Vineyard Management for Improved Fruit and Wine Quality

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Purdue University
Wine Grape Team

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Iowa Fruit and Vegetable Growers Meeting, Feb 22, 2001, Cedar Rapids

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Vineyard Management Principles

- Variety/site suitability
- Proper crop balance
- Appropriate harvest decisions
- Appropriate training system
Matching Variety to Site

- Cold hardiness-winter temperature
  - Zone 4b (-20 to -25F)
  - Zone 5a (-15 to -20F)

- Date of ripening-temperature during ripening period
  - Early (<80 days from bloom to harvest)
  - Late (>120 days from bloom to harvest)
Match Cold Hardiness to Climate

- **Very hardy (-20 to -30°F)**
  - Frontenac, LaCrescent, Marquette, DeChaunac, LaCrosse, Edelweiss, St. Croix, St. Pepin, Esprit
- **Hardy (-15 to -25°F)**
  - Concord, Steuben, Foch, Noiret, Corot noir, Vignoles, Chancellor, Norton, Melody
- **Moderately hardy (-10 to -20°F)**
  - Seyval, Chardonel, Cayuga white, Traminette
- **Slightly hardy (-5 to -15°F)**
  - Chambourcin, Vidal
- **Tender (0°F to -10°F)**
  - All vinifera
Cold damage
Match Ripening Date to Climate

• **Heat units** (growing degree days base 50°F)
  – Iowa varies between 3,500 and 2,500
  – Cultivars vary season of ripening, need for heat

• **Frost Free Days**
  – In Iowa season length varies from 140 to 170+ days
  – Mid to late ripening varieties need 160-180 days
  – Early varieties need less
Theories on Heat Affects

- California Zones I-V based on GDDs base 50°F (Amerine & Winkler, 1944)
- Temps >86°F day & >64°F night are detrimental to fruit quality
  Optimal temperature is 68-77°F day, 59-68°F night (Coombe, 1987)
- Mean temp of 64-70°F during final month of ripening (Gladstones, 1992)
- Daily heat load (>22°C) during last 28 days (Happ, 2004)
- Quality ripening days (daily heat accumulation base 50 <22°F)
  veraison to harvest (Butler, 2004)
Match Variety to Ripening Season Temperatures

Fruit quality is best when ripened under **warm days** and **cool nights**

- Don’t grow early ripening grapes in a long season, hot area (excess heat)
  - Low sugars, low acid, high pH, poor color, poor flavor & aroma
- Don’t grow late ripening grapes in a short season, cool area (insufficient heat)
  - Low sugar, high acid, low pH, unripe herbaceous flavors
### Relative Date of Ripening

<table>
<thead>
<tr>
<th>Early</th>
<th>Foch, Marquette, St. Croix, Edelweiss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid</td>
<td>Frontenac, LaCrescent, Seyval, LaCrosse, Chardonel, Cayuga White, Vignoles, DeChaunac, Traminette, Noiret, Corot noir, etc.</td>
</tr>
<tr>
<td>Late</td>
<td>Chambourcin, Norton, Vidal</td>
</tr>
</tbody>
</table>
ISU Grape Cultivar Trials
Planting Sites

