A Progress Report for a Research and Extension Project Submitted to:
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Project Title: Side by side evaluation of clones and hybrids of *Vitis vinifera* 'Riesling' in the Lake Erie Region of Pennsylvania

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Co-PI Collaborators with contact info: Dr. Michela Centinari: Department of Plant Science, Associate Professor of Viticulture at Penn State, Phone: 814-867-0514; email: mzc22@psu.edu M. Centinari has an appointment split across research and extension. To this project, she adds pertinent expertise in wine grape production and physiology.

New Research ☐ Continued Research ☒

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Summary Impact Statement: *Vitis vinifera* 'Riesling' is an important variety for wine grape growers in Pennsylvania, New York, and other regions of the Northeast. There are many clones and hybrids of Riesling, but to our knowledge, direct, multi-year comparisons of these clones and hybrids do not exist for the Pennsylvania/New York grape growing regions, to aid growers in choosing which ones to grow. This project is yielding valuable viticultural comparisons of several of the most popular clones and hybrids of Riesling, growing side-by-side in the same vineyard, that could aid producers in making clonal and varietal decisions when planning an expensive new vineyard. Data from 2021 and 2022 will detail comparisons of 4 clones (90, 110, 198, 239) and 2 hybrids (Geisenheim and NY81) of Riesling regarding canopy density and fruiting zone microclimate, fruit rot susceptibility, yield parameters, cluster architecture, cold hardiness, fruit composition, and the response to efforts to alleviate bunch rot development with pre and post bloom mechanized leaf removal. Multiple years of data will be necessary to identify and confirm patterns that will lead to more reliable recommendations.

Objectives: Our objectives for the 2021 season were as follows:

1. Compare the viticultural characteristics (phenology, vegetative growth, cluster/berry weight, yield, cluster architecture), fruit disease susceptibility (powdery mildew and bunch/sour rot), cold hardiness, and fruit composition, of 4 clones (90, 110, 198, 239) and 2 hybrids (Geisenheim and NY81) of Riesling.
2. Compare the response to pre bloom and post bloom mechanical defoliation of these 4 clones and 2 hybrids of Riesling, and how it relates to canopy microclimate, disease development, and fruit yield and quality.

Activities/methods

Vines in the experimental vineyard were planted on a 6-foot (between vines) x 9-foot (between rows) spacing. All vines were trained to a vertical shoot position (VSP) system, cane pruned, and thinned in spring to 4 shoots per foot of row (96 shoots per 4-vine panel). No cluster thinning was done. Each

clone/variety is represented in 12-vine plots within a row, with each plot replicated in 5 randomized complete blocks (60 vines per clone/variety). Within each plot, a different treatment was imposed on each of the 4-vine panels: i) mechanized cluster-zone defoliation just before bloom (MD1), ii) mechanized cluster-zone defoliation at fruit set (MD2), and iii) no defoliation (control; C). Mechanized leaf removal was accomplished with a BlueLine Deleafer (Blueline Manufacturing Company) that jets compressed air into the fruit-zone to shatter leaf tissue along the first 5-6 nodes on shoots but leave inflorescences relatively undamaged. The tractor mounted air sheer system is applied to both sides of the canopy, one pass on each side, at a tractor speed of about 0.8 mph.

During the 2021 season, key phenology stages, leaf removal efficiency, canopy density (EPQA), cluster morphology (cluster weight and length, #berries/cluster, cluster compactness), fruit susceptibility to bunch rots (total rot at harvest), fruit composition (brix, pH, TA) and yield per vine and per shoot at harvest was recorded. Bud survival and fruitfulness (shoots/bud, clusters/shoot), and susceptibility to crown gall will be recorded in early 2022. A conventional fungicide program was applied throughout the season for control of all diseases, including bunch rots. Weather data was collected with an onsite weather station.

Results/Progess

Phenology

Bud swell occurred during the first week of April on Geisenheim, which was generally ahead of all other varieties/clones in the vineyard. By April 12, Geisenheim achieved >10% pink while other varieties/clones were just at early to mid-bud swell. By late April, all hybrids/clones had greater than 50% broken buds, however exact bud break dates for each variety were not determined.

