Vineyard Irrigation
Principles, Practices, and Consequences

Terry Prichard
Water Management Specialist
Dept. Land, Air, and Water Resources
UC Davis

Rhonda Smith
UC Farm Advisor
Sonoma County
Vineyard Irrigation

The act of supplying or controlling water to the vineyard

Main Purpose:
Produce quality fruit
Vine Irrigation Strategies

- Full potential water use
- Withhold irrigation
  - Severity
    - Moderate vine water deficits
    - Severe vine water deficits
  - Timing
    - Early season
    - Mid season
    - Late season
Deficit Irrigation

- Supplying vines with less irrigation water than they can use.
  - Causing reduced soil moisture availability
  - Causing vine water stress

Purpose: Produce Quality Fruit
Vineyard Irrigation: Principles, Practices and Consequences

- Vine Water relations
- Vine Water use
- Vine Water deficits
  - Effects on fruit quality/yield
- How to develop a strategy to achieve consistent results
- When to begin irrigation
- How much to apply
- How to evaluate the strategy
Stress Threshold
Regulated Deficit Irrigation

- Measure plant stress
- Ability to estimate full potential vine water use
- Micro-irrigation System
Simple Volumetric Model

\[
\text{Soil Stored Moisture} + \text{In-season Effective Rainfall} - \text{Irrigation} = \text{Vine Water Use}
\]

\[
\text{Vine Water Use} = \text{Evaporation} + \text{Transpiration}
\]
Runoff

Evaporation

Rainfall

Transpiration

Irrigation

Deep Percolation

Soil storage

Runoff
Winegrape Water Relations

Drought tolerant
Winegrapes

Drought tolerant

Developing deep roots
Increasing Organic Acids
Closing stoma
Dropping Leaves
<table>
<thead>
<tr>
<th>Water Use</th>
<th>% of ETc</th>
<th>50</th>
<th>75</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield</td>
<td>% of 100% treatment</td>
<td>80</td>
<td>90</td>
<td>100</td>
</tr>
</tbody>
</table>

From Q TLP
Physiological Role of Water in Vines

- Solvent—carrier for nutrients/gases
- Reactant in chemical reactions
  - Photosynthesis
- Support
  - Turgor/Growth
- Transpirational Cooling
Water Use

- 80-90% of tissue weight
- **Transpiration**
  - Loss of water to the atmosphere
  - 90% of uptake lost

1v = 15-30 min
T = 2°/min
Transpiration
Water movement

Figure 25. Stomata open to allow carbon dioxide (CO₂) to enter a leaf and water vapor to leave.
Photosynthesis

Figure 25. Stomata open to allow carbon dioxide (CO₂) to enter a leaf and water vapor to leave.
Stomata
Normally open in the light
Stomata

$\text{CO}_2$ in Water vapor out
How do Stoma Open

1. The light at dawn is the signal that is recognized by a receptor on the guard cell.

2. The receptor signals the guard cell’s plasma membrane to start pumping protons (H\(^+\)) out of the guard cell. This loss of positive charge creates a negative charge in the cell.

3. Potassium ions (K\(^+\)) enter the guard cell through channels in the membrane.
How do Stoma Open

- As the potassium ions accumulate in the guard cell, the osmotic pressure is increased.
- Higher osmotic pressure attracts water to enter the guard cell increasing turgor
- The pressure causes the shape of the guard cells to change and a pore is formed, allowing gas exchange
How do Stoma Close

When water uptake is exceeded by transpiration, stoma will close because there will not be enough water to create pressure in the guard cells.

Abscisic acid hormone causes $\text{Cl}^-$ and Organic acids to be pumped out of the cell reducing osmotic pressure and turgor.

This response helps the plant conserve water.
## Guard Cells

<table>
<thead>
<tr>
<th>Time</th>
<th>Osmotic Pressure, lb/in²</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 A.M.</td>
<td>212</td>
</tr>
<tr>
<td>11 A.M.</td>
<td>456</td>
</tr>
<tr>
<td>5 P.M.</td>
<td>272</td>
</tr>
<tr>
<td>12 midnight</td>
<td>191</td>
</tr>
</tbody>
</table>

Other lower epidermal cells 150 constant
Stomatal Index

Stoma Number : All Cells

High

late in the Permian period (275–290 million years ago) in the Pleistocene epoch (1–8 million years ago).