North
-20° to -25°

ISU Northeast R & D Farm

Central

ISU Horticulture Res. Station

ISU Armstrong R & D Farm
-15° to -20°

ISU Southeast R & D Farm

South
-10° to -15°
# Harvest Dates & Maturity

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Hort Res. Sta.</th>
<th>Armstrong Farm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Date</td>
<td>SS</td>
</tr>
<tr>
<td>Edelweiss</td>
<td>Aug 16</td>
<td>14.0</td>
</tr>
<tr>
<td>Marechal Foch</td>
<td>Aug 24</td>
<td>19.0</td>
</tr>
<tr>
<td>St. Croix</td>
<td>Aug 30</td>
<td>17.5</td>
</tr>
<tr>
<td>Seyval Blanc</td>
<td>Aug 30</td>
<td>19.5</td>
</tr>
<tr>
<td>Frontenac</td>
<td>Sep 19</td>
<td>22.4</td>
</tr>
<tr>
<td>Traminette</td>
<td>Sep 13</td>
<td>18.4</td>
</tr>
<tr>
<td>La Crosse</td>
<td>Sep 13</td>
<td>17.8</td>
</tr>
<tr>
<td>Vignole</td>
<td>Sep 19</td>
<td>22.4</td>
</tr>
<tr>
<td>Chambourcin</td>
<td>Oct 4</td>
<td>22.0</td>
</tr>
<tr>
<td>Cynthiana</td>
<td>Oct 13</td>
<td>22.5</td>
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</table>
Iowa Ripening Season Temperatures

<table>
<thead>
<tr>
<th>Location</th>
<th>August</th>
<th>September</th>
<th>October</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Max</td>
<td>Min</td>
<td>Mean</td>
</tr>
<tr>
<td>Burlington (1st FF Nov 1)</td>
<td>84</td>
<td>64</td>
<td>74</td>
</tr>
<tr>
<td>Des Moines (1st FF Oct 30)</td>
<td>84</td>
<td>64</td>
<td>74</td>
</tr>
<tr>
<td>Sioux City (1st FF Oct 18)</td>
<td>84</td>
<td>62</td>
<td>73</td>
</tr>
</tbody>
</table>

Gladstones suggested 64-70°F
Appropriate Varieties for Iowa?

Varieties cold hardy enough for region
• All the early to mid season varieties should ripen well.
• Late varieties might not ripen fully in some years.
Rainfall During Ripening

Rainfall between veraison and harvest almost always leads to a reduction in fruit quality

- Occurrence of bunch/fruit rots
  Vignoles, Seyval, etc are very prone to bunch rots
  LaCrescent, Frontenac, etc are more tolerant
- Dilution of sugar, acid, flavors

Harvest decisions are often influenced by rainfall and resulting rots
## Iowa Ripening Season Precipitation

<table>
<thead>
<tr>
<th>Location</th>
<th>August Mean inches</th>
<th>September Mean inches</th>
<th>October Mean inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burlington</td>
<td>3.16</td>
<td>2.70</td>
<td>2.09</td>
</tr>
<tr>
<td>(Total 27.6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Des Moines</td>
<td>4.07</td>
<td>3.07</td>
<td>2.35</td>
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<tr>
<td>(Total 32.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sioux City</td>
<td>3.10</td>
<td>2.65</td>
<td>1.75</td>
</tr>
<tr>
<td>(Total 25.2)</td>
<td></td>
<td></td>
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</table>
Appropriate Harvest Decisions

- Sugar, acid and pH?
- Flavor, aroma?
- Skin and seed maturity?

- Problem with MN varieties and high acidity.
  - As we wait for TA to drop, flavors are lost, fruit shrivels…
- Problem with NY varieties: low sugar and acid
  - What guidelines will be used to harvest these?

- Berry Sensory Workshop July-August 2008
Achieving Balance

- The ultimate goal in grape growing is finding the proper balance between vegetative vigor and fruit production.
  - Achieving proper balance leads to reduced variability and improved quality….Sustainability.
  - Produce maximum yields of highest quality fruit possible
- Balance depends on site (climate, soils), variety & rootstock (if applicable), viticultural practices, etc.
- Pruning and crop load adjustment are the basic tools for achieving balance.
Characteristics of Balanced Vines

- Cane pruning weights of 0.2 to 0.4 lb per ft of trellis
- Crop load ratio (yield:pruning wt) of 5-10 (vinifera) or 8-12? (American/hybrids)
- 4-5 shoots per ft of trellis
- Shoot length 4-6 feet (untrimmed)
- Internode length 4 - 6 inches
- Minimal lateral shoots
- 1.5 - 2 leaf layers max
Achieving Balance though Pruning

