

**Year-end Report
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Optimized wine quality potential through fruit-zone management practices in red varieties

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Introduction/background: Selective leaf removal from canopy fruit zones is commonly used in humid grape growing regions as a means of suppressing certain fruit diseases and, less consistently, improving the chemical composition of fruit. Leaf removal effects on fruit composition can be highly variable; the magnitude and timing of leaf removal, the variety, growing region, and seasonal weather all impact how fruit exposure affects grape composition. Consequently, leaf removal recommendations are often generalized with little or no regard to how or if a specific grape compound or compound class will change between varieties or even between viticultural regions. Thus, it is our intention to evaluate if changing the magnitude and timing of leaf and removal would change Cabernet franc and Petit verdot fruit/wine composition and consumer acceptability of wines. The compounds or compound classes of interest in fruit and wines have all been shown to be affected by either light, temperature, or both: carotenoids, norisoprenoids, anthocyanins, and total phenolics. Carotenoids are precursors to norisoprenoids, which are important aroma impact compounds in both red and white wines. Anthocyanins and other flavonoids are important for red wine properties such as color and mouthfeel. Our overarching goal is to determine how fruit exposure, as governed by severity of leaf removal, impacts these aroma, color, and mouthfeel constituents in two important, red wine varieties. We ultimately aim to evaluate the impact of the field treatments on consumer acceptability of resultant wines.

Design/Methods: The main project is being conducted in a commercial vineyard in Shenandoah County, with a smaller experiment conducted with Cabernet Sauvignon grown at the AHS Jr. AREC near Winchester. In the Shenandoah County vineyard, two separate complete randomized designs, consisting of five-vine-panel experimental units each replicated six times, were set up in adjacent Cabernet franc and Petit Verdot blocks. In addition to the no leaf removal-control ("NONE"), treatments were "PRE-BLOOM" (removal of the first six basal leaves/laterals at two to three days pre-bloom), "MEDIUM" (C. franc: removal of the primary leaf and lateral opposite the basal cluster at two weeks post-fruit set; P. Verdot: removal of the primary leaf and lateral from both opposite the bottom primary cluster and the node directly above bottom cluster at two weeks post-fruit set), and "HIGH" (removal of all primary leaves and

laterals opposite the top primary cluster down to the cordon at two weeks post-fruit set). Fruit zone architecture (e.g., fruit exposure and leaf layer number) and light environment were measured at various points of the season. Berry temperatures were collected in the morning, around solar noon, and in the afternoon on both east/west sides of the canopy on six different dates. Berry samples were collected, weighed, and frozen at -80°C on six different dates for future compositional analyses. Yield data was collected by vine and cluster compactness was evaluated on 10 clusters per experimental unit at harvest. Soluble solids, pH, and titratable acidity were determined from 120 berry samples at harvest. Grape anthocyanins and total phenolics were determined from 120 berry samples randomly collected at harvest. While this was done in 2013, the entire experiment is being repeated during the 2014 season (and previously in the 2012 season): the three years' data will provide a measure of seasonal impact on our results.

Results: Cluster exposure flux availability (CEFA) is a measure of the amount of sunlight received by clusters at veraison, with values ranging from 0 to 1. A value of 1 is analogous to 100% exposure. The CEFA values measured at veraison were increased equally by the HIGH and PRE-BLOOM leaf removal treatments in both varieties (Fig. 1). Both HIGH and PRE-BLOOM had higher CEFA values than MEDIUM, which had higher CEFA values than NONE. There was a linear increase in CEFA with leaf removal magnitude (1 = NONE; 2 = MEDIUM; 3 = HIGH/PRE-BLOOM).

Average seasonal berry temperatures tended to be greater in HIGH and PRE-BLOOM leaf removal treatments (Table 1). This was likely a consequence of greater radiant heating due to greater fruit exposure in those treatments. However, berry temperatures during the post-veraison period spent minimal time above 35 °C – 35C is a temperature which has been shown to limit anthocyanin accumulation in grape skins. Difference in berry temperature between well exposed and shaded fruit was driven by the amount of light (PAR) received in fruit-zones (PAR) (Fig. 2). Lower light conditions, which occurred relatively more frequent, resulted in less of a difference in berry temperature.

Table 1. Leaf removal effect on average seasonal berry temperature and berry temperature time spent above 35 °C from post-veraison through harvest, 2013.