Both these periods are known from geological evidence to have been times of low levels of atmospheric carbon dioxide and ice ages.

Low

During the Cretaceous period, a time of high CO2 levels and warm climate.
Vine Water Use and Status
Water Use

Climate
Evapotranspiration Reference (ETo)

Sun Interception (Kc)
Size of Canopy
Time of season (canopy Expansion)
Spacing
Trellis

Plant Controls
Stoma--- Severe climate or limited soil availability

Available Moisture
Climate (ETo)

- Light intensity
- Air temperature
- Humidity
- Wind speed

Reference ET
What is the volume of irrigation water required to produce high quality fruit?

It varies:

- Canopy size
- Soil resource (available soil moisture storage)
- Climate (demand)
Figure D-1. Lodi Eto, 1984 - 2003 Average Stations # 42 and # 166
Seasonal Vine Full Potential Water Use, Lodi Average ETo
Full Potential water Use
Balance Vegetative / Reproductive Structure
Irrigation Management Philosophy

*Controlled water deficits can improve fruit quality with little effect on yield*
Irrigation Scheduling

- Vine Use
- Water Use
- Water Supply
- Irrigation
  - In-Season Rain
  - Soil Stored Water
Vine Water Stress

- Caused by reduced soil water availability
- Increasing canopy size
- Increasingly hot, dry climatic condition
- Longer days
Vine Water Stress

Without irrigation:

- Stress occurs later in:
  - Deep root zones
  - Heavier soils
  - Cooler climate areas
Vine Water Stress

- Measured as midday leaf water potential
  - Using a pressure chamber
    - aka pressure bomb
Diurnal Leaf Water Potential

Time

1 3 5 7 9 11 13 15 17 19 21 23

- Bars

0 2 4 6 8

4 8
Most soils provide adequate water for stage I:

- Basic shoot growth
- Root growth
- Berry cell division
Water deficits in Stage II

- Leading up to veraison
  - Reduce main shoot growth
  - Reduce the number and length of lateral shoots

- Limiting shoot growth to near 1 meter provides adequate leaf area and allows diffuse light into the fruiting area
  - 0.8-1.2 m²/kg fruit – single canopy
  - 0.5-0.8 m²/kg fruit – divided canopy
Water deficits in Stage III

- Continued moderate deficits
  - Prevent resumption of main and lateral shoot growth
  - Provide water to maintain photosynthetic capacity
  - Increases diffuse light into fruit

- Irrigate post harvest
Moderate Water Deficits

- Reduce vegetative growth
  - Shoot length
  - No. of lateral shoots
- Increase light in canopy
- Remove lower leaves
Relative Rate vs. Leaf Water Potential

Net Photosynthesis

Expansive Growth

Midday Leaf Water Potential (bars)

Percentage

0  20  40  60  80  100  120

4  5  7  8  9  10  11  12  13  14  15
Deficit Effects on Vine and Fruit

- Beneficial or Harmful

- Depending on the severity and timing of the deficit
Moderate Water Deficits
Open canopy—diffused light
Figure E-1. Shoot Length of Full Irrigation and Deficit Treatments
Hopland Cabernet 1999

Date

Full Water
RDI - 12/60%
RDI - 12/35%

Begin Irrigating Full Water
Begin Irrigating RDI
## Syrah 2006 Canopy Measurements