• Pruning is the annual removal of wood from the previous season.
• Pruning is the primary method of adjusting crop size (yield) to balance vines.
• Basics:
  – Each bud (node) retained produces one shoot
  – Each shoot produces 1-3 clusters
  – Each shoot produces leaves with capacity to ripen fruit
How much to prune? ~90% of 1-year-old wood (canes) pruned each year
Balanced Pruning

- Research based method developed by Nelson Shaulis to quantify pruning severity.
- Uses a measurement - the weight of canes (previous season’s growth) to estimate a vine’s capacity to ripen a crop.
- Pruning weight (aka vine size) is applied to a formula to determine the appropriate number of buds to retain.
- Pruning formulas are based on the growth and fruiting characteristics of a variety.
Balanced Pruning

• Vine capacity often varies greatly between adjoining vineyard blocks, and even vines within a row.

• Balanced pruning should help avoid:
  – under pruning (over cropping) small vines.
  – over pruning (under cropping) large vines.
  – variability in fruit quality.

• Balancing pruning is the first step in achieving the annual desired fruit quality, and with maintaining or improving the vine’s capacity for the following season.
  – Maximum yields without sacrificing vine size
# Balanced Pruning Formulas

<table>
<thead>
<tr>
<th>Grape Variety</th>
<th>Pruning Formula</th>
<th>Cluster Thinning</th>
</tr>
</thead>
<tbody>
<tr>
<td>American</td>
<td>30+10</td>
<td>No</td>
</tr>
<tr>
<td>French Hybrids</td>
<td>20+10, 15+10, 5+10</td>
<td>Yes, usually</td>
</tr>
<tr>
<td>New Hybrids</td>
<td>20+20, 20+10?</td>
<td>Yes / No?</td>
</tr>
<tr>
<td>Seedless Table</td>
<td>30+10</td>
<td>Yes</td>
</tr>
<tr>
<td>Vinifera</td>
<td>20+20</td>
<td>Yes / No?</td>
</tr>
</tbody>
</table>
Example of Balanced Pruning

- Pruning Formula: $30 + 10$
  - Leave 30 nodes (“count buds”) for first pound of canes removed plus 10 for each additional pound

- Pruning wt = 1 lb – leave 30 nodes
- Pruning wt = 2 lb – leave 40 nodes
- Pruning wt = 2.5 lb – leave 45 nodes
- Pruning wt = 3 lb – leave 50 nodes
Balanced Pruning Reality

- Unfortunately, achieving balance through pruning alone is usually not possible.
- Balanced pruning only works well on American-type varieties.
- Hybrids tend to be more fruitful:
  - More clusters per shoot
  - Very large clusters
  - More shoots per “count” node
- Hybrids require more careful management to maintain “vine balance.”
One shoot per bud
Non-count shoots
Non-count shoots
Non-count shoots
Problem with balanced pruning formulas:
- On small vines they tend to suggest a very low number of shoots, which would produce far below the optimum leaf area for the vine. (e.g. 5+10 for Seyval)

Another approach to balancing vines
- Instead of applying a formula to determine number of buds, why not leave enough shoots to fill the trellis space then use a formula to adjust the number of clusters to meet a targeted “crop load” value?
- That will help maximize “vine capacity” (leaf area) without causing vine imbalance.
Using Target Crop Load Approach

1. Prune and thin to 40-50 shoots per vine (at 8 ft vine spacing)
2. Use long-term average cluster weight data to calculate number of clusters needed for yield that will give a desired “crop load ratio” based on “vine size” data.
3. Thin clusters to appropriate number

Required data:
- Vine size (pruning weight)
- Vine yield (crop weight)
- Cluster weight (number of clusters per vine)
Variety Performance over 12 years  
Southwest Purdue Ag Center