Petit Verdot		
Leaf removal	Berry temp. (°C)	Mins. > 35.0 °C
NONE	26.2 d	0
MEDIUM	26.8 c	0
HIGH	27.3 a	16
PRE-BLOOM	27.0 b	1
Cabernet franc		
Leaf removal	Berry temp. (°C)	Mins. > 35.0 °C
NONE	26.6 c	0
MEDIUM	26.9 b	0
HIGH	27.5 a	16
PRE-BLOOM	27.4 a	1

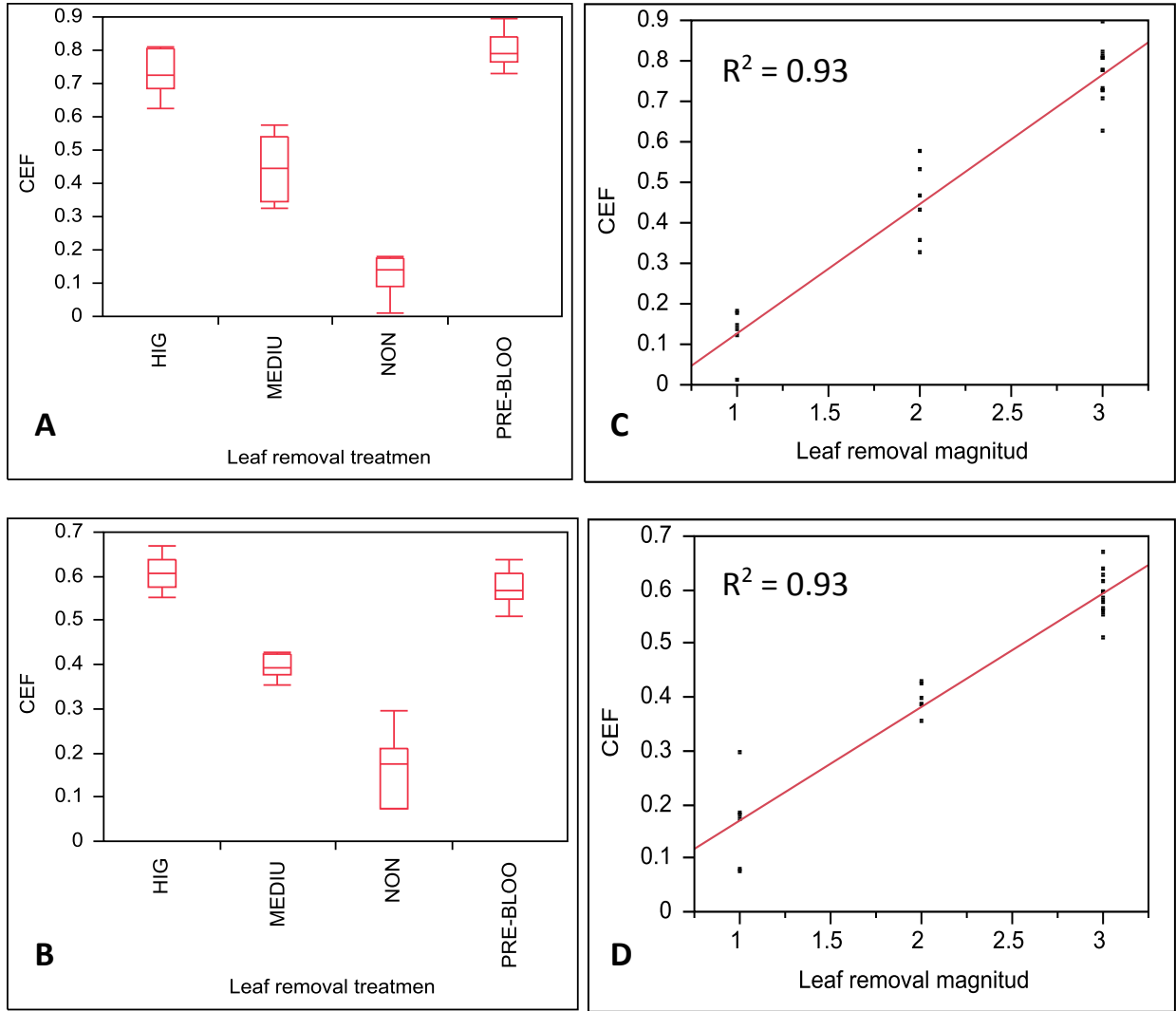


Fig. 1. Cluster exposure flux availability (CEFA) as affected by leaf removal treatment in Cabernet franc (A) and Petit Verdot (B). The linear relationship between leaf removal magnitude and CEFA in Cabernet franc (C) and Petit Verdot (D).