<table>
<thead>
<tr>
<th>Irrigation</th>
<th>Shoot Length (cm)</th>
<th>Nodes per Shoot</th>
<th>Node Length (cm)</th>
<th>Pruning Weight lb/Vine</th>
<th>Pruning: Yield ratio</th>
<th>Land Surface Shaded</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-1</td>
<td>66.2 a</td>
<td>16.4 a</td>
<td>4.0</td>
<td>7.8 a</td>
<td>3.3 a</td>
<td>71a</td>
</tr>
<tr>
<td>I-2</td>
<td>56.6 b</td>
<td>14.5 b</td>
<td>3.9</td>
<td>4.4 b</td>
<td>5.1 b</td>
<td>55 b</td>
</tr>
<tr>
<td>I-3</td>
<td>49.8 c</td>
<td>12.9 c</td>
<td>3.9</td>
<td>3.9 c</td>
<td>4.9 b</td>
<td>51 c</td>
</tr>
<tr>
<td>P =</td>
<td>0.00</td>
<td>0.00</td>
<td>0.12</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Brix</th>
<th>Shoot Length (cm)</th>
<th>Nodes per Shoot</th>
<th>Node Length (cm)</th>
<th>Pruning Weight lb/Vine</th>
<th>Pruning: Yield ratio</th>
<th>Land Surface Shaded</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>57.2</td>
<td>14.5</td>
<td>3.9</td>
<td>5.5</td>
<td>4.6 b</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>56.8</td>
<td>14.8</td>
<td>3.8</td>
<td>5.2</td>
<td>4.8 b</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>58.5</td>
<td>14.6</td>
<td>4.0</td>
<td>5.5</td>
<td>4.0 a</td>
<td></td>
</tr>
<tr>
<td>P =</td>
<td>0.74</td>
<td>0.85</td>
<td>0.20</td>
<td>0.18</td>
<td>0.01</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Spurs</th>
<th>Shoot Length (cm)</th>
<th>Nodes per Shoot</th>
<th>Node Length (cm)</th>
<th>Pruning Weight lb/Vine</th>
<th>Pruning: Yield ratio</th>
<th>Land Surface Shaded</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>59.6 a</td>
<td>15.0</td>
<td>4.0</td>
<td>5.4</td>
<td>4.3</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>55.4 b</td>
<td>14.2</td>
<td>3.9</td>
<td>5.4</td>
<td>4.6</td>
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</tr>
<tr>
<td>P=</td>
<td>0.03</td>
<td>0.12</td>
<td>0.21</td>
<td>0.79</td>
<td>0.075</td>
<td></td>
</tr>
</tbody>
</table>

| Interactions | NS | NS | NS | NS | NS | NS |

*a Different letters in the same column indicate significant differences as indicated by the stated p value using Duncan’s means separation test.*
Timing of Water Deficits

- **Early season**
  - bud break through set

- **Mid season**
  - set through veraison

- **Late season**
  - veraison through harvest

- **Postharvest**
Deficit Irrigation Syrah @ Harvest

Timing
Severity
Stress Threshold
Regulated Deficit Irrigation

Requirements

- Measure plant stress
- Ability to estimate full potential vine water use
- Micro-irrigation System
  - Uniformly
  - Small water volumes
  - Frequently
Surface Irrigation
Quality Goals

- Titratable acidity
- Tartaric/Malic ratio
- pH
- Potassium
- Color
- Character
Figure E-1. Shoot Length of Full Irrigation and Deficit Treatments
Hopland Cabernet 1999

- Full Water
- RDI - 12/60%
- RDI - 12/35%

Date

- Begin Irrigating Full Water
- Begin Irrigating RDI
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cumulative Light</th>
<th>Absorbance @420 nm</th>
<th>Absorbance @520 nm</th>
<th>Color Hue Abs 280 nm</th>
<th>Phenolics (Abs 280 nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 (100%)</td>
<td>1.32 d</td>
<td>0.162 d</td>
<td>0.169 f</td>
<td>0.962 a</td>
<td>29.9 c</td>
</tr>
<tr>
<td>T2 (70%, post ver)</td>
<td>2.19 cd</td>
<td>0.227 bc</td>
<td>0.289 bc</td>
<td>0.789 bc</td>
<td>36.6 abc</td>
</tr>
<tr>
<td>T3 (70%, Pre ver)</td>
<td>1.70 cd</td>
<td>0.226 bc</td>
<td>0.268 bcd</td>
<td>0.847 b</td>
<td>33.1 cde</td>
</tr>
<tr>
<td>T4 (50% Post ver)</td>
<td>4.00 bc</td>
<td>0.295 a</td>
<td>0.373 a</td>
<td>0.790 bc</td>
<td>39.3 a</td>
</tr>
<tr>
<td>T5 (50% Pre ver)</td>
<td>3.20 cd</td>
<td>0.250 ab</td>
<td>0.335 ab</td>
<td>0.745 c</td>
<td>38.2 ab</td>
</tr>
</tbody>
</table>

Prichard and Verdegaal 1988
Table E-1. Hopland 1998 Cabernet Sauvignon Must Analysis

