Vineyard Water Management

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Texas A&M AgriLife Extension Service

Grape Camp
November 7, 2016
Lady Bird Johnson Park Pioneer Pavilion, Fredericksburg, TX
Terroir Concept

- **Climate**
- **Soil**
- **Genetic factor**
- **Human factor**
  - Vineyard operations: water management...
  - Winemaking

**Wine quality**

Seguin 1986; Vaudour 2002; van Leeuwen et al., 2006
Terroir and Water Management

**Climate**
- Temperature
- Radiation
- Precipitation

**Soil**
- Composition and physical structure
- Water-holding capacity
- Pedoclimate
- Nutrients

**Genetic factor**
- Variety
- Rootstock

**Human factor**
- Viticulture practices
  - Irrigation
  - Floor management
  - ...
- Winemaking
Vine Water Relations

Stomata open in sunlight for photosynthesis

Air (CO$_2$) move in

Water vapor move out

Melotto et al., 2008
Stomata partially close in response to water stress → reduction of photosynthesis
Irrigation Management

1. When to start irrigation?

2. How much water to apply?

3. Should the irrigation strategy change during the season?
When to start irrigation?
When to start irrigation?

Timing of irrigation determined by 3 techniques:

1. **Physiological technique → Visual symptoms**

   - Grayish-green shoot tips
   - Wilted leaves
   - Curled and brown leaves
   - Shriveled berries

Photos by Michelle Moyer and Markus Keller, Washington State University
When to start irrigation?

2. Vine water status ➔ Pressure chamber (pressure bomb)

<table>
<thead>
<tr>
<th>Stem water potential</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than -1 MPa</td>
<td>No stress</td>
</tr>
<tr>
<td>-1 to -1.2 MPa</td>
<td>Mild stress</td>
</tr>
<tr>
<td>-1.2 to 1.4 MPa</td>
<td>Moderate stress</td>
</tr>
<tr>
<td>-1.4 to -1.6 MPa</td>
<td>High stress</td>
</tr>
<tr>
<td>Above -1.6 MPa</td>
<td>Severe stress</td>
</tr>
</tbody>
</table>

Prichard et al. 2004
Photos from UCCE Sonoma County
3. Soil water status → Moisture sensors

- Different types of sensors
- Critical values vary with sensor type
- Sensors determine if:
  - Rainfall reaches root area
  - Length of irrigation time
- Proper placement of sensors
How much water to apply?
How much water to apply?

Evapotranspiration = ET

Evapotranspiration:
Loss of water from **soil evaporation** and **vine transpiration**
How much water to apply?

Reference Evapotranspiration = ET₀

ET₀ calculated using:
- Air temperature
- Humidity
- Solar radiation
- Wind speed

http://texaset.tamu.edu/
How much water to apply?