<table>
<thead>
<tr>
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<th>Vine Size (lb)</th>
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<tr>
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<td>1.1</td>
<td>17</td>
<td>0.41</td>
<td>47</td>
<td>24</td>
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<tr>
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<td>26</td>
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<tr>
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<td>1.0</td>
<td>22</td>
<td>0.45</td>
<td>49</td>
<td>22</td>
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<tr>
<td>Norton</td>
<td>17</td>
<td>3.2</td>
<td>5</td>
<td>0.19</td>
<td>90</td>
<td>168</td>
</tr>
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<td>Foch</td>
<td>24</td>
<td>2.2</td>
<td>11</td>
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<td>10</td>
<td>0.29</td>
<td>41</td>
<td>41</td>
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</tbody>
</table>
 Variety performance over 6 yrs at Lafayette

<table>
<thead>
<tr>
<th>Variety</th>
<th>Yield (lb)</th>
<th>Vine Size (lb)</th>
<th>Crop load ratio</th>
<th>Cluster wt (lb)</th>
<th>Clusters per vine</th>
<th>Clusters for crop load ratio =10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cayuga White</td>
<td>24</td>
<td>1.0</td>
<td>24</td>
<td>.32</td>
<td>75</td>
<td>31</td>
</tr>
<tr>
<td>Corot Noir</td>
<td>18</td>
<td>1.2</td>
<td>16</td>
<td>.31</td>
<td>58</td>
<td>39</td>
</tr>
<tr>
<td>Frontenac</td>
<td>12</td>
<td>0.9</td>
<td>13</td>
<td>.17</td>
<td>71</td>
<td>53</td>
</tr>
<tr>
<td>LaCrescent</td>
<td>12</td>
<td>1.3</td>
<td>9</td>
<td>.18</td>
<td>67</td>
<td>72</td>
</tr>
<tr>
<td>Noiret</td>
<td>15</td>
<td>2.5</td>
<td>5</td>
<td>.31</td>
<td>48</td>
<td>80</td>
</tr>
<tr>
<td>Traminette</td>
<td>14</td>
<td>2.2</td>
<td>6</td>
<td>.22</td>
<td>64</td>
<td>100</td>
</tr>
</tbody>
</table>
Asynchronous Berry Development in Concord

**Balanced**
- 40 nodes/vine
- 6 tons/acre

**Overcropped**
- 160 nodes/vine
- 12 tons/acre

Source: D. Miller, MSU
Vine Balance Summary

- Pruning and crop load adjustment are the most important management practices for achieving vine balance and good fruit quality.

- Goals
  - Balance fruit production with vegetative growth
    Produce maximum yields of highest quality fruit possible without sacrificing vine capacity
  - Maintain consistent vine balance
  - Reduce fruit and vine variability

- Growers need to collect data on yield, pruning weight, cluster weight, shoots per vine, etc.
Choosing an Appropriate Training System

• Variety traits
  – Vigor
  – Growth habit
  – Cold hardiness
  – Disease susceptibility (esp. fruit rots)
  – Relative fruit quality

• Management concerns
  – Mechanical or hand harvesting/pruning
Training System Goals

• Position annual shoot growth for optimum exposure of fruit and leaves

• Promote balanced fruit and vegetative growth

• Position fruit for ease of pest management and harvest

• Facilitate pruning and vineyard management
Training Systems

- High Cordon - standard for hybrids in the Midwest

- Mid-Wire Cordon - with VSP facilitates leaf removal and improved cluster exposure to sunlight

- Divided canopy systems (GDC, Scott Henry, Smart Dyson, etc.) to manage high vigor varieties/sites (reduce shading, increase yields, etc.)
## Matching the Training System to Growth Habit

<table>
<thead>
<tr>
<th>Types of grapes</th>
<th>Growth habit</th>
<th>Training System</th>
</tr>
</thead>
<tbody>
<tr>
<td>American</td>
<td>procumbent (downward)</td>
<td>High cordon or cane</td>
</tr>
<tr>
<td>French hybrid</td>
<td>mostly procumbent</td>
<td>High cordon</td>
</tr>
<tr>
<td></td>
<td>several upright</td>
<td>or mid-wire cordon with VSP</td>
</tr>
<tr>
<td>European (vinifera)</td>
<td>mostly upright</td>
<td>Mid or low wire</td>
</tr>
<tr>
<td></td>
<td></td>
<td>cordon or cane with VSP</td>
</tr>
</tbody>
</table>
Upright Varieties