<table>
<thead>
<tr>
<th></th>
<th>°Brix</th>
<th>pH</th>
<th>Titratable Acidity (gm/L)</th>
<th>Malate (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 (100)</td>
<td>23.0</td>
<td>3.37</td>
<td>6.68</td>
<td>3555</td>
</tr>
<tr>
<td>T2 (-14/60)</td>
<td>23.1</td>
<td>3.49</td>
<td>4.94</td>
<td>2528</td>
</tr>
<tr>
<td>T3 (-14/35)</td>
<td>22.4</td>
<td>3.51</td>
<td>5.39</td>
<td>1450</td>
</tr>
<tr>
<td>T4 (-12/60)</td>
<td>23.2</td>
<td>3.43</td>
<td>6.04</td>
<td>2645</td>
</tr>
<tr>
<td>T5 (-12/35)</td>
<td>23.0</td>
<td>3.50</td>
<td>5.97</td>
<td>1808</td>
</tr>
<tr>
<td>P=</td>
<td>0.4788</td>
<td>0.4152</td>
<td>0.0004</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Treatments: T1 (100) = full potential water use
T2-T5 = Leaf water potential at irrigation start / RDI %

Lundquist, Smith and Prichard com
<table>
<thead>
<tr>
<th>Treatment (Threshold/RDI%)</th>
<th>Must Malic Acid Concentration (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full potential</td>
<td>3.83</td>
</tr>
<tr>
<td>-13/60%</td>
<td>1.92</td>
</tr>
<tr>
<td>-13/35%</td>
<td>1.45</td>
</tr>
<tr>
<td>-15/60%</td>
<td>1.27</td>
</tr>
<tr>
<td>-15/35%</td>
<td>1.14</td>
</tr>
</tbody>
</table>

Prichard and Verdegaal 1996
Table E-2. Skin phenolics and Anthocyanins in Cabernet Franc

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Skin Phenolics mg/cm²</th>
<th>Skin Anthocyanins mg/cm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (grower std)</td>
<td>0.46</td>
<td>0.51</td>
</tr>
<tr>
<td>Early Deficit (pre-veraison)</td>
<td>0.56</td>
<td>0.61</td>
</tr>
<tr>
<td>Late Deficit (post veraison)</td>
<td>0.52</td>
<td>0.59</td>
</tr>
<tr>
<td>Continual Deficit (pre &amp; post veraison)</td>
<td>0.57</td>
<td>0.65</td>
</tr>
</tbody>
</table>

Matthews and Anderson, 1988
## Yield and Yield Components

### 2006 Syrah, Galt

<table>
<thead>
<tr>
<th>Irrigation</th>
<th>Yield (lb/vine)</th>
<th>Relative Yield %</th>
<th>Berry Size (g)</th>
<th>Relative Berry Size %</th>
<th>Fruit Load (berry/vine)</th>
<th>Relative Fruit Load %</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-1</td>
<td>25.3 a¹</td>
<td>100</td>
<td>1.64 a</td>
<td>100</td>
<td>6993 a b</td>
<td>93</td>
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<tr>
<td>I-2</td>
<td>22.0 b</td>
<td>87</td>
<td>1.34 b</td>
<td>82</td>
<td>7527 a</td>
<td>100</td>
</tr>
<tr>
<td>I-3</td>
<td>18.5 c</td>
<td>73</td>
<td>1.27 b</td>
<td>77</td>
<td>6619 b</td>
<td>88</td>
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<tr>
<td>P =</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.03</td>
<td></td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Brix</th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>23.4 a</td>
<td>100</td>
<td>1.51 a</td>
<td>100</td>
<td>7078 a b</td>
<td>95</td>
</tr>
<tr>
<td>26</td>
<td>23.0 a</td>
<td>98</td>
<td>1.33 b</td>
<td>94</td>
<td>7431 a</td>
<td>100</td>
</tr>
<tr>
<td>28</td>
<td>19.3 b</td>
<td>82</td>
<td>1.14 b</td>
<td>88</td>
<td>6630 b</td>
<td>89</td>
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<td>P =</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.05</td>
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</table>