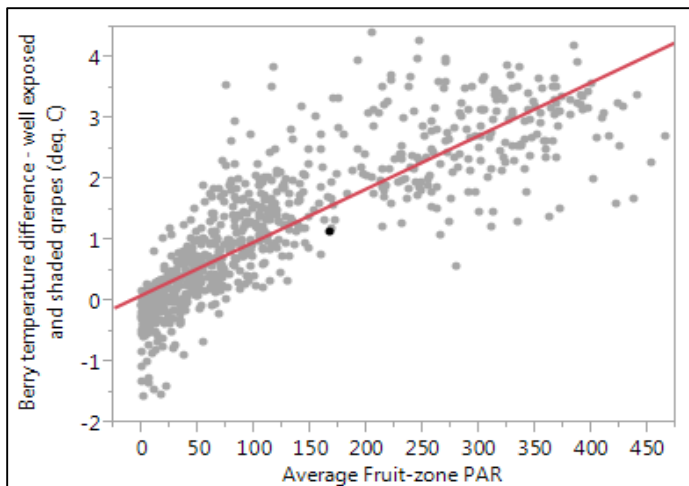


Fig. 2. Berry temperature difference between well-exposed and shaded fruit as a function of average fruit-zone photosynthetic active radiation (PAR). Interpretation: the greater the incident sunlight within the fruit zone, the greater the temperature differential between exposed and shaded fruit.

Pre-bloom leaf removal (PRE-BLOOM) reduced cluster compactness which we measured as the ratio of berry number to rachis length (Table 2). Though PRE-BLOOM reduced rachis length, berry number per cluster was reduced to a greater extent, resulting in less compact clusters (data not shown). PRE-BLOOM reduced yield weight by 40% and 46% compared to NONE in Petit Verdot and Cabernet franc, respectively (Table 2). Due to lower berry number and berry weight, PRE-BLOOM reduced cluster weight in both varieties, but no component of yield was significantly different between MEDIUM and PRE-BLOOM in Cabernet franc. Compared to NONE, PRE-BLOOM reduced berry weight by 18% in Petit Verdot but only by 6% in Cabernet franc. Berry weights were consistently reduced by PRE-BLOOM at every sample date after 14-Aug in Petit Verdot (Fig. 3) but never in Cabernet franc (data not shown).

Table 2. Crop yield, components of yield, and cluster compactness as affected by leaf removal treatment, 2013.

	Yield weight (tons/acre)	Cluster weight (g)	Berry # / cluster	Berry weight (g)	Cluster compactness
Petit Verdot					
NONE	5.60 a	93.4 a	74.8 a	1.25 a	9.21 ab
MEDIUM	5.25 a	92.4 a	75.2 a	1.23 a	9.10 ab
HIGH	5.01 a	94.3 a	76.6 a	1.23 a	9.68 a
PRE-BLOOM	3.35 b	64.5 b	63.5 b	1.02 b	8.29 b
Cabernet franc					
NONE	2.58 a	83.5 a	59.7 a	1.40 a	6.08 a
MEDIUM	1.91 bc	64.8 bc	48.3 bc	1.35 ab	5.54 ab
HIGH	2.02 ab	75.6 ab	54.8 ab	1.37 ab	5.87 a
PRE-BLOOM	1.39 c	55.4 c	42.2 c	1.31 b	5.09 b

