2012 Research Report
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Early leaf removal to improve crop control, cluster morphology and berry quality in vinifera grapes

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Abstract
The impact of early leaf removal treatments around bloom were investigated on Chardonnay (clone 5) and Pinot Noir (clones UCD 4 and UCD 9) grafted on 3309C at the Southwest Michigan Research and Extension Center (SWMREC) in Benton Harbor. Leaf pulling treatments were manually applied during pre-bloom, at full bloom and at fruit set. The treatments consisted in defoliation of the first six nodes of all the shoots. Fruit set, canopy development, berry skin characteristics, basic fruit chemistry parameters and, yield components were measured at harvest. Defoliation treatments in both Chardonnay and Pinot Noir improved grape quality, reducing rot incidence at harvest and increasing polyphenols content of the fruit at harvest.

1 – Introduction and Priority Addressed:

Crop control and management is pivotal in cool climate viticulture to assure high quality fruit (wines). Leaf removal in the fruiting zone frequently is performed from fruit-set to veraison in several cool grape growing regions (Reynolds et al., 1996[1]) to improve light exposure, and temperature of the cluster with beneficial effects on berry quality and color. Recent trials reported that manual defoliation near the time of bloom is effective in reducing yield, because affecting fruit set (Sabbatini et al, 2010[2], Sabbatini and Howell, 2010[3]) and berry size, and leading to looser clusters with improved must composition (Intrieri et al., 2008[4]).

2 - Original goals and objectives of the project:

The proposed goal of this project was to verify if early leaf removal (pre-bloom, full-bloom and fruit set) can be consistently used to control yield through reduction of fruit-set in highly productive *Vitis vinifera* cultivars characterized by compact clusters.

The research reported in this document was initiated to investigate:

1. *The effect of early leaf removal on fruit set and yield per vine*
2. *Whether the expected yield reduction is primarily derived from reduced fruit-set and/or reduced berry size*
3. *The effects of leaf removal on grape quality (fruit chemistry and skin/pulp ratio);*
4. *The effect of the treatments on cluster morphology and on bunch rot incidence.*

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[1] Reynolds A.G., Wardle D.A, Naylor A.P., 1996. Impact of training system, vine spacing, and basal leaf removal on Riesling. Vine performance, berry composition, canopy microclimate, and vineyard labor requirements. Amer. J.Enol Vit. 47: 63-76.

[2] Sabbatini P., Howell G.S., Wolpert J., 2010. Controlled Cultural Reduction in Fruit Set and Subsequent Harvest Season Botrytis Cluster Rot Complex. Italus Hortus, pp 27-32.

[3] Sabbatini P. and Howell G.S., 2010. Effects of early defoliation on yield, fruit composition and harvest season cluster rot complex of grapevines. Hortscience, Vol 45 (12); pp 1804-1808.

[4] Intrieri C., Filippetti I., Allegro G., Centinari M., Poni S. 2008. Early defoliation (hand versus mechanical) for improved crop control and grape composition in Sangiovese (Vitis vinifera L.). Austr. J. Grape and Wine Res. 14, 25-32.

3 - Work accomplished during the period, including material and methods and results:

Two clones of Pinot Noir (UCD 9 and UCD 4) and Chardonnay trained at VSP were pruned during the winter of 2012 (60 buds/vine) and subsequently thinned after to a balanced crop level. Leaf removal treatments were applied at three different stage of shoot development during the early season. Six nodes per shoot were defoliated removing whole leaves at three stages of cluster development: before bloom, full bloom and fruit set (stage 17, 23 and 27 according to Eichorn and Lorenz). Control treatment was also included in the experiment, with no leaf removal performed (Table 1). On each experimental vine, five shoots bearing two clusters were selected and tagged at the beginning of the experiment: shoot length was measured at each time of defoliation, and two weeks after the last defoliation treatment. The impact of leaf removal on vines leaf area was estimated at each time of defoliation on 20 homogeneous shoots sampled in the same experimental plot: leaf area (LA) removed, total LA and shoot length was measured. The average LA removed used to estimate the impact of leaf area removed on treated vines, and the regression between shoot length and total LA was used to estimate LA of the defoliated shoots.

