Root-zone and vineyard floor effect on Cabernet Sauvignon vine performance.

Cain Hickey

Tony Wolf, Tremain Hatch, Brycen Hill

February 20, 2018
Oregon Wine Symposium
Vine size (vigor, growth)

- Often “excessive” in humid climates
  - VA, NC, GA, PA, NY, etc... OR????

- Likely due to:
  - Low evapotransitive demand of atmosphere (high humidity)
  - Supra-optimal availability of soil water
    - Variable seasonal rainfall
  - Nutrients are often not limiting
    - Grower-applied amendments
    - Inherent soil organic matter
## Canopy microclimate differences as a function of canopy density.

<table>
<thead>
<tr>
<th>Microclimate characteristic</th>
<th>Interior region of a <strong>SPARSE</strong> canopy</th>
<th>Interior region of a <strong>DENSE</strong> canopy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunlight</td>
<td>Most leaves and fruit receive some direct sunlight at some point during the day</td>
<td>Most leaves and fruit are in the shade for the day</td>
</tr>
<tr>
<td>Temperature</td>
<td>Fruit and leaves are warmed by sunlight and may be cooler than air temperature at night</td>
<td>Most leaves and fruit are at approximately ambient temperature, both day and night</td>
</tr>
<tr>
<td>Humidity</td>
<td>Leaves and fruit experience ambient humidity values</td>
<td>Humidity can build up slightly within the canopy</td>
</tr>
<tr>
<td>Wind speed</td>
<td>Leaves and fruit are exposed to ambient wind speed values</td>
<td>Wind speeds are reduced within the canopy</td>
</tr>
<tr>
<td>Evaporative potential</td>
<td>Evaporation rates are similar to ambient values</td>
<td>Evaporation rates are reduced within the canopy</td>
</tr>
</tbody>
</table>

Smart and Robinson (1991)
Why do we care about excessive vine growth?

• It *may* limit crop quality
  • Disease
  • Quality
  • Quantity?
    • maybe – if vine becomes overly vegetative and sunlight is limited

• Because of the above, regulating vegetative growth is important
Why does Oregon care about reducing vine vigor?

• Reduce the need for remedial canopy management measures?
  • Hedging, lateral and leaf removal
    • Labor-related concern

• Reduced vigor increases fruit quality?
  • If so, likely related to microclimate of vineyard:
    • Reduced vigor = smaller canopy = more light penetration (really a light effect)
    • Reduced vigor = smaller berries = greater skin: volume ratio (really concentration effect)
Tight VSP:

Aesthetically pleasing

Not a “workhorse”...
Modified ballerina:

Vines don’t know they are “over-cropped”

Have yet to see a crop load approaching 10
Remedial vine size management

- Canopy management
  - Leaf removal (1-2 x / season)
  - Hedging (3-4 x / season)
  - Lateral shoot removal (2-3 x / season)

***All of these take time and cost money***
**Proactive** vine size management

- Site selection
- Cultivar selection
- **Rootstock selection**
- Vine spacing?
- Trellis system
- Pruning methods (cane vs. spur)
- **Under-trellis cover cropping**
- Vine spacing?
- Root restriction

***All of these can cost money, but may limit time spent on remedial measures in the long run***
Why use cover crops in vineyards?

• Row middles:
  • accommodate vineyard equipment
  • Maintain soil place (i.e. limit erosion) and structure (i.e. limit compaction)

• Under-trellis:
  • *further* reduce erosion on highly (> 20 %) sloped sites
  • improve soil “health” (organic matter, improve beneficial microbes)
  • reduce vine vigor through competition
  • improve fruit composition?
Why use rootstocks in (*vinifera*) vineyards?

- Tolerate soil-borne insect pests
  - phylloxera, nematodes
- Tolerate salinity, acidity, alkalinity
- Tolerate drought
- Confer scion vigor

![Trait ratings of rootstocks (greater = higher number)]

<table>
<thead>
<tr>
<th>Rootstock</th>
<th>Scion vigor</th>
<th>Drought tol.</th>
<th>Phylloxera tol.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-3309</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>101-14</td>
<td>2-3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>420 A</td>
<td>1-2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td><em>Riparia gloire</em></td>
<td>1-2</td>
<td>1</td>
<td>5</td>
</tr>
</tbody>
</table>

Adapted from Wolf (2008)
Two parts:
1. cover crop and rootstock study (6 years)
2. root restriction bag study (2 years)
Part 1: Can vine size be regulated with cover crops and rootstocks, and will this change fruit composition?