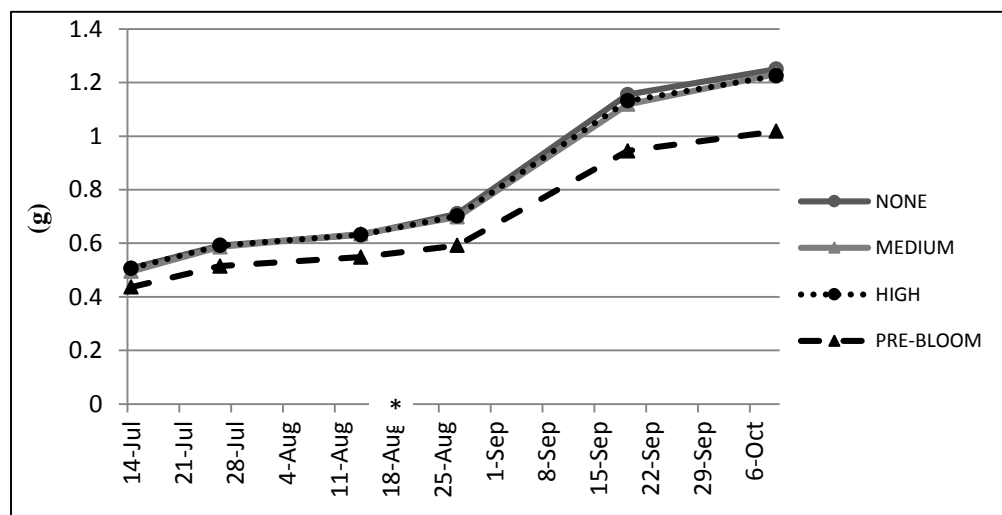


Fig. 3. Leaf removal effect on Petit Verdot berry weight on six different dates, 2013.

No leaf removal (NONE) had significantly greater soluble solids and titratable acidity (TA) than only HIGH in Petit Verdot (Table 3). There were no significant differences in soluble solids between leaf removal treatments, but both HIGH and PRE-BLOOM tended to increase pH and decrease TA in Cabernet franc. Leaf removal treatment had no effect on berry anthocyanins, however PRE-BLOOM significantly increased total berry phenolics in both varieties (Table 3).

Table 3. Leaf removal treatment effect on primary fruit chemistry and berry anthocyanins and total phenolics, 2013.

	Soluble solids (°Brix)	pH	TA (g/L)	Anthocyanins (mg/g berry)	Total phenolics (au/g berry)
Petit Verdot					
NONE	23.02 a	3.55	7.02 a	1.06	85.3 b
MEDIUM	22.77 ab	3.57	6.71 ab	1.11	89.6 ab
HIGH	22.50 b	3.55	6.31 b	1.11	88.7 b
PRE-BLOOM	22.95 ab	3.56	6.76 ab	1.07	98.6 a
Cabernet franc					
NONE	23.62	3.47 c	8.31 a	0.83	92.3 b
MEDIUM	23.63	3.49 bc	7.98 a	0.92	88.3 b
HIGH	23.40	3.55 a	7.08 b	0.77	94.7 b
PRE-BLOOM	23.83	3.54 ab	6.92 b	0.87	112.6 a

Discussion: Removing leaves from fruit-zones resulted in a linear increase in incident radiation to the fruit-zones and an increase in average seasonal berry temperature. Although extremes of berry temperature are the primary environmental factors that can limit anthocyanin accumulation in grapes, there was no difference in anthocyanin levels between leaf removal treatments. There are two possible reasons for this. First, even the most exposed grapes did not experience much time above 35 °C, a temperature shown to limit anthocyanin accumulation in grape skins. Second, the amount of time that leaf removal treatments resulted in a difference in berry temperature was limited by the high frequency of low ambient light conditions; put differently, cloudy weather, which is a frequent occurrence during VA growing seasons, nulls the leaf removal effect on increasing berry temperature and limiting anthocyanin accumulation. Similar studies under the intense sunlight conditions of Washington State have produced somewhat different results. There was a significant, inverse relationship between total berry phenolics and berry weight: as berry weight decreased, total berry phenolics increased. This trend suggests a concentration effect of smaller berries having a higher skin: pulp ratio and may partially explain why pre-bloom leaf removal increased total berry phenolics. However, pre-bloom leaf removal in Cabernet franc did not reduce berry weight as much as it did with Petit Verdot. Thus, it is possible that there was an absolute increase in total berry phenolics, potentially due to fruit exposure occurring two weeks earlier in the pre-bloom leaf removal treatment compared to post-bloom leaf removal. Pre-bloom leaf removal reduced yields and loosened cluster architecture; both appeared to be a consequence of a reduction in fruit set. The berry-size reduction that occurred in Petit Verdot may have been due to a reduction in cell division, thus limiting berry expansion potential. However, pre-bloom leaf removal may have also reduced seed number per berry, which we'll examine in more detail during 2014.

If both fruit-zone leaf removal and fruit thinning are already management practices, then pre-bloom leaf removal may be a useful tool to achieve an added benefit of loosening cluster architecture. It would be premature to try and identify optimal leaf removal practices for each variety as berry and wine samples remain to be evaluated for carotenoids, norisoprenoids, anthocyanins, and total phenolics and wines remain to be evaluated for consumer preference.

Again, this work is being repeated for the third and final season during 2014.