Vignoles
Chardonel
Cayuga White
Traminette
High Cordon Training
Downward shoot positioning is critical to reducing shading of the cordon.
Concerns with High Cordon: Shading
Mid-wire Cordon with VSP
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Concerns with Mid-Wire Cordon

• Upright growing shoots tend to be very vigorous (strong sink strength)

• Excessive vigor can result in low fruitfulness

• Hedging is necessary to prevent shading, but may result in excessive lateral growth, requiring additional trimming.

• On high vigor sites, vine size may be too high to leave appropriate shoots per foot of trellis and leaf layers.
Concerns with Scott Henry

- Upper and lower canopy differences

- Upright growing shoots tend to be very vigorous (strong sink strength)

- Excessive vigor can result in low fruitfulness

- Hedging is necessary to prevent shading, but may result in excessive lateral growth, requiring additional trimming.

- On high vigor sites, divided canopy helps maintain desired shoots per foot of trellis and leaf layers.
Fig. 12. The Smart-Dyson Ballerina training system. This is a Mid-Wire Cordon training system with a portion of its shoots positioned downward.
Training Summary

• Choose training system based on:
  – Growth habit
  – Vine vigor
  – Cold hardiness
  – Disease pressure

• Training system should provide well-spaced distribution of fruiting wood with good exposure to sunlight
Traminette Training System Study
## Yield Components, Vine Size, Crop Load

5 year means

<table>
<thead>
<tr>
<th>Training System</th>
<th>Yield (kg/vine)</th>
<th>Pruning Wt (kg/vine)</th>
<th>Crop Load (yld/pw)</th>
<th>Cluster wt (g)</th>
<th>Berry wt (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High cordon</td>
<td>6.29 ab</td>
<td>0.83 b</td>
<td>8.1 a</td>
<td>102.4</td>
<td>1.77</td>
</tr>
<tr>
<td>Mid-wire cordon</td>
<td>5.82 b</td>
<td>1.06 a</td>
<td>6.0 b</td>
<td>95.3</td>
<td>1.77</td>
</tr>
<tr>
<td>Scott Henry</td>
<td>7.43 a</td>
<td>1.11 a</td>
<td>7.8 a</td>
<td>106.7</td>
<td>1.72</td>
</tr>
</tbody>
</table>

** ** **** **** ns ns
## Point Quadrat Analysis

4 year means

<table>
<thead>
<tr>
<th>Training System</th>
<th>Shoots/vine</th>
<th>Gaps (%)</th>
<th>Leaf layers (%)</th>
<th>Interior leaves (%)</th>
<th>Exterior clusters (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High cordon</td>
<td>54.6 b</td>
<td>2.0 c</td>
<td>4.2 a</td>
<td>54.4 a</td>
<td>17.8 b</td>
</tr>
<tr>
<td>Mid-wire cordon</td>
<td>51.5 b</td>
<td>7.0 b</td>
<td>1.9 b</td>
<td>32.2 b</td>
<td>40.5 b</td>
</tr>
<tr>
<td>Scott Henry</td>
<td>79.8 a</td>
<td>11.0 a</td>
<td>1.7 b</td>
<td>28.8 b</td>
<td>38.4 a</td>
</tr>
</tbody>
</table>

