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Early season grapevine canopy management, Part II: Early leaf removal (ELR)

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In the previous post, we discussed shoot thinning as a method to achieve vine balance and improve the canopy microclimate (Part I: Shoot Thinning (https://psuwineandgrapes.wordpress.com/2017/05/19/early-season-grapevine-canopy-management-part-i-shoot-thinning/#comments)). In this post, we will discuss the use early leaf removal (ELR), a canopy management practice implemented around bloom. ELR primarily serves to reduce the severity of *Botrytis* bunch rot infection in susceptible varieties (Wines and Vines: Benefits and Costs of Early Leaf Removal (https://www.winesandvines.com/buyersguide/?pLev=detail&pId=395&articleId=168427)), but may also be an effective practice for reducing crop yield.

ELR is currently considered an experimental canopy management practice for vineyards. While it shows great promise within the research and Extension literature (1, 2, Cornell Cooperative Extension 2016 (https://grapesandwine.cals.cornell.edu/sites/grapesandwine.cals.cornell.edu/files/shared/Veraison-To-Harvest-2016-Issue-6.pdf))), Penn State Extension does not currently recommend implementing ELR as a *replacement* for traditional methods (i.e., cluster thinning, fungicide sprays) for yield and rot control. However, growers curious about the effects of ELR may find it useful as a supplementary canopy management practice, especially for disease management and crop reduction.

Throughout this post, we will discuss the effects of ELR on:

- Crop level in highly-fruitful varieties that produce a high number of clusters (3-4 per shoot) or large clusters such as vinifera cvs. Grüner Veltliner, Sangiovese, and Barbera.
- *Botrytis* bunch rot infection.
- Fruit and wine composition.

What is Early Leaf Removal (ELR) and how does it work?

ELR is the removal of basal leaves of the main shoots and, optionally, lateral shoots developed from the basal nodes (http://gph.is/2r3ZLc0 (http://gph.is/2r3ZLc0); Figure 1).

Figure 1. ELR on *V. vinifera* cv. Grüner Veltliner at trace-bloom June 7, 2016, Fero Vineyards, Lewisburg, PA. Undefoliated vine (left), defoliated vine (right).

ELR is typically performed shortly before (pre-bloom) or at the beginning of bloom (trace-bloom; Figure 2A). In some cases, however, it has been performed later during full-bloom or at the onset of fruit-set (Figure 2B).

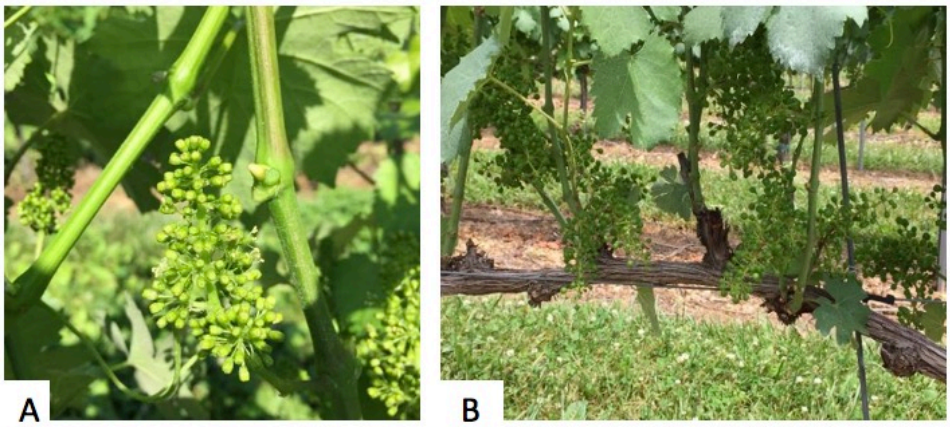

Figure 2. ELR on *V. vinifera* cv. Grüner Veltliner, at trace-bloom June 7, 2016 (A) and fruit-set June 14, 2016 (B), Fero Vineyards, Lewisburg, PA.

Before and during bloom, the oldest basal leaves have a major role in providing carbohydrates (*e.g.*, sugars) to support the growing shoot and inflorescence (*i.e.*, flower clusters). In contrast, young leaves on the middle and top part of the shoot are still developing and not very photosynthetically 'active' at this time (3). Literature suggests the removal of basal leaves at bloom may starve the inflorescence for a carbohydrates food source (4). The lack of carbohydrate resources reduces fruit-set (*i.e.*, the percentage of flowers that will develop into berries), which likely reduces the number of berries per cluster at harvest (5). When ELR is performed later, at the onset of fruit-set, removing basal leaves may induce a reduction in berry size and an increase in berry abscission due to carbohydrate limitation at the onset of fruit development (6). **Therefore, yield reduction achieved with ELR is the result of *reduced cluster weight* (reduced number of berries per cluster and/or reduced berry weight). In contrast, yield reduction achieved by cluster thinning is the result of a reduced number of *clusters per vine*.**

Why are ELR practices currently under research investigation?