50% bloom was achieved by Geisenheim on June 8, by NY81 on June 9, and by all clones (90, 110, 198, 239) on June 13. Geisenheim and NY 81 reached veraison, the week of August 1, with Geisenheim slightly ahead of NY81. On the other hand, the Riesling clones did not reach 8 °Brix until the week of August 16, with clones 90 and 110 being slightly more advanced than clones 198 and 239. Geisenheim and NY81 were already at 13.4 and 10.9 °Brix, respectively, on August 16. By August, hybrids and clones were about 2-3 weeks apart in development, remaining that way through harvest. NY81 was harvested first (September 13) followed by Geisenheim (September 20) and the 4 clones (October 6-7).

Leaf removal efficiency; Table 1

MD1 was applied on June 10, when Geisenheim was in early bloom, NY81 was at trace bloom, and clones were not yet blooming. MD2 was applied 2 weeks later, on June 24, just after shoots were tucked into catch wires. The leaf removal efficiency of each defoliation was determined by subtracting the weight of leaf tissue remaining after each defoliation, from the weight of leaves in the control, on the first 6 nodes of a sample of shoots in each panel. Efficiency was highest on the two hybrids and clone 90 for both MD1 and MD2. Clone 239 was in the top statistical tier for efficiency for MD1, but in the bottom statistical tier for MD2.

Enhanced point quadrat analysis (EPQA); Table 2.

Canopy density and light penetration into the fruit zone were measured just after veraison by Point Quadrat Analysis (PQA) and an LP80 ceptometer. These measurements were combined to provide an EPQA (enhanced PQA) of several canopy characteristics.

The interaction between variety and treatment (MD) was not significant for any EPQA parameter, which means that MD produced similar results across varieties. The MD treatment improved all canopy density measurements regardless of timing. However, in general MD2 had lower canopy density than MD1, possibly because the MD2 treatment was applied 2 weeks later, allowing less time for vegetative regrowth into the fruit zone. The two hybrids tended to have more open canopies than the clones. For example, Geisenheim tended to have lower overall canopy density than clones 90 and 110. Also, NY 81 had higher cluster sunlight exposure than clones 90 and 110.

Bunch rot; Tables 3 and 4.

Total bunch rot was rated on September 12 on NY81 (the day before harvest) and on all other varieties on September 17. Clones only were rated for total bunch rot again on October 5-6. For both September and October rot ratings, the variety by treatment (MD) interaction was not significant for any bunch rot parameter, which means that MD produced similar results with respect to rot reduction, across all varieties. Also, MD, regardless of timing, was effective in reducing bunch rot at both September and October ratings. The hybrids had higher rot levels than the clones in the September ratings (regardless of treatment) likely because they were riper than the clones. There were no differences in bunch rot among the clones in September or October.

Yield results; Tables 5-8.

The variety by treatment interaction was significant for yield, yield per shoot, and cluster weight (MD did not produce similar results with respect to these parameters, across all varieties), and PROC GLIMMIX with a SLICE option in the LSmeans statement was used to compare each variety within treatments and to compare treatments within each variety. For example, MD, regardless of timing (MD1 vs MD2), reduced yield, yield per shoot, and cluster weight for most varieties, but with two exceptions: clone 239, where C (no MD) and MD1 vines were not different for these parameters, and clone 90/12 where yield and yield per shoot of C (no MD) and MD2 vines were not different (tables 5-7, upper case letters, within rows). Also, for Geisenheim, MD1 reduced yield, yield per shoot, and cluster weight more than MD2 (tables 5-7, upper case letters). This greater reduction with MD1, exclusive to Geisenheim, is thought to relate to the timing: MD1 was applied when Geisenheim was already in bloom, whereas all other varieties were either at trace bloom (NY81) or had not yet begun bloom (all clones). Flowers in bloom may be more easily damaged/removed by air pulse leaf removal than flowers not yet in bloom, leading to a greater reduction in berries per cluster and cluster weight. This explanation will be further addressed when dissections of frozen clusters over the winter provide more data on cluster morphology. A grower may be able to create differential levels of cluster weight reduction or cluster compactness, by slightly altering the timing of early MD in relation to bloom.