<table>
<thead>
<tr>
<th>Spurs</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>20.5 b</td>
<td>88</td>
<td>1.42 a</td>
<td>100</td>
<td>6609 b</td>
<td>88</td>
</tr>
<tr>
<td>18</td>
<td>23.4 a</td>
<td>100</td>
<td>1.41 a</td>
<td>99</td>
<td>7484 a</td>
<td>100</td>
</tr>
<tr>
<td>P=</td>
<td>0.00</td>
<td>0.81</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Interactions | NS | NS | NS | |

¹ Different letters in the same column indicate significant differences as indicated by the stated p value using Duncan’s means separation test

Prichard, Verdegaal, and Ingels
# Hopland Cabernet

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (kg/vine)</th>
<th>Berry wt. (gm/berry)</th>
<th>Fruit Load (Berries/vine)</th>
<th>Cluster No. (Clust./vine)</th>
<th>Cluster wt. (gm/cluster)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 (100)</td>
<td>12.6</td>
<td>1.12</td>
<td>12188</td>
<td>89</td>
<td>150</td>
</tr>
<tr>
<td>T2 (-1.4/60)</td>
<td>9.7</td>
<td>0.93</td>
<td>11179</td>
<td>83.8</td>
<td>126</td>
</tr>
<tr>
<td>T3 (-1.4/35)</td>
<td>9.1</td>
<td>0.91</td>
<td>11394</td>
<td>83.7</td>
<td>117</td>
</tr>
<tr>
<td>T4 (-1.2/60)</td>
<td>10</td>
<td>0.95</td>
<td>11460</td>
<td>82.3</td>
<td>132</td>
</tr>
<tr>
<td>T5 (-1.2/35)</td>
<td>9.6</td>
<td>0.92</td>
<td>11658</td>
<td>84.2</td>
<td>116</td>
</tr>
<tr>
<td>T6 (-1.2/35-60)</td>
<td>9.7</td>
<td>0.93</td>
<td>11592</td>
<td>83.7</td>
<td>119</td>
</tr>
</tbody>
</table>

Treatment p= 0.0006 0.0001 0.522 0.1968 0.0004
Response to increased irrigation is linear

Yield as a function of water consumption Syrah 2005-2008 Galt

\[ y = 0.4868x + 4.7188 \]

\[ R^2 = 0.9988 \]
# Deficit Irrigation (white grape)

<table>
<thead>
<tr>
<th>Variable</th>
<th>% of ETc</th>
<th>% of 100% treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berry Size</td>
<td>84</td>
<td>93</td>
</tr>
<tr>
<td></td>
<td>97</td>
<td>100</td>
</tr>
</tbody>
</table>

From LE Williams
### Cabernet Deficit Irrigation

<table>
<thead>
<tr>
<th>Variable</th>
<th>% of ETc</th>
<th>% of 100% treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berry Size</td>
<td>50</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>75</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

From TLP
Developing a Deficit Irrigation Strategy

Types of deficit strategies

- Irrigate early season with decreasing portion of full vine water use as the season progresses
- Irrigate at a portion of full vine water use beginning early season
- Wait to irrigate until water deficits have curbed vegetative growth then irrigate with a portion of full vine water use
Stress Threshold Regulated Deficit Irrigation

- Wait to irrigate until water deficits have curbed vegetative growth then irrigate with a portion of full vine water use
Regulated Deficit Irrigation (RDI)

- Supplying vines with less irrigation water than they can use.
- Causing reduced soil moisture availability
- Causing vine water stress
  - Constant reduction (start early with a % reduction) $\text{ETc} \times \text{RDI}\% = \text{volume}$
  - Variable RDI % over irrigation season
Stress Threshold Regulated Deficit Irrigation

- Wait to irrigate until water deficits have curbed vegetative growth then irrigate with a portion of full vine water use.
<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Stress Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>less than -10 Bars</td>
<td>no stress</td>
</tr>
<tr>
<td>2</td>
<td>-10 to -12 Bars</td>
<td>mild stress</td>
</tr>
<tr>
<td>3</td>
<td>-12 to -14 Bars</td>
<td>moderate stress</td>
</tr>
<tr>
<td>4</td>
<td>-14 to -16 Bars</td>
<td>high stress</td>
</tr>
<tr>
<td>5</td>
<td>above -16 Bars</td>
<td>severe stress</td>
</tr>
</tbody>
</table>
Selecting an Appropriate Stress Threshold and RDI