***Table 1**. Dates of leaf removal treatments in 2012, growing degree days (GDD), minimum and maximum temperatures and precipitation.*

Treatment	Date of treatment	GDD[z]	Temperature (^oC)[y] Min	Max	Precipitation (mm)[x]	GDD[w]	Precipitation (mm)[v]
Pre-bloom	June 1, 2012	310	12.2	31.5	18.8	1593	212
Full Bloom	June 12, 2012	370	13.1	32.2	22.5	1593	212
Fruit-set	June 21, 2012	490	11.2	30.8	28.3	1593	212

[z]Growing degree days (GDD base 10^oC) calculated as described by Baskerville and Emin (1969) from April 1 to the date of treatment.
[y]Temperature (^oC) registered during the time of treatment (± 5 d).
[x]Accumulated precipitation (mm) from June 1 to the time of treatment.
[w]Growing degree days (GDD base 10^oC) calculated as described by Baskerville and Emin (1969)from April 1 to harvest.
[v]Accumulated precipitation (mm) from June 1 to harvest.

Table 2. Vegetative measurements on defoliated shoots. Leaf area removed was estimated at each time of defoliation, shoot length and total leaf area were measured two weeks after fruit set.

	Time of defoliation		
	Before bloom	Full bloom	Fruit set
CHARDONNAY			
Shoot length (cm)	68	71	85
Leaf area removed (cm^2)	570	599	690
Leaf area estimated (cm^2)	950	1080	1500
Control leaf area (cm2)	1106	1440	2000
PINOT NOIR			
Shoot length (cm)	67	76	95
Leaf area removed (cm^2)	400	420	550
Leaf area estimated (cm2)	698	877	1290
Control leaf area (cm^2)	650	850	1280

The impact of leaf removal on vines leaf area was estimated at each time of defoliation on 20 homogeneous shoots sampled in the same experimental plot: leaf area (LA) removed; total LA and shoot length was measured. The average LA removed used to estimate the impact of leaf area removed on treated vines, and the regression between shoot length and total LA was used to estimate LA of the defoliated shoots (Table 2).

To investigate the effect of the defoliation treatment (leaf pulling) on fruit set, each basal inflorescence on the tagged shoots was photographed against a dark background, and visible flowers in the pictures counted. The number of actual flowers was then estimate using a regression equation established on the destructive sampling of 20 inflorescences for both Chardonnay and Pinot Noir. The same procedure was repeated at fruit set to estimate the number of berries set per cluster. The regressions obtained from this part of the study were reported last year. Fruit set was reduced both in Pinot noir and Chardonnay when leaf pulling was performed before and at full bloom (Tab 3).

At harvest yield per vine was recorded, and clusters from the tagged shoots were separately collected and analyzed in the lab. Weight and number of berries, weight and length of the rachis was recorded per cluster.

Table 3 - *The estimated number of flowers and berries, and fruit set percentage.*

	Time of defoliation			
	Control	Before bloom	Full bloom	Fruit set
CHARDONNAY				
Number of berries	75 a	62 b	68.0 b	79.2 a
Fruit set (%)	21.2 a	15.0 b	16.3 b	22.1 a
PINOT NOIR				
Number of berries	140.8 a	105.2 b	102.9 b	133.0 a
Fruit set (%)	38.6 a	29.0 b	27.2 b	37.0 a

Tab. 4. *Effect of leaf pulling on basic fruit chemistry parameters at harvest.*

	Time of defoliation			
	Control	Before bloom	Full bloom	Fruit set
CHARDONNAY				
Brix (%)	23.6 a	22.7 a	23.0 a	22.8 a
pH	3.40 a	3.36 a	3.38 a	3.38 a
Titrable acidity (g/l)	4.93 a	4.38 a	5.37 a	4.73 a
Terpenes (mg/l)	0.51 a	0.85 b	0.91 b	0.62 a
PINOT NOIR				
Brix (%)	20.9 a	22.0 b	22.1 b	20.5 a
pH	3.60 a	3.68 a	3.66 a	3.61 a
Titrable acidity (g/l)	6.00 a	6.10 b	6.12 b	5.99 b
Phenolic Content (au/g)	0.72 a	0.75 a	0.98 b	0.96 b
Anthocyanin (mg/g)	0.20 a	0.23 a	0.38 b	0.36 b