There are some variety effects on yield within each treatment category (Control, MD1 and MD2) – lowercase letters, within columns. For example, for the control vines, Geisenheim and 198/9 have the highest yield and yield per shoot, and NY81 the lowest (in all treatments). However, for MD2 treated vines, Geisenheim still had the highest yield and yield per shoot, while yield and yield per shoot of 198/9 vines was significantly lower. The reasons for this are still unknown.

Clone 239 had the smallest clusters, regardless of treatment, and appeared to be the least affected by MD. On the other hand, Geisenheim had the largest clusters for C (no MD) and MD2 but was greatly reduced by MD1 (as stated above).

For number of clusters per vine (Table 8), there was a variety effect but no treatment effect, or treatment x variety effect. This means that varieties did not respond differently to MD with respect to clusters/vine. However, clone 239 had the highest clusters per vine, being superior to clone 90, Geisenheim, and NY81.

Next Steps: Cluster morphology (cluster length, berries/cluster, cluster compactness), fruit composition at harvest (total soluble solids (Brix), pH, and titratable acidity (TA), the collection of data regarding bud winter survival and susceptibility to crown gall (collectively, cold hardiness), and return fruitfulness (shoots/bud, clusters/shoot), will be determined/completed in winter and spring of 2022. Also, it will be essential that this research is repeated in 2022 to examine for patterns and consistencies across years, among the various varieties and clones being examined. This will enable researchers to formulate more accurate, reliable recommendations for wine growers.

Technology Transfer Plan: The progress of this project was briefly discussed at a meeting with wine and juice grape processors and Cornell/Penn State extension staff on 1/13/22. In 2022, after all data have

been analyzed, the results will be discussed with extension/research colleagues and growers at extension based/grower meetings in Pennsylvania and New York, and possibly other parts of the Northeast. At completion of the project, the results will be submitted for publication in a peer-reviewed journal.

Table 1. Leaf removal efficiency of MD1 (June 10) and MD2 (June 24)

Variety/clone	Percent leaf area removed by MD1	Percent leaf area removed by MD2
90	41.2 ab	50.9 abc
110	30.8 c	43.1 cd
198	33.6 bc	45.3 bcd
239	41.2 ab	37.9 d
Geisenheim	41.2 ab	56.6 ab
NY81	50.0 a	60.3 a
P-value	0.011	0.004

Means followed by the same letter within columns are not significantly different according to Fisher's LSD ($P \leq 0.05$).

Table 2. Enhanced point quadrat analysis characteristics of Riesling varieties with and without MD. Measurements were taken close to the onset of fruit ripening in 2021.

	Percent gaps (%)	Leaf layer number (n)	Interior leaves (%)	Interior clusters (%)	Leaf exposure availability (%)	Cluster exposure availability (%)
Treatment (T)						
Control	1.11 b	2.67 a	40.0 a	64.8 a	34.2 c	23.5 c
MD1	5.19 a	1.52 b	25.8 b	31.9 b	54.4 b	54.3 b
MD2	4.64 a	1.25 c	21.3 b	24.0 c	60.1 a	62.9 a
p value (T)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Variety (V)						
239	3.70	1.74 ab	27.5	41.1 ab	50.7 ab	46.5 ab
198/9	2.97	1.76 ab	28.0	41.5 ab	49.9 ab	46.1 ab
90/12	4.84	2.04 a	30.6	48.2 a	46.9 b	42.3 b
110/17	2.96	2.00 a	31.8	49.3 a	47.3 b	43.6 b
Geisenheim	2.22	1.59 b	24.9	32.4 b	53.3 a	50.5 a
NY81	5.19	1.77 ab	31.6	28.9 b	49.3 ab	52.5 a
p value (V)	0.357	0.003	0.134	<0.001	0.005	0.001
p value (TxV)	0.493	0.082	0.120	0.212	0.200	0.433

Means followed by the same letter within columns are not significantly different (Tukey test at $P \leq 0.05$).

Table 3. Bunch rot disease response to MD1 and MD2, all varieties, September 12 and 17 rating.

	Percentage cluster with rot (%)	Percentage cluster area with rot (%)
Treatment (T)		
Control	42.8 a	2.23 a
MD1	26.2 b	0.98 b
MD2	28.0 b	1.23 b
p value (T)	<0.001	<0.001
Variety (V)		
239	19.7 b	0.63 c
198/9	23.0 b	0.96 bc
90/12	22.0 b	0.83 c
110/17	24.0 b	1.00 bc
Geisenheim	55.7 a	3.82 a
NY81	49.7 a	1.65 b
p value (V)	<0.001	<0.001
p value (TxV)	0.335	0.123

Means followed by the same letter within columns are not significantly different (Tukey test at $P \leq 0.05$).