An increased number of studies is investigating the use of ELR as a potential alternative to cluster thinning techniques used for crop yield control in highly-fruitful wine grape varieties (5, 6, 7). As opposed to traditional cluster thinning, ELR can be more easily mechanized. (***Author's note:*** for more

information on mechanization, see ***Additional Resources*** at the bottom of the post.) ELR may additionally confer **benefits** such as:

1. Reduced severity of *Botrytis* rot infection

Cluster compactness, or the tightness of berries on the cluster, has been positively related to the severity of *Botrytis* bunch rot infections (8). It is suggested that more compact clusters experience more rot. ELR decreases cluster compactness by reducing the number of berries per cluster and/or the berry size. Decreased cluster compactness through implementing ELR has reduced *Botrytis* rot infections in several tight-cluster varieties such as Pinot Noir, Riesling, Chardonnay, and Vignoles (1, 9, 10, 14). As an additional benefit, the removal of basal leaves increases sunlight penetration and air movement in the fruiting zone, which is important for improving spray penetration within the canopy (2016 Post Bloom Disease Management Review (https://psuwineandgrapes.wordpress.com/2016/07/01/2016-post-bloom-disease-management-review/)).

2. Improved fruit and wine composition

ELR has consistently been reported to alter fruit composition, particularly for red *Vitis vinifera* varieties in Mediterranean climates (Tempranillo, Sangiovese, Barbera, etc.; 2, 5, 6, 12). In several instances, fruit harvested from ELR vines had higher levels of total soluble solids (TSS, °Brix), phenolic compounds (e.g., flavonols), and total anthocyanins compared to un-defoliated vines (2, 11, 12). ELR can also reduce methoxypyrazines, 'herbaceous' aromas found in higher concentrations among immature grapes at harvest, and may contribute to improved wine color intensity (13). ELR may alter three important parameters associated with berry development and ripening (2):

- **Decreased berry size** – Smaller berries tend to have greater skin-to-pulp ratio and higher concentrations of desirable phenolic and aroma compounds which are mainly present in the skin.
- **Increased leaf area-to-yield ratio on a per shoot basis** – A greater leaf area-to-yield ratio may translate into higher sugar produced per shoot. More sugar availability could contribute to better fruit ripening.
- **Improved canopy microclimate** – ELR, like traditional leaf removal, improves the microclimate of the fruiting zone through decreased leaf density and increased sunlight penetration to the fruit. Higher temperatures coupled with increased sunlight exposure in the fruiting zone can be especially important under cool or cloudy ripening conditions, as they may accelerate berry ripening, resulting in higher TSS, decreased malic acid, increased anthocyanin concentration, and degradation of green volatile aroma compounds such as methoxypyrazines that may mask fruity or floral aromas. Higher ultraviolet (UV) radiation in the fruiting zone in response to increased sunlight penetration may increase production of flavonols, as flavonols biologically act to protect berries from UV exposure (3, 11). Flavonol compounds along with anthocyanin influence red wine color and are used as determinants of quality in fruit (11).

It is important to keep in mind that yield reduction is not desirable in all grape varieties. The use of ELR with varieties that do not typically over-crop may result in under-cropped situations with potential negative effects on fruit quality and vine health, in addition to unnecessary yield reductions and thus revenue loss.

How many leaves should be removed to induce yield reduction?

Unfortunately, there is no "one size fits all" number of leaves to remove when implementing ELR as a vineyard management practice. The required number of leaves removed to significantly reduce yield through reduced fruit-set depends on several factors, including shoot length and the shoot leaf area at the time of removal. For example, by pulling 5 basal leaves on a shoot with only 8 leaves at trace-bloom, we would remove about 63% of the total *number* of leaves. The percentage of leaf *area* removed would be even higher as the remaining leaves at the top of the shoot are much smaller than those removed from the bottom of the shoot. In contrast, a longer shoot with 15 leaves total will only lose 33% of the leaf area when 5 basal leaves are pulled. Thus, removing 5 leaves from a short shoot would have a more severe effect of depriving the inflorescence of sugar resources than removing the same number of leaves on long shoots (Figure 3).