The number of clusters and total yield per vine was not affected by the leaf removal treatment in both Chardonnay and Pinot Noir. Early defoliation reduced berry weight and number of berries per cluster, leading to a reduced cluster weight. Since the rachis length was not affected by the defoliation treatment, the observed lower cluster compactness of the earliest defoliation treatments was due to the reduced number of berries per cluster. All the defoliation treatments, for both varieties significantly reduced the number of rot berries per cluster, also on clusters with a more usual compact architecture. Lower level of bunch rot incidence can eventually be ascribed to the improved fruit zone microclimatic conditions, in particular air circulation, and lower humidity, but also to a better penetration of fungicides applications. Juice from berries collected at harvest was used for basic chemistry analysis. However, our results indicate that basic fruit chemistry was only partially affected by the defoliation. As expected, all the defoliation treatments increased the phenolics content of berries and increase anthocyanin level in Pinot Noir juice or terpenes in Chardonnay. Leaf removal at earlier stages of cluster development, at bloom or before bloom, appear to be an effective strategy to control berry size and berry numbers per cluster. Consequently it could be used as a method to achieve smaller cluster and therefore control vine crop load. Defoliation treatments in both Chardonnay and Pinot Noir improved grape quality, reducing the rot incidence at harvest and increasing polyphenols content, as a consequence of both reduced cluster compactness and better fruit zone microclimatic conditions. Investigations on the effect of defoliation on year 2 bud fruitfulness will be performed during this last year of the project.

4 - Conclusion

Leaf removal at earlier stages of cluster development, at bloom or before bloom, appear to be:

- Effective strategy, at least in Pinot Noir, to control berry size and berry numbers per cluster. Consequently it could be used as a method to achieve smaller cluster and therefore control vine crop load. D
- Defoliation treatments in both Chardonnay and Pinot Noir improved grape quality, reducing the rot incidence at harvest and increasing polyphenols content, as a consequence of both reduced cluster compactness and better fruit zone microclimatic conditions.

5 - Communications Activities, Accomplishments, and Impacts:

During the project, Dr. Sabbatini has given numerous talks at grape grower meetings to highlight the preliminary results of this research. This has included the Great Lakes Expo, summer grape IPM meetings in southwest and northwest Michigan, at the 2012 Midwest Grape and Wine Conference (St. Louis, MO), Wineries Unlimited Conference (Richmond, Virginia). We are developing a manuscript for publication and we will work towards an extension publication by MSU Extension.

The funds provided by the MGWIC were used to partially cover the cost of a MS student (Dana Acimovic) working full time of this project. Matching funds were secured through the GREEEN project.

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Figure 1*. Florets and berries counted on pictures to estimate fruit set as described in the proposal and in the 2010 research report. Each basal cluster per tagged shoot was photographed at pre-bloom and a one week after fruit set against a dark background with a digital camera (Panasonic, Lumix GH2, Tokyo, Japan) positioned perpendicular and at 10 cm from the cluster. A regression between actual flower number and the number of flowers at pre-bloom counted on the digital image was calculated for 50 clusters taken from guard vines in each variety. The linear relationship was used to estimate flower numbers on tagged clusters (Table 5). The same procedure was repeated after fruit set and the linear relationship was used to estimate fruit-set on tagged clusters (Table 5). Calculation of percentage of fruit-set cannot be performed at harvest using ratio between the actual number of berries in the treatment and in control due the enormous variability in flower numbers per cluster.*

Figure 2*. Dana Acimovic (MS student) taking pictures of clusters in bloom of Pinot noir vines with Jake Emling (left: MS student) and Salomon Tadesse (post-doc from Italy) during the spring of 2012.*