- Research
- Experience

- Select conservative levels of both and monitor results
  - Evaluate your current practice to any new strategy
Mid-day Leaf Water Potential
Hopland Cabernet 2000

Bars

5/20 6/3 6/17 7/1 7/15 7/29 8/12 8/26 9/9 9/23 10/7 10/21

Begin irrigation T1

Begin irrigation T4, T5, T6

Begin irrigation T2

T1 100%
T2 14/60
T4 12/60
Selecting a Stress Threshold

- Vigor
- Variety
- Climate
- Goal
Stress Thresholds

- **Red Varieties**
  - Tolerate (and benefit) more severe deficits
    - -13 to -15 bars
  - Benefit (quality) more from more severe deficits
    - Curb vegetative growth and open up canopy

- **White Varieties**
  - Do no benefit by more severe deficits
    - Only severe enough to curb vegetative growth
RDI %

- Conservative RDI’s are near 50% or more of full vine water use.
- Risky RDI’s are 35 and below
Figure E-3. Leaf Water Potentials
Cabernet Sauvignon, Hopland, 2000

Bars

-4.00
-6.00
-8.00
-10.00
-12.00
-14.00
-16.00

5/20 6/3 6/17 7/1 7/15 7/29 8/12 8/26 9/9 9/23 10/7 10/21

Begin irrigation T 1

Begin irrigation T 4, T 5, T 6

Switch T 6 to 60%

T 1 100%  T 4 12/60  T 5 12/35  T 6/12/35-60
Sensitivity to High Stress Threshold and Low RDI’s

- White varieties  Most sensitive
- Merlot
- Cabernet
- Syrah
- Zinfandel  Least Sensitive
Variable RDI 50-100% at 19 Brix

2006 Syrah Leaf Water Potential

MDLWP (Bars)

Irr T1

Irr T2

Irr T3

Harvest

Start T1

Start T2 & 3

Increase T2
Irrigation of Quality Winegrapes

- Determine
  - When
  - How much

- Achieve a predictable response
When to begin Irrigation

- Shoot Tip Rating
Tip Ratings

1. Tendrils longer than tip
2. Tendrils even with tip
3. Tendrils behind tip
4. Tendrils yellow/withering
5. Tendrils gone
6. Tip dead
When to begin Irrigation

Figure F-2. Shoot growth rates, Cabernet Sauvignon, 1999 Hopland
Shoot tip ratings, Cabernet Sauvignon, 1999 Hopland

<table>
<thead>
<tr>
<th>Date</th>
<th>Rating</th>
</tr>
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<tbody>
<tr>
<td>5/28/99</td>
<td></td>
</tr>
<tr>
<td>6/11/99</td>
<td></td>
</tr>
<tr>
<td>6/24/99</td>
<td></td>
</tr>
<tr>
<td>7/8/99</td>
<td></td>
</tr>
<tr>
<td>7/22/99</td>
<td></td>
</tr>
<tr>
<td>7/29/99</td>
<td></td>
</tr>
<tr>
<td>8/12/99</td>
<td></td>
</tr>
<tr>
<td>8/26/99</td>
<td></td>
</tr>
</tbody>
</table>
When to Begin irrigation

- Soil water depletion level
- Specific soil water content

<table>
<thead>
<tr>
<th>Year</th>
<th>Water content</th>
<th>LWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>98</td>
<td>3.4</td>
<td>-12</td>
</tr>
<tr>
<td>99</td>
<td>3.8</td>
<td>-12</td>
</tr>
<tr>
<td>2000</td>
<td>2.4</td>
<td>-12</td>
</tr>
</tbody>
</table>
Syrah 2007 at -14 bars
Parts of a pressure chamber.
Leaf Collection
Cutting the Petiole
Place leaf in bag in chamber
Petiole in gland
Diurnal Leaf Water Potential

Time

- Bars

1 3 5 7 9 11 13 15 17 19 21 23 1 3 5 7 9 11 13 15 17 19 21 23

0 2 4 6 8
Leaf water potential, Merlot, Lodi 6/11/99

Weather condition at sampling
Soil dryness
When and how to sample

- Pre Dawn leaf water potential
- Mid-day leaf water potential
- Mid-day stem water potential

All are linearly correlated
Table F-1. Values of midday stem water potential (in Bars) to expect for fully irrigated prune, under different conditions of air temperature and relative humidity.
(from Ken. Shackel)

