: The focused timing of specific FRAC groups (13, U6 and U8), from just after full bloom through the end of the critical window improved overall disease control relative to their inclusion earlier in the critical window.

Industry Value and Benefit:

While the majority of the industry uses mechanical approaches to canopy, there are many small vineyards throughout the region that complete tasks by hand. From this study, we have seen that the fears of poor yields and fruit development surrounding the adoption of early fruit-zone leaf removal, particularly pre-bloom leaf removal, do not appear to be founded. This information will hopefully encourage those using hand labor to shift the timing of their practices. Prebloom leaf removal also reduced the likelihood of sunburn, by allowing sufficient time for canopy refill in mid to late summer. From our initial analyses and sensory evaluation of wines, bloom to postbloom leaf removal resulted in higher perceived astringency whereas prebloom leaf removal had lower perceived astringency. Leaf removal also helped improve disease control and spray penetration, but not to the same degree as proper timing of key synthetic products. Leaf removal would be a beneficial addition to most powdery mildew management programs, but is not a substitute for proper program design and product rotation.

<u>Information Dissemination, Extension, and Outreach Activities:</u>

Research Publications: *One is currently being prepared for submission to Catalyst, and when wine sensory is completed, that will be submitted to AJEV.*

Moyer, M.M., J.M. Newhouse, and G.G. Grove. 2016. Efficacy of Biopesticides and Leaf Removal in Grapevine Powdery Mildew Management. Plant Health Progress 17(2):84-91.

Presentations:

"Powdery Mildew: Biology and Management." 8 Mar 2016. Oregon Wine Research Institute. Oregon State University. Corvallis, OR, USA.

J.M. Newhouse, G.G. Grove, and Moyer, M.M. 2015. Combating *Erysiphe necator* in *Vitis vinifera* 'Chardonnay': Effectively using Chemical and Cultural Tactics. 66th ASEV Annual Meeting. Portland, OR, USA. Technical Abstracts: p. 71.

"Canopy Management in Contrasting Climates." 18 Jun 2015. American Society for Enology and Viticulture Annual Meeting, Outreach Symposium. Portland, OR, USA.

"Managing Powdery Mildew: How Specific Product Use Can Change the Timing of the 'Critical Period' for Intervention." 25 Jun 2014. ASEV Annual Meeting. Austin, TX, USA.

Posters: *Posters are presented annually at WSGS and WAWGG. Selected highlights are below.*

Moyer, M.M., J.M. Newhouse, M. Garcia, G.G. Grove. 6 Feb 2014. "Managing Powdery Mildew: How Specific Product Use Can Change the Timing of the "Critical Period" for Intervention." WAWGG Annual Meeting. Kennewick, WA, USA. (***1st Place Professional***)

Newhouse, J.M., G.G. Grove, and M.M. Moyer. 6 Feb 2014. "Effectiveness of Biopesticide-Based Programs on Grape Powdery Mildew." WAWGG Annual Meeting. Kennewick, WA, USA. ***(3rd Place Professional Poster)***

Newhouse, J.M., G.G. Grove, and M.M. Moyer. 2014. Efficacy of Biopesticide-based Programs on *Erysiphe necator* in *Vitis vinifera* 'Chardonnay." 65th ASEV Annual Meeting. Austin, TX, USA. Technical Abstracts: p. 166.

Moyer, M.M., J.M. Newhouse, M. Garcia, and G.G. Grove. 2014. Managing Powdery Mildew: How Specific Product Use Can Change the Timing of the 'Critical Period' for Intervention." 65th ASEV Annual Meeting. Austin, TX, USA. Technical Abstracts: p. 80.

Extension Publications:

Hoheisel, G.A., and M.M. Moyer (eds). Updated Annually. Pest Management Guide for Grapes in Washington. WSU Extension #EB0762. Pullman, WA, USA. 68 pp.

Various articles in different editions of *Viticulture and Enology Extension News.* Available at: http://wine.wsu.edu/research-extension/publications/newsletter/

Literature Cited:

Carroll, J.E. and W.F. Wilcox. 2003. Effects of humidity on the development of grapevine powdery mildew. Phytopathology 93:1137-1144.

Delp, C.J. 1954. Effect of temperature and humidity on the grape powdery mildew fungus. Phytopathology 44:615-626.

Komm, B.L. and M.M. Moyer. 2015. Effect of Early Fruit-Zone Leaf Removal on Canopy Development and Fruit Quality in Riesling and Sauvignon blanc. AJEV. 66:424-434.

Nair, N.G. and R.N. Allen. 1993. Infection of grape flowers and berries by *Botrytis cinerea* as a function of time and temperature. Mycol. Res. 97:1012-1014.

Palliotti, A., M. Gatti and S. Poni. 2011. Early leaf removal to improve vineyard efficiency: Gas exchange, source-to-sink balance, and reserve storage responses. AJEV. 62:219-228.

Scheiner, J.J., G.L. Sacks, B. Pan, S. Ennahlie, L. Tarlton, A. Wise, S.D. Lerch and J.E. Vanden Heuvel. 2010. Impact of Severity and Timing of Basal Leaf Removal on 3-Isobutyl-2-Methoxypyrazine Concentrations in Red Winegrapes. AJEV. 61:358-364.

Tardaguila, J., F. Martinez de Toda, S. Poni and M.P. Diago. 2010. Impact of early leaf removal on yield and fruit and wine composition of *Vitis vinifera* L. Graciano and Carignan. AJEV. 63:372-382.

Thomas, C.S., J.J. Marois and J.T. English. 1987. The effects of wind speed, temperature, and relative humidity on development of aerial mycelium and conidia of *Botrytis cinerea* on Grape. Phytopathology 78:260-265.