- Cabernet Sauvignon (2006); clone 337
- low, bilateral cordon trained to VSP
- 6 years (most responses)

- UTGC:
  - Herbicide strip (HTS)
  - Creeping red fescue under-trellis (CC)
    - Established 2008

- Rootstocks:
  - 101-14
  - 420-A
  - Riparia gloire
Vine vigor
(shoot growth rate)

<table>
<thead>
<tr>
<th>Shoot growth rate (cm/day)</th>
<th>May – June, 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>CC</td>
<td>1.81</td>
</tr>
<tr>
<td>HTS</td>
<td>2.44</td>
</tr>
</tbody>
</table>
Vine size
(pruning weight)

Characteristics of the ideal canopy (Smart and Robinson 1991).

<table>
<thead>
<tr>
<th>Canopy characteristic</th>
<th>Optimal value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cane pruning weights</td>
<td>0.3 – 0.6 kg / m of canopy</td>
</tr>
</tbody>
</table>
Fruit-zone microclimate at veraison (pre-lateral / leaf removal)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>CEL&lt;sup&gt;a&lt;/sup&gt;</th>
<th>CEFA&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTGC&lt;sup&gt;b,c&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC</td>
<td>0.43 b</td>
<td>0.37 a</td>
</tr>
<tr>
<td>HTS</td>
<td>0.65 a</td>
<td>0.26 b</td>
</tr>
<tr>
<td>Rootstock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>101-14</td>
<td>0.58 a</td>
<td>0.28 a</td>
</tr>
<tr>
<td>420-A</td>
<td>0.56 a</td>
<td>0.32 a</td>
</tr>
<tr>
<td><em>Riparia</em></td>
<td>0.48 a</td>
<td>0.34 a</td>
</tr>
</tbody>
</table>
### Tissue nutrient concentration, 2011

<table>
<thead>
<tr>
<th>Rootstock</th>
<th>BLOOM LEAF PETIOLES (%)</th>
<th>VERAISON LEAF PETIOLES (%)</th>
<th>VERAISON LEAF BLADES (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nitrogen</td>
<td>Potassium</td>
<td>Nitrogen</td>
</tr>
<tr>
<td><strong>UTGC</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC</td>
<td>0.70 b</td>
<td>2.25</td>
<td>0.37</td>
</tr>
<tr>
<td>HTS</td>
<td>0.81 a</td>
<td>1.99</td>
<td>0.37</td>
</tr>
<tr>
<td><strong>Rootstock</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>101-14</td>
<td>0.73</td>
<td>2.81 a</td>
<td>0.38</td>
</tr>
<tr>
<td>420-A</td>
<td>0.76</td>
<td><strong>1.18 b</strong></td>
<td>0.36</td>
</tr>
<tr>
<td>Riparia</td>
<td>0.77</td>
<td>2.37 a</td>
<td>0.37</td>
</tr>
</tbody>
</table>

Midday stem water potential
(vine hydration status)
Crop yield and some components

Table 1. Effects of UTGC and rootstock on mean values of yield components and crop yield from 2008 to 2013.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Crop yield (t/acre)</th>
<th>Cluster weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTGC&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC</td>
<td>3.73&lt;sup&gt;b&lt;/sup&gt;</td>
<td>139&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>HTS</td>
<td>4.29&lt;sup&gt;a&lt;/sup&gt;</td>
<td>172&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Rootstock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>101-14</td>
<td>3.80&lt;sup&gt;b&lt;/sup&gt;</td>
<td>141&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>420-A</td>
<td>3.71&lt;sup&gt;b&lt;/sup&gt;</td>
<td>155&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td>Riparia</td>
<td>4.53&lt;sup&gt;a&lt;/sup&gt;</td>
<td>170&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Fruit composition