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# Fruit Composition

## 5 year means

<table>
<thead>
<tr>
<th>Training System</th>
<th>Soluble Solids (%)</th>
<th>Titratable Acidity (g/L)</th>
<th>pH</th>
<th>FVT</th>
<th>PVT</th>
</tr>
</thead>
<tbody>
<tr>
<td>High cordon</td>
<td>22.2</td>
<td>7.2 a</td>
<td>3.14</td>
<td>0.85</td>
<td>5.29</td>
</tr>
<tr>
<td>Mid-wire cordon</td>
<td>22.5</td>
<td>6.8 b</td>
<td>3.16</td>
<td>0.73</td>
<td>5.71</td>
</tr>
<tr>
<td>Scott Henry</td>
<td>22.4</td>
<td>7.1 a</td>
<td>3.14</td>
<td>0.73</td>
<td>5.73</td>
</tr>
<tr>
<td>ns</td>
<td><strong>ns</strong>*</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
</tbody>
</table>

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Sensory Analysis

- Can panelists detect a difference between wines from the training systems?
- 12 trained panelists
- 2002 and 2003 wines
- Triangle tests
  - Compusense software
**Sensory Results**

Panelists correctly detected a difference between HC and MWC.

100 % 2003; 87.5% 2002

Less likely for panelists to detect a difference between SH and MWC, or SH and HC for both years (50-60% accuracy).
## Scott Henry Canopy Comparisons

<table>
<thead>
<tr>
<th>Training System</th>
<th>Shoots/cordon</th>
<th>Gaps (%)</th>
<th>Leaf layers</th>
<th>Interior leaves (%)</th>
<th>Exterior clusters (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High cordon</td>
<td>54.6</td>
<td>2.0</td>
<td>4.2</td>
<td>54.4</td>
<td>17.8</td>
</tr>
<tr>
<td>Mid-wire cordon</td>
<td>51.5</td>
<td>7.0</td>
<td>1.9</td>
<td>32.2</td>
<td>40.5</td>
</tr>
<tr>
<td>Scott Henry Upper</td>
<td>39.5</td>
<td>13.3 a</td>
<td>1.6 b</td>
<td>25.6</td>
<td>40.8</td>
</tr>
<tr>
<td>Scott Henry Lower</td>
<td>39.0</td>
<td>6.2 b</td>
<td>2.2 a</td>
<td>36.3</td>
<td>31.5</td>
</tr>
</tbody>
</table>

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Scott Henry Canopy Comparisons

<table>
<thead>
<tr>
<th>Training System</th>
<th>Yield (kg/vine)</th>
<th>Pruning Wt (kg/vine)</th>
<th>Cane Wt (g)</th>
<th>Crop Load (yld/pw)</th>
<th>Cluster Wt (g)</th>
<th>Berry Wt (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High cordon</td>
<td>6.29</td>
<td>0.83</td>
<td>15.2</td>
<td>8.1</td>
<td>102.4</td>
<td>1.77</td>
</tr>
<tr>
<td>Mid-wire cordon</td>
<td>5.82</td>
<td>1.06</td>
<td>20.6</td>
<td>6.0</td>
<td>95.3</td>
<td>1.77</td>
</tr>
<tr>
<td>Scott Henry Upper</td>
<td>4.31 a</td>
<td>0.75 a</td>
<td>19.0</td>
<td>5.7 b</td>
<td>115.0 a</td>
<td>1.76 a</td>
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<tr>
<td>Scott Henry Lower</td>
<td>3.12 b</td>
<td>0.37 b</td>
<td>9.5</td>
<td>8.4 a</td>
<td>94.9 b</td>
<td>1.34 b</td>
</tr>
</tbody>
</table>

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Summary

• Proper selection of variety to match site
  – Cold hardiness
  – Date of ripening

• Proper balance between yield and vegetative vigor
  – Crop load adjustment through pruning and thinning
  – Record keeping (data collection)

• Selecting an appropriate training system
  – Match growth habit of variety
  – Improve fruit/wine quality
Acknowledgements

• Patty Skinkis - Former graduate student, now Assistant Professor of Viticulture, Oregon State University
• Paul Howard - Research technician
• Christian Butzke, Jill Blume, Ellie Butz - enology and sensory assistance

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• Indiana Wine Grape Council
• Purdue Agriculture Research Centers