Reference Evapotranspiration = $ET_0$

http://texaset.tamu.edu/

<table>
<thead>
<tr>
<th>Date</th>
<th>$ET_0$ (in)</th>
<th>Max Temp (°F)</th>
<th>Min Temp (°F)</th>
<th>Min RH (%)</th>
<th>Solar Rad. (MJ/m²)</th>
<th>Rainfall (in)</th>
<th>Wind 4am (mph)</th>
<th>Wind 4pm (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oct 26, 2016 - Wed</td>
<td>0.23</td>
<td>82</td>
<td>52</td>
<td>20</td>
<td>16.22</td>
<td>0.00</td>
<td>2.24</td>
<td>12.32</td>
</tr>
<tr>
<td>Oct 25, 2016 - Tue</td>
<td>0.13</td>
<td>75</td>
<td>53</td>
<td>48</td>
<td>12.71</td>
<td>0.00</td>
<td>0.81</td>
<td>13.44</td>
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<tr>
<td>Oct 24, 2016 - Mon</td>
<td>0.17</td>
<td>81</td>
<td>43</td>
<td>25</td>
<td>16.43</td>
<td>0.00</td>
<td>0.76</td>
<td>7.56</td>
</tr>
<tr>
<td>Oct 23, 2016 - Sun</td>
<td>0.17</td>
<td>85</td>
<td>47</td>
<td>15</td>
<td>16.25</td>
<td>0.00</td>
<td>2.49</td>
<td>5.08</td>
</tr>
<tr>
<td>Oct 22, 2016 - Sat</td>
<td>0.23</td>
<td>81</td>
<td>40</td>
<td>18</td>
<td>17.45</td>
<td>0.00</td>
<td>0.00</td>
<td>13.64</td>
</tr>
<tr>
<td>Oct 21, 2016 - Fri</td>
<td>0.19</td>
<td>73</td>
<td>38</td>
<td>22</td>
<td>17.42</td>
<td>0.00</td>
<td>1.54</td>
<td>13.00</td>
</tr>
<tr>
<td>Oct 20, 2016 - Thu</td>
<td>0.17</td>
<td>67</td>
<td>45</td>
<td>19</td>
<td>17.71</td>
<td>0.00</td>
<td>4.84</td>
<td>7.29</td>
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<tr>
<td><strong>Data Summary</strong></td>
<td><strong>1.30</strong></td>
<td><strong>85</strong></td>
<td><strong>38</strong></td>
<td><strong>23</strong></td>
<td><strong>114.19</strong></td>
<td><strong>0.00</strong></td>
<td><strong>1.81</strong></td>
<td><strong>10.33</strong></td>
</tr>
</tbody>
</table>
Grapevine Evapotranspiration = $ET_c$

$ET_0 \times K_c = ET_c$

$K_c$ increases during late-spring and early summer with canopy vigor.
How much water to apply?

Crop Coefficient ($K_c$)

- For a particular vineyard block
- At a specific time
How much water to apply?

Crop Coefficient ($K_c$)

- For a particular vineyard block
- At a specific time

\[
\text{Percentage shaded area} \times 0.017 = K_c
\]

(PSA)

\[
\text{PSA} = \frac{\text{Average width shaded area}}{\text{Row width}}
\]

Photos courtesy of Dr Ed Hellman

Williams and Ayars 2005
How much water to apply?

Crop Coefficient ($K_c$)

- For a particular vineyard block
- At a specific time

\[
\text{Percentage shaded area} \times 0.017 = K_c \\
\text{(PSA)}
\]
How much water to apply?

Crop Coefficient ($K_c$)

- For a particular vineyard block
- At a specific time

Percentage shaded area $\times 0.017 = K_c$

(PSA)

$PSA = \frac{Average\ width\ shaded\ area}{Row\ width}$

Williams and Ayars 2005
Photos courtesy of Dr Ed Hellman
How much water to apply?

Crop Coefficient ($K_c$)

Percentage shaded area $\times 0.017 = K_c$

(PSA)

Average width shaded area / Row width $\times 100 = PSA$

/ 10 ft $\times 100 = 30\%$

Williams and Ayars 2005
Photos courtesy of Dr Ed Hellman
**How much water to apply?**

**Crop Coefficient ($K_c$)**

Percentage shaded area (PSA) \times 0.017 = K_c

30\% \times 0.017 = K_c

0.51 = K_c
How much water to apply?

Grapevine Evapotranspiration = $ET_c$

$ET_c = \text{Reference } ET_0 \times \text{Crop Coefficient } (K_c)$

$1.3 \text{ inches} \times 0.51 = 0.663 \text{ inches}$

$0.663 \text{ inches} \times 27,152 \text{ gal/acre-inch} = 18,001 \text{ gal/acre}$
## How much water to apply?