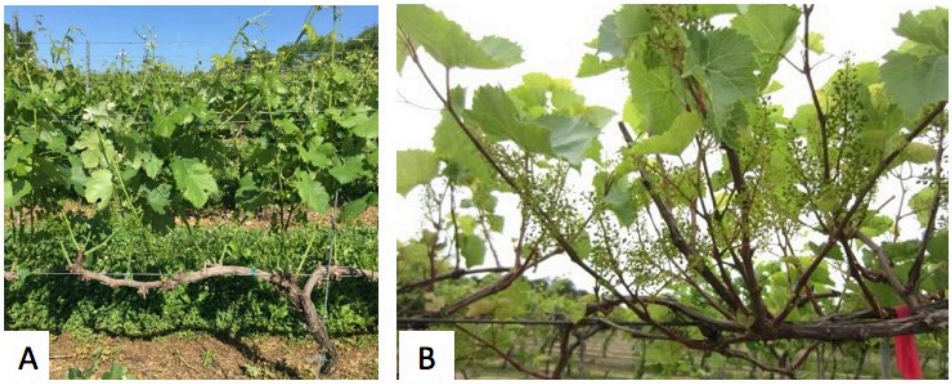

Figure 3. Example of different shoot lengths at trace-bloom. A) 5 leaves removed from long shoots with an average of 15 leaves in *V. vinifera* cv. Grüner Veltliner (Lewisburg, PA) and B) 5 leaves removed from short shoots with and average of 8 leaves in French-American hybrid cv. Chancellor (LEGREC, North East, PA, photo credit: Bryan Hed).

Sometimes the degree of ELR is severe in order to induce a yield reduction commensurate with the more traditional cluster thinning technique. For example, Pinot Noir grown in southwestern Michigan showed a reduction in yield from 6.1 tons per acre in non-defoliated vines to 3.6 tons per acre when about half (8 out of 15) of the leaves on the shoots were removed (1). This was a 40% reduction in yield. Comparatively, when 4 or 6 leaves were removed from the Pinot Noir, no significant effect was found in crop yield (1).

With the high potential for crop yield reduction, Dr. Michela Centinari's lab has been experimenting with ELR for the past two years. We have been examining the effects of ELR at trace-bloom on Grüner Veltliner (*V. vinifera*) grown in Central Pennsylvania. Grüner Veltliner is highly fruitful, typically producing 2-3 large clusters per shoot. In our experimental practices, we removed 5 basal leaves at trace-bloom. Our objective was to compare the use of ELR to cluster thinning for crop yield reduction. Our first year of data found that the implementation of ELR decreased yields by only about 15% (10.7 tons per acre in the non-defoliated control to 9.3 tons per acre in defoliated vines). In comparison, vines thinned to 1 cluster per shoot had a 45-50% reduction in yield compared to the un-thinned control (10.7 tons per acre to 6.5 tons per acre).

This suggests that a greater leaf removal intensity may be needed for this variety to produce yield reduction comparable to cluster thinning, and we are currently testing different intensity levels of trace-bloom ELR to evaluate if the amount of leaf area removed correlates with reduction of fruit-set and yield at harvest.

Again, ELR is still considered an experimental canopy management technique. For those growers growing high yielding varieties and looking to reduce crop level, cluster thinning is still the recommended practice. For more information on how to implement appropriate CT techniques, please see Cornell Cooperative Extension Fruit thinning in wine grapes (https://nygpadmin.cce.cornell.edu/uploads/doc_17.pdf) and Crop thinning: cluster thinning or cluster removal (http://articles.extension.org/pages/31767/crop-thinning:-cluster-thinning-or-cluster-removal).

Considerations regarding ELR

Other factors to consider if you are interested in applying ELR:

- **Fruit-set percentage** – One of the factors facing the unpredictability of ELR is the weather conditions between bloom and fruit set. Since weather can have a large effect on the percentage of fruit-set (Fruit set in grapes 101 (https://psuwineandgrapes.wordpress.com/2015/08/07/fruit-set-in-grapevines-101/)), ELR may potentially exacerbate 'poor' fruit-set if extended periods of wet, cool (< 59°F), overcast, or very hot (> 90°F) weather conditions occur following leaf removal. Additionally, berry sunburn may be a potential concern with ELR when performed under chronic high light and temperature intensity.
- **Bud Fruitfulness** – While it is generally acknowledged that increased sunlight exposure is positive for bud development, a potential reduction in bud fruitfulness (number of clusters per shoot) may occur in the following season as a result of bud damage from ELR (14). Although still uncertain, bud damage may be the result of physical damage during leaf removal and/or reduction of carbohydrate supply during bud development.
- **Carbohydrate Storage in Cool Climate Grown Vines** – Carbohydrates are the main energy source for grapevine growth, stress defense, and fruit ripening. Post-harvest carbohydrate storage in perennial tissues is a determinant of vine overwinter survival and is fundamental for shoot development in the following season. Removing leaves during ELR may alter the amount of carbohydrates produced by the leaves over the season and how carbohydrates are distributed among the vine organs. Currently, limited information is available on how ELR affects carbohydrates storage in perennial tissues and how this relates to dormant tissue (buds and canes) cold hardiness. This is a point of current interest to Centinari's lab at Penn State, with current research being conducted in *vinifera* and hybrid wine grape varieties.
- **Crop Estimation** – Yield predictions based on ELR use is currently not available. In this regard cluster thinning is a more conservative approach. Unlike ELR, which is performed very early in the season, cluster thinning severity can be decided upon estimation of final yield.

