Grapevine Irrigation and Nitrogen Management

George Zhuang
Viticulture Farm Advisor
UC Cooperative Extension - Fresno County
Vineyard Irrigation and Sustainability – Dr. Larry Williams, UC Davis

• **Maintain productivity over time**
• **Maximize fruit quality**

• Increase vineyard *water use efficiency* or decrease *water footprint* (*in general, if the vineyard is irrigated any reduction in applied water will increase WUE, decrease water footprint*).

• Minimize/maximize soil water depletion (function of soil type and rooting depth, cover crop management)

• Some of the above factors will be a function of location in California and price of grapes
How to Make Irrigation Decisions?
- Dr. Larry Williams, UC Davis

• When should one initiate irrigations at the beginning of the season?
• How much water should one apply?
• How does the design of your irrigation system affect the ability to irrigate your vineyards?
• Are there deficit irrigation practices to minimize production loss and maximize fruit quality?
When to Start?

- Visual assessment
- Soil moisture
- Plant water stress
Visual Assessment

- Budbreak
- Shoot tip
- Leaf
- Tendril
- Inflorescence/berry
Soil Moisture

- Tensiometer (centibar) – measures the attraction of soil to its water. Soil-water suction or tension is a measure of the soil’s \textit{matric potential}.
- Gravimetric (%) – taking a known volume of soil and weighing it first and then taking its dry weight.
- Neutron probe, capacitance sensors, TDR – are used to measure soil volumetric water content ($\theta_v$).
Soil Moisture
Plant Water Stress

- Pressure chamber
- Sap flow sensor
- ...

Irrigation starts when midday leaf water potential reaches -10 bars
How Much to Irrigate?

• Evapotranspiration (ET)
  ▪ Historical ET
  ▪ Crop ET (ETc): ETc = ETo × Kc, Dr. Larry Williams, UC Davis
  ▪ Actual Crop ET (ETa): surface renewal, e.g., Tule Technology
Grapevine ET

- ETc = ETo × Kc
- ETo from CIMIS Stations
- Kc
  - Measuring canopy cover
  - Estimate Kc by using GDD

\[
Kc = (0.017 \times \text{Shaded percentage of field})
\]
**Grapevine Kc**

- Estimate Kc by using GDD (Dr. Larry Williams, UC Davis)

<table>
<thead>
<tr>
<th>Trellis/Canopy type</th>
<th>Row Spacing (ft)</th>
<th>Kc Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>VSP</td>
<td>7</td>
<td>Kc=0.74/(1+e^(-(x-525)/301))</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>Kc=0.65/(1+e^(-(x-525)/301))</td>
</tr>
<tr>
<td>CA Sprawl</td>
<td>10</td>
<td>Kc=0.84/(1+e^(-(x-325)/105))</td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>Kc=0.76/(1+e^(-(x-325)/105))</td>
</tr>
<tr>
<td>Quad-cordons</td>
<td>11</td>
<td>Kc=0.93/(1+e^(-(x-300)/175))</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>Kc=0.85/(1+e^(-(x-300)/175))</td>
</tr>
</tbody>
</table>
Grape Weekly ET Reports

2018 Weekly ET Reports

The California Department of Water Resources and the University of California Cooperative Extension have teamed up to provide Weekly ET Reports to agricultural water users. Reports include water use information for a variety of crops. Reports will be posted every Friday or Saturday for next week’s guidelines.

Weekly ET Reports for grapes use raisin grape (7’ x 11’ vine/row spacing with 566 vines/acre) and wine grape (7’ x 10’ vine/row spacing with 622 vines/acre on "California Sprawl" trellis) as examples. Acre-inch and gallons per vine will be reported this year. Growers might apply differently according to the vine/row spacing and trellis type in your vineyard.

04052018 FresnoEast Weekly Evapotranspiration Report

04122018 Fresno Weekly Evapotranspiration Report

04192018 Fresno Weekly Evapotranspiration Report

04262018 Fresno Weekly Evapotranspiration Report

05032018 Fresno Weekly Evapotranspiration Report

05102018 FresnoEast Weekly Evapotranspiration Report
# Weekly Soil Moisture Loss in Inches

**(Estimated Crop Evapotranspiration or ETc)**  
**06/20/18 through 07/05/18**

<table>
<thead>
<tr>
<th>Crops (Leafout Date)</th>
<th>#188 Madera II***</th>
<th>#39 Parlier</th>
<th>#86 Lindcove</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6/20-7/5</td>
<td>7/6-7/12</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water Use</td>
<td>Seasonal Water Use</td>
<td>Estimated ETC</td>
</tr>
<tr>
<td>Almonds (3/16) *</td>
<td>1.97</td>
<td>20.45</td>
<td>1.90</td>
</tr>
<tr>
<td>Pistachio (4/21) *</td>
<td>2.08</td>
<td>10.68</td>
<td>2.04</td>
</tr>
<tr>
<td>Citrus (2/1)</td>
<td>1.26</td>
<td>18.71</td>
<td>1.20</td>
</tr>
<tr>
<td>Raisin Grapes (3/16) (11 ft. row spacing)</td>
<td>1.62</td>
<td>13.86</td>
<td>1.55</td>
</tr>
<tr>
<td>Winegrapes (3/16) (10 ft. spacing on California Sprawl Trellis)</td>
<td>1.80</td>
<td>14.50</td>
<td>1.76</td>
</tr>
<tr>
<td>Walnuts (4/4)</td>
<td>1.82</td>
<td>15.75</td>
<td>1.83</td>
</tr>
<tr>
<td>Stone Fruit (3/16)</td>
<td>1.72</td>
<td>14.74</td>
<td>1.69</td>
</tr>
</tbody>
</table>