Grapevine Evapotranspiration = $ET_c$

### 1. Crop coefficient ($K_c$)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average width of shaded area (ft)</td>
<td>3</td>
</tr>
<tr>
<td>Row spacing (ft)</td>
<td>10</td>
</tr>
<tr>
<td>Percent shaded area (PSA) (%)</td>
<td>30.0</td>
</tr>
<tr>
<td>$K_c$</td>
<td>0.51</td>
</tr>
</tbody>
</table>

### 2. How much water to apply - Water requirement formula

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative one-week reference $ET_0$ (inches)</td>
<td>1.3</td>
</tr>
<tr>
<td>$ET_c$ (inches)</td>
<td>0.663</td>
</tr>
<tr>
<td>Water requirement (1 week) (gallons per acre)</td>
<td>18001.78</td>
</tr>
<tr>
<td>Vine spacing (ft)</td>
<td>4</td>
</tr>
<tr>
<td>Water requirement (1 week) (gallons per vine)</td>
<td>16.53</td>
</tr>
</tbody>
</table>
How much water to apply?

Replacing **ALL** water used by vine

No deficit irrigation

Replacing **PORTION** of water used by vine

Deficit irrigation
Should the irrigation strategy change during the season?
Budbreak to bloom:

- Young bud hydration
- Shoot growth
- Canopy development
- Nutrient uptake from soil

No deficit irrigation
Irrigation and Vine Developmental Stages

Bloom to veraison:

- Canopy growth
- Cluster development
- Next season buds formation
- Cell division and expansion (berry size)

Deficit irrigation
Irrigation and Vine Developmental Stages

Veraison to harvest:

- Excess water $\rightarrow$ berry splitting and dilution of quality compounds
- Severe water stress $\rightarrow$ high alcohol and astringency

➢ Water deficit depending on strategy
Irrigation and Vine Developmental Stages

A: Young vineyard
B: Vineyard for aromatic whites and fruity reds
C: Vineyard for concentrated reds

Adapted from Ojeda et al. 2014
Irrigation and Vine Developmental Stages

After harvest:

• Reserve for next season
• Signs of acclimation
• Root development

No deficit irrigation
Floor management
Water management by floor management

Cover crops:

- reduction of excessive vine vigor

Photos courtesy of Dr Ed Hellman
Water management by floor management

Cover crops:

- adapted to high rainfall regions

High rainfall

Low rainfall

Photos courtesy of Dr Ed Hellman
Cover crops:

- Several options:
  - Type of cover crops
  - Cover crop width
  - Mowing height and timing

Photos courtesy of Dr. Ed Hellman
Water management by floor management

Cover crops:

• To be avoided in new planted vineyards
Grape Irrigation Decision Guide

What time of year is it?

Budbreak to bloom
- Sufficient rainfall to replenish 100% of vine water loss?
  - Yes
    - No need to irrigate
  - No
    - Water to replace full ET
      - No want to practice deficit irrigation?
        - Yes
          - Slowly reduce irrigation rates
        - No
          - Continue with current strategy
      - Continue with current strategy

Bloom to veraison
- Signs of water stress?
  - Yes
    - How severe are signs?
      - Mild
        - Continue with current strategy. Adapt it with conditions
      - Severe
        - Increase irrigation rates
  - No
    - Signs of water stress?
      - Yes
        - Vigorous canopy?
          - Yes
            - Irrigation
          - No
            - Reduce irrigation rates
      - No
        - Slowly reduce irrigation rates

Veraison to harvest
- Signs of water stress?
  - Yes
    - Vigorous canopy?
      - Yes
        - Irrigation
      - No
        - Reduce irrigation rates
  - No
    - Rainfall or sufficient irrigation?
      - No need to irrigate
      - Irrigation

Harvest to dormant
- Rainfall or sufficient irrigation?
  - Yes
    - No need to irrigate
  - No
    - Irrigation

Adapted from Washington State University Extension, Irrigation basics for eastern Washington vineyards
Grape Irrigation Decision Guide

What time of year is it?

Budbreak to bloom

Sufficient rainfall to replenish 100% of vine water loss?