<table>
<thead>
<tr>
<th>Temperature (°F)</th>
<th>Air Relative Humidity (RH, %)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td>70</td>
<td>-6.8</td>
</tr>
<tr>
<td>75</td>
<td>-7.3</td>
</tr>
<tr>
<td>80</td>
<td>-7.9</td>
</tr>
<tr>
<td>85</td>
<td>-8.5</td>
</tr>
<tr>
<td>90</td>
<td>-9.3</td>
</tr>
<tr>
<td>95</td>
<td>-10.2</td>
</tr>
<tr>
<td>100</td>
<td>-11.2</td>
</tr>
<tr>
<td>105</td>
<td>-12.3</td>
</tr>
<tr>
<td>110</td>
<td>-13.6</td>
</tr>
<tr>
<td>115</td>
<td>-15.1</td>
</tr>
</tbody>
</table>
Pressure Chamber MDLWP

Vine selection

- Select six vines with out nutritional, disease or any other obvious out of norm conditions
- If considerable differences in soil conditions exist split the block into two for sampling
- Tag the vine so you can return to them on the next sample date
Pressure Chamber MDLWP

- **Sample number of 2 per vine**
  - If more than 1 bar difference between leaves sample a third.

- **Leaf selection**
  - Young fully expanded leaf which has had full sun. Shaded leaves will not give the same as sun exposed leaves.
Pressure Chamber MDLWP

- Sample Collection
  - Cover the leaf with a plastic bag while still attached to the vine
  - Excise the leaf at the petiole (leave long enough to stick out of the chamber)
  - Place leaf into chamber as quickly as possible
Pressure Chamber MDLWP

Measurement

- With leaf in chamber, increase pressure at no more than 0.3 bars per second until water appears on the surface of the cut petiole
- Note the pressure
Pressure Chamber MDLWP

- **Problems**
  - Breaks in the leaf veins can cause low readings
  - Tightening the petiole seal too tight exuding non xylem water
  - Waiting too long to make the reading
Stress Threshold + RDI

- Begin irrigation at a specific leaf water potential “Stress Threshold”

- After threshold, irrigate at fraction of full water use
When to begin Irrigation

Stress Threshold Method

leaf water potential threshold

-12 to -14 bars
Mid-day Leaf Water Potential
Hopland Cabernet 2000

Bars

5/20 6/3 6/17 7/1 7/15 7/29 8/12 8/26 9/9 9/23 10/7 10/21

-16.00 -14.00 -12.00 -10.00 -8.00 -6.00 -4.00

Begin irrigation T1

Begin irrigation T4, T5, T6

Begin irrigation T2

T1 100%
T2 14/60
T4 12/60
How Much Water

Stress Threshold Method + RDI

After threshold a fraction of full vine water use

Full vine water use \times RDI \%

Rdi \% --- 35 - 60\%
Post Threshold RDI %

- Prevent new vegetative growth
- Provide fruit cover
- Continue photosynthesis
Mid-day Leaf Water Potential
2000 Cabernet, Hopland

- Begin irrigation T1
- Begin irrigation T4, T5, T6
- Switch T6 to 60%
Water Use of Full Potential & Stress Threshold / RDI 60%
Monitor Effects of Strategy

Leaf Water Potential
Vegetative Growth
Yield
Quality
Winemaker Comments
Post Threshold Water Potential

Figure J-1. Leaf Water Potentials
Hopland Cabernet Sauvignon 2000

Begin irrigation T1

Begin irrigation T4

T1 100%

T4 -12/60%
Visual fruit lighting / condition

Sunburn, Shrivel, Rot
Figure F-1. Shoot length, Cabernet Sauvignon, 1999 Hopland
Fruit Condition / Yield
Vine Water Use vs. Soil Water Reservoir
Vine Water Use vs. Soil Water Reservoir
Vineyard Development

Soil/Climate Resources

➢ Selection
  • Rootstock
  • Clone
  • Spacing
  • Trellis type
Considerations Using ST+RDI

- Young Vines
- Extreme Climate Periods
- Use of Cover Crops
- Rootstocks
- Low Vigor Vineyards
- Extreme Climate areas
- Leaf Removal
- Water Savings
- Water Use Efficiency
Young Vines
Low Vigor Vineyards