Past 7 days precipitation (inches)  
Accumulated precipitation (inches) (1/1/2018)  
6.33  
4.96  
3.32

Dates in parentheses above, indicate leaf out or starting date for ET accumulation for the specific crop.  
* Estimates are for orchard floor conditions where vegetation is managed by some combination of strip applications of herbicides, frequent mowing or tillage, and by mid and late season shading and water stress. Weekly estimates of soil moisture loss can be as much as 25 percent higher in orchards where cover crops are planted and managed more intensively for maximum growth.  
** Very vigorous, non-self affected peak season pistachio Kc can be as high as 1.19 resulting in about 85% greater water use than shown in these tables.  
*** CIMIS station #188 Madera II has been taken out of service due to a conversion of the pasture to permanent crops. For the remainder of the irrigation season Historical Average ETc will be used for the weekly report.

## Past Weekly Applied Water in Inches, Adjusted for Efficiency

<table>
<thead>
<tr>
<th>Crops</th>
<th>#188 Madera II</th>
<th>#39 Parlier</th>
<th>#86 Lindcove</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almonds (3/16)</td>
<td>65% 75% 85% 95%</td>
<td>65% 75% 85% 95%</td>
<td>65% 75% 85% 95%</td>
</tr>
<tr>
<td>Pistachio (4/21)</td>
<td>3.0 2.6 2.3 2.1</td>
<td>3.2 2.8 2.4 2.4</td>
<td>3.1 2.7 2.4 2.1</td>
</tr>
<tr>
<td>Citrus (2/1)</td>
<td>3.2 2.8 2.4 2.2</td>
<td>3.4 2.9 2.6 2.3</td>
<td>3.3 2.9 2.5 2.3</td>
</tr>
<tr>
<td>Raisin Grapes (3/16) (11 ft. row spacing)</td>
<td>1.9 1.7 1.5 1.3</td>
<td>2.0 1.7 1.5 1.4</td>
<td>1.9 1.7 1.5 1.3</td>
</tr>
<tr>
<td>Winegrapes (3/16) (10 ft. spacing on California Sprawl Trellis)</td>
<td>2.5 2.2 1.9 1.7</td>
<td>2.6 2.3 2.0 2.1</td>
<td>2.6 2.2 2.0 1.7</td>
</tr>
<tr>
<td>Walnuts (4/4)</td>
<td>2.8 2.4 2.1 1.9</td>
<td>2.9 2.5 2.2 2.0</td>
<td>2.8 2.5 2.2 1.9</td>
</tr>
<tr>
<td>Stone Fruit (3/16)</td>
<td>2.6 2.3 2.0 1.8</td>
<td>2.8 2.4 2.1 1.9</td>
<td>2.7 2.4 2.1 1.9</td>
</tr>
</tbody>
</table>

1 The amount of water required by a specific irrigation system to satisfy evapotranspiration. Typical ranges in irrigation system efficiency are Drip, 10%-95%; Micro-sprinkler, 80%-90%; Sprinklers, 70%-85%; and Border-furrow, 50%-75%.

## Past Weekly Applied Water in Gallon per Tree or Vine

<table>
<thead>
<tr>
<th>Crops</th>
<th>#188 Madera II</th>
<th>#39 Parlier</th>
<th>#86 Lindcove</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almonds 115 Trees/A</td>
<td>708</td>
<td>614</td>
<td>543</td>
</tr>
<tr>
<td>Pistachio 106 Trees/A</td>
<td>797</td>
<td>698</td>
<td>598</td>
</tr>
<tr>
<td>Citrus 110 Trees/A</td>
<td>469</td>
<td>420</td>
<td>370</td>
</tr>
<tr>
<td>Raisin Grapes 566 Vines/A</td>
<td>120</td>
<td>106</td>
<td>91</td>
</tr>
<tr>
<td>Winegrapes 622 Vines/A</td>
<td>122</td>
<td>105</td>
<td>92</td>
</tr>
<tr>
<td>Walnuts 76 Trees/A</td>
<td>1000</td>
<td>857</td>
<td>750</td>
</tr>
<tr>
<td>Stonefruit 172 Trees/A</td>
<td>410</td>
<td>363</td>
<td>316</td>
</tr>
</tbody>
</table>

For further information concerning all counties receiving this report, contact the Fresno Co. Farm Advisor's office at (559) 241-7526.
How to Schedule Irrigation?

• Obtain gallons/vine/week from crop ET reports, historical ET...
• Number of emitters per vine, e.g., 2 emitters/vine
• Flow rate per emitter, e.g., 0.5 gallon/hour
• Hours/week = (gallons/vine/week)/(number of emitters/vine × flow rate)
Need Deficit Irrigation?

- It depends on your production goal:
  - Yield
  - Quality
- Overall, berry size/yield is maximized with applied water at 80% of ETc (Dr. Larry Williams, UC Davis)
Use ET to Schedule Irrigation

• Midday leaf water potential well responds with ETc in San Joaquin Valley

Syrah: 80% ETc pre-veraison and 60% ETc post-veraison
Do I Need Fertilizer?

- Vine vigor
- Canopy
- Fertilizer history
- Soil and root