Table 5: Effects of UTGC, rootstock, and UTGC/rootstock on mean estimated skin (2009 to 2011) and berry (2013) phenolics and anthocyanins.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>2009 to 2011</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Anthocyanins</td>
</tr>
<tr>
<td></td>
<td>phenolics</td>
<td>(A$_{280}$, AU)</td>
</tr>
<tr>
<td></td>
<td>(A$_{280}$, AU)</td>
<td>(mg/g berry)</td>
</tr>
<tr>
<td>UTGC$^{b,c}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CC</td>
<td>45.15 a</td>
<td>37.59 a</td>
</tr>
<tr>
<td>HTS</td>
<td>42.00 a</td>
<td>36.45 a</td>
</tr>
<tr>
<td>Rootstock$^{c}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>101-14</td>
<td>44.18 a</td>
<td>38.31 a</td>
</tr>
<tr>
<td>420-A</td>
<td><strong>41.74 a</strong></td>
<td><strong>35.65 a</strong></td>
</tr>
<tr>
<td>Riparia</td>
<td>44.80 a</td>
<td>37.09 a</td>
</tr>
</tbody>
</table>
Part 1: Discussion / take home

• Under-trellis cover crops appear to “compete” with vines for nitrogen more so than water.
  • Root displacement in soil profile? (Klodd et al. 2016)

• 420-A may limit wine pH (indirect K+ effects) but also may limit color
  • “berlandieri-based” rootstocks exclude K+ (Wolpert et al. 2005)

• Under-trellis cover crops regulated vine growth more so than rootstock choice.

• Fruit composition was marginally affected by treatments

• Riparia increased crop yield (berry weight) while CC reduced crop yield (berry # / cluster)
Part 2: root bag restriction effects on vine size, crop yield, and fruit composition
Part 2: root restriction effects on vine size, crop yield, and fruit composition

- Cabernet Sauvignon; clone 337; low, bilateral cordon trained to VSP
- 2 years

- Two “side studies”:
  - Root restriction (0.015 m$^3$)
  - No root manipulation (NRM)
  - 3 different root restriction volumes
    - 0.026, 0.035, and 0.058 m$^3$
    - No root manipulation (NRM)
0.015 m³ volume root restriction vs. NRM

Shoot growth in 2010
0.015 m³ volume root restriction vs. NRM

Pruning weight averaged over 2010 and 2011.

Smart and Robinson (1991)
Root restriction (m3 vol.) had many of these characteristics of the ideal canopy (Smart and Robinson 1991).

<table>
<thead>
<tr>
<th>Canopy characteristic</th>
<th>Optimal value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shoot length</td>
<td>15-20 nodes</td>
</tr>
<tr>
<td>Lateral shoot development</td>
<td>Ideally none</td>
</tr>
<tr>
<td>Growing shoot tip presence</td>
<td>Ideally none</td>
</tr>
<tr>
<td>Cane pruning weights</td>
<td>0.3 – 0.6 kg / foot of canopy</td>
</tr>
</tbody>
</table>
• Vine hydration status
vs.
• Photosynthesis
0.015 m$^3$ volume root restriction vs. NRM

- Crop yield reduction by 0.015 m$^3$
  - Reduced berry weight
  - Reduced berry number per cluster
  - Reduced cluster weight
  - Similar cluster number per vine

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Crop yield (t/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root restriction$^a$</td>
<td></td>
</tr>
<tr>
<td>0.015 m$^3$</td>
<td>2.56 b</td>
</tr>
<tr>
<td>NRM</td>
<td>3.98 a</td>
</tr>
</tbody>
</table>

36% reduction in crop yield due to 0.015 m$^3$
0.015 m³ volume root restriction vs. NRM

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th></th>
<th></th>
<th>2011</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Brix</td>
<td>pH</td>
<td>TA</td>
<td>Brix</td>
<td>pH</td>
<td>TA</td>
</tr>
<tr>
<td>0.015 m³</td>
<td>24.5 b</td>
<td>3.41</td>
<td>5.35</td>
<td>20.9</td>
<td>3.37 b</td>
<td>5.13 b</td>
</tr>
<tr>
<td>NRM</td>
<td>25.5 a</td>
<td>3.44</td>
<td>5.43</td>
<td>21.4</td>
<td>3.44 a</td>
<td>5.81 a</td>
</tr>
</tbody>
</table>

Bar chart showing total skin anthocyanins (au) for NRM and 0.015 m³ treatments.
Multi-volume (0.026, 0.035, 0.058 m³) root restriction vs. NRM

• Immediately thought that 0.015 m³ was maybe “too much” growth regulation...