Summary

ELR holds potential as a way to reduce yield and *Botrytis* rot infection for some grape varieties grown in the Mid-Atlantic and other cool-climate regions. However, more research is needed to better understand the consistency of ELR practices on vine physiology, yield reductions, and fruit quality. Current efforts are on-going by the Centinari lab and Bryan Hed at the Lake Erie Grape Regional Extension Center (LEGREC) to evaluate the use of manual and mechanized ELR in hybrid and *V. vinifera* varieties across Pennsylvania.

Additional Resources

PSU Wines and Grapes blogs: An Overview of Cluster-Zone Leaf Removal Strategies for Cool Climate Vineyards (https://psuwineandgrapes.wordpress.com/2015/09/11/an-overview-of-cluster-zone-leaf-removal-strategies-for-cool-climate-vineyards/) and 2016 Post Bloom Disease Management Review (https://psuwineandgrapes.wordpress.com/2016/07/01/2016-post-bloom-disease-management-review/)

Intrieri C, Filippetti I, Allegro G, *et al*. 2008. Early defoliation (hand vs mechanical) for improved crop control and grape composition in Sangiovese (*Vitis vinifera* L.). *Aus. J. Grape Wine Res.* doi: 10.1111/j.755-0238.2008.00004.x

References Cited

1. Acimovic D, Tozzini L, Green A, *et al*. 2017. Identification of a defoliation severity threshold for changing fruitset, bunch morphology and fruit composition in Pinot Noir. *J. Grape Wine Res.* doi: 10.1111/ajgw.12235
2. Bubola M, Sivilotti P, Janjanin D, and Poni S. Early leaf removal has larger effect than cluster thinning on cv. Teran grape phenolic composition. *AJEV*. doi: 10.5344/ajev.2016.16071
3. Illand P, Dry P, Proffit P, and Tyerman S. Photosynthesis. *In* The Grapevine, from the science to the practice of growing vines for wine. pp. 91-107.
4. Coombe BG. The effect of removing leaves, flowers and shoot tips on fruit-set in *Vitis vinifera* L. *J. Hortic. Sci.* 37:1-15.
5. Poni S, Casalini L, Bernizzoni F, *et al*. 2006. Effects of early defoliation on shoot photosynthesis, yield components, and grape composition. *AJEV*. 57: 397-407.
6. Tardaguila J, Martinez de Toda F, Poni S, and Diago MP. 2010. Impact of early leaf removal on yield and fruit and wine composition of *Vitis vinifera* Graciano and Carignan. *AJEV*. 61(3):372-381.
7. Silvestroni O, Lanari V, Lattanzi T, *et al.* Impact of crop control strategies on performance of high-yielding Sangiovese grapevines. *AJEV.* doi: 10.5344/ajev.2016.15093
8. Vail ME and JJ Marois. 1991. Grape cluster architecture and the susceptibility of berries to *Botrytis cinerea*. *Phytopathology* 81:188-191.
9. Sternad Lemut M, Sivilotti P, Butinar L, *et al*. Pre-flowering leaf removal alters grape microbial population and offers good potential for a more sustainable and cost-effective management of a Pinot Noir vineyard. *J. Grape Wine Res.* doi: 10.1111/ajgw.12148
10. Hed B, Ngugi HK, and Travis JW. Short- and long-term effects of leaf removal and gibberellin on Chardonnay grapes in the Lake Erie region of Pennsylvania. *AJEV.* 66(1): 22-29.
11. Moreno D, Vilanova M, Gamero E, *et al.* Effects of preflowering leaf removal on phenolic composition of Tempranillo cv. in semi-arid terroir of western Spain. *AJEV*. doi: 10.5344/ajev.2014.14087
12. Risco D, Pérez D, Yeves A, *et al*. Early defoliation in a temperate warm and semi-arid Tempranillo vineyard: vine performance and grape composition. *Aus J Grape and Wine Res.* doi: 10.1111/ajgw.12049
13. Sivilotti P, Herrera JC, Lisjak K, *et al*. 2016. Impact of leaf removal, applied before and after flowering, on anthocyanin, tannin, and methoxypyrazine concentrations in 'Merlot' (*Vitis vinifera*) grapes and wines. *J. Agric. Food Chem.* 64:4487-4496.
14. Sabbatini P, and Howell GS. 2010. Effects of early defoliation on yield, fruit composition, and harvest season cluster rot complex of grapevines. *HortScience* 45(12):1804-1808.

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