Yes  No

No need to irrigation  Water to replace full ET

Adapted from Washington State University Extension, Irrigation basics for eastern Washington vineyards
Grape Irrigation Decision Guide

What time of year is it?

Budbreak to bloom

- Sufficient rainfall to replenish 100% of vine water loss?
  - Yes: No need to irrigation
  - No: Water to replace full ET

- Want to practice deficit irrigation?
  - Yes: Slowly reduce irrigation rates
  - No: Continue with current strategy

Bloom to veraison

- Signs of water stress?
  - No: Continue with current strategy. Adapt it with conditions
  - Yes: How severe are signs?
    - Mild: Increase irrigation rates
    - Severe: Increase irrigation rates

Adapted from Washington State University Extension, Irrigation basics for eastern Washington vineyards
Grape Irrigation Decision Guide

*What time of year is it?*

**Budbreak to bloom**
- **Sufficient rainfall to replenish 100% of vine water loss?**
  - Yes → No need to irrigation
  - No → Water to replace full ET
  - If water to replace full ET:
    - **Want to practice deficit irrigation?**
      - Yes → Slowly reduce irrigation rates
      - No → Continue with current strategy
    - **How severe are signs?**
      - Mild → Continue with current strategy
      - Severe → Increase irrigation rates

**Bloom to veraison**
- **Signs of water stress?**
  - No → Continue with current strategy
  - Yes → How severe are signs?
    - Mild → Increase irrigation rates
    - Severe → Quickly reduce irrigation rates

**Veraison to harvest**
- **Signs of water stress?**
  - No → Vigorous canopy?
    - Yes → Reduce irrigation rates
    - No → Slowly reduce irrigation rates
  - Yes → Quickly reduce irrigation rates

Adapted from Washington State University Extension, Irrigation basics for eastern Washington vineyards
Grape Irrigation Decision Guide

What time of year is it?

**Budbreak to bloom**
- Sufficient rainfall to replenish 100% of vine water loss?
  - Yes: No need to irrigate
  - No: Water to replace full ET
    - Signs of water stress?
      - No: Continue with current strategy
      - Yes: How severe are signs?
        - Mild: Continue with current strategy. Adapt it with conditions
        - Severe: Increase irrigation rates
          - Want to practice deficit irrigation?
            - Yes: Slowly reduce irrigation rates
            - No: Continue with current strategy

**Bloom to veraison**
- Signs of water stress?
  - No: Continue with current strategy
  - Yes: How severe are signs?
    - Mild: Continue with current strategy
    - Severe: Increase irrigation rates
      - Rainfall or sufficient irrigation?
        - Yes: Slowly reduce irrigation rates
        - No: Irrigation

**Veraison to harvest**
- Signs of water stress?
  - Yes: Vigorous canopy?
    - Yes: Reduce irrigation rates
    - No: Increase irrigation rates
  - No: Reduce irrigation rates

**Harvest to dormant**
- Rainfall or sufficient irrigation?
  - Yes: No need to irrigate
  - No: Irrigation

Adapted from Washington State University Extension, Irrigation basics for eastern Washington vineyards
Conclusion

- Irrigation + floor management to manage soil moisture
- Understanding of vine environment
- There are no silver bullets!
- Grapevines are tolerant to water stress
THANK YOU
FOR YOUR ATTENTION!
More literatures

- Burt 2012, Wine Grape Irrigation Management
- Hellman, Irrigation Scheduling of Grapevines with Evapotranspiration Data
- Washington State University Extension, Irrigation basics for eastern Washington vineyards
- Peters, Practical use of soil moisture sensors for irrigation scheduling
- Prichard et al. 2004, Deficit irrigation of quality winegrapes using micro-irrigation techniques
- Prichard, Winegrape irrigation scheduling using deficit irrigation techniques
- Westover and Beal 2014, Using Soil Moisture Sensors for Vineyard Irrigation Management