Table 4. Bunch rot disease response to MD1 and MD2, all varieties/clones, October rating.

	Percentage cluster with rot (%)	Percentage cluster area with rot (%)
Treatment (T)		
Control	73.8 a	7.72 a
MD1	58.8 b	3.74 b
MD2	55.3 b	3.05 b
p value (T)	<0.001	<0.001
Variety (V)		
239	58.0	4.32
198/9	57.3	3.92
90/12	66.1	5.54
110/17	69.0	5.57
p value (V)	0.093	0.196
p value (TxV)	0.499	0.205

Means followed by the same letter within columns are not significantly different (Tukey test at $P \leq 0.05$).

Table 5. Yield response (kg/vine) to treatment (MD1 and MD2) across all varieties.

Treatment (TRT) / Variety (v)	Control[zy]	MD1[zy]	MD2[zy]
239	6.70 A cd	6.40 AB ab	5.56 B bc
198/9	8.27 A ab	6.73 B a	5.83 B bc
90/12	7.47 A bc	5.68 B bc	6.45AB b
110/17	7.68 A b	5.74 B b	5.77 B bc
Geisenheim	8.98 A a	5.85 C ab	7.71 B a
NY81	6.17 A d	4.76 B c	4.95 B c
P value V	< 0.001		
P value TRT	< 0.001		
P value V x TRT	0.027		

[z]Different lowercase letters indicate mean differences within each treatment for the variety main effect (i.e., means between column) at $P = 0.10$

[y]Different uppercase letters indicate mean differences within each variety for the treatment main effect (i.e., means between rows) at $P = 0.10$

Table 6. Cluster weight response (g/cluster) to treatment (MD1 and MD2) across all varieties.

Treatment (TRT) / Variety (v)	Control[zy]	MD1[zy]	MD2[zy]
239	103.9 A d	90.4 AB c	88.7 B d
198/9	134.8 A bc	109.0 B ab	106.1 B bc
90/12	145.4 A ab	122.2 B a	117.2 B b
110/17	126.4 A c	99.4 B bc	99.4 B cd
Geisenheim	155.7 A a	102.9 C bc	137.1 B a
NY81	119.9 A c	95.6 B bc	98.3 B cd
P value V	< 0.001		
P value TRT	< 0.001		
P value v x TRT	0.072		

[z]Different lowercase letters indicate mean differences within each treatment for the variety main effect (i.e., means between column) at $P = 0.10$

[y]Different uppercase letters indicate mean differences within each variety for the treatment main effect (i.e., means between rows) at $P = 0.10$

Table 7. Yield per shoot response (g) to treatment (MD1 and MD2) across all varieties.

Treatment (TRT) / Variety (v)	Control[zy]	MD1[zy]	MD2[zy]
239	300.7 A bc	289.0 A ab	245.6 B b
198/9	362.8 A a	300.6 B a	259.7 C b
90/12	320.5 A b	261.3 B bc	282.1 AB ab
110/17	322.8 A b	255.5 B bc	250.7 B b
Geisenheim	369.6 A a	243.8 C c	315.6 B a
NY81	263.1 A c	203.3 B d	207.2 B c
P value V	< 0.001		
P value TRT	< 0.001		
P value v x TRT	0.027		

[z]Different lowercase letters indicate mean differences within each treatment for the variety main effect (i.e., means between column) at $P = 0.10$

[y]Different uppercase letters indicate mean differences within each variety for the treatment main effect (i.e., means between rows) at $P = 0.10$

Table 8. Number of clusters per vine response (g) to treatment (MD1 and MD2) across all varieties.

	Number of clusters/vine
Treatment (T)[a]	
Control	58.4
MD1	57.8
MD2	56.4
p value (T)	0.666
Variety (V)	
239	67.0 a
198/9	60.1 ab
90/12	51.0 c
110/17	59.7 ab
Geisenheim	57.0 bc
NY81	50.4 c
p value (V)	<0.001
p value (TxV)	0.740