• ...let’s try larger volumes...

• 0.026 m³
• 0.035 m³
• 0.058 m³
Multi-volume (0.026, 0.035, 0.058 m³) root restriction vs. NRM

- Pruning weight

- 0.026 and 0.035 m³
  - “in the zone”
Multi-volume (0.026, 0.035, 0.058 m$^3$) root restriction vs. NRM

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Crop yield (t/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root restriction$^a$</td>
<td></td>
</tr>
<tr>
<td>0.026 m$^3$</td>
<td>5.23</td>
</tr>
<tr>
<td>0.035 m$^3$</td>
<td>5.96</td>
</tr>
<tr>
<td>0.058 m$^3$</td>
<td>5.18</td>
</tr>
<tr>
<td>NRM</td>
<td>5.50</td>
</tr>
</tbody>
</table>
Multi-volume (0.026, 0.035, 0.058 m$^3$) root restriction vs. NRM

Table 29. Treatment effects on soluble solids ($^\circ$Brix), pH, and titratable acidity (g/L) in 2015-2016.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.026 m$^3$</td>
<td>23.10a</td>
<td>22.15a</td>
<td>3.27b</td>
<td>3.61a</td>
<td>6.88b</td>
<td>5.35b</td>
</tr>
<tr>
<td>0.035 m$^3$</td>
<td>22.80a</td>
<td>21.73a</td>
<td>3.26b</td>
<td>3.59a</td>
<td>7.67a</td>
<td>5.57b</td>
</tr>
<tr>
<td>0.058 m$^3$</td>
<td>23.08a</td>
<td>22.28a</td>
<td>3.29b</td>
<td>3.61a</td>
<td>7.65a</td>
<td>5.91ab</td>
</tr>
<tr>
<td>NRM</td>
<td>22.18a</td>
<td>20.35b</td>
<td>3.34a</td>
<td>3.56a</td>
<td>8.12a</td>
<td>6.82a</td>
</tr>
<tr>
<td>Significance $^c$</td>
<td>NS</td>
<td>0.0010</td>
<td>0.0041</td>
<td>NS</td>
<td>0.0025</td>
<td>0.0138</td>
</tr>
</tbody>
</table>
Multi-volume (0.026, 0.035, 0.058 m³) root restriction vs. NRM

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Anthocyanin concentration (mg/g)</th>
<th>Absorbance at 280 nm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2015</td>
<td>2016</td>
</tr>
<tr>
<td>0.026 m³</td>
<td>1.25 a</td>
<td>1.30 a</td>
</tr>
<tr>
<td>0.035 m³</td>
<td>1.10 ab</td>
<td>1.04 ab</td>
</tr>
<tr>
<td>0.058 m³</td>
<td>1.05 ab</td>
<td>1.04 ab</td>
</tr>
<tr>
<td>NRM</td>
<td>0.96 b</td>
<td>0.84 b</td>
</tr>
<tr>
<td>Significance</td>
<td>0.0155</td>
<td>0.0045</td>
</tr>
</tbody>
</table>

DeAnna D'Atillio
Canopy management labor savings of 4.8-8.7 hours per acre
Overall take home

• Use proactive tools to “match” your site and production goals
  • High clay, high O.M., flat land VS.
  • Rocky, low O.M. sloped land
  • Think about vine spacing, trellis system, and cultivar.

• Cover crops may provide tandem vineyard benefits (soil health, reduced leaching and erosion)
  • Wait until at least year 2-3 to establish
  • Watch nitrogen levels
  • Choose species wisely (F. rubra)

Poling (2006)
• **Riparia** worked well
  • attenuated vegetative growth
  • increased crop yield; maintained wine quality potential

• If experimenting with **root restriction**:  
  • Irrigation may be necessary in dry summers
  • Can “tame” canopy vigor
  • Choose volume wisely (≥ 0.026 m³)

• 0.026 and 0.038 m³ may be “best” in terms of growth regulation and crop yield maintenance

Vine size – fruit quality comment
Farming is a business – need quantity and quality; you can have both

Comment on vine size – crop yield - quality
Thanks very much

- Russ Moss
- Sierra Winegarner
- Bree Boskov
- Jason Tosch
- Gill Giese
- Tony Wolf
- Brycen Hill
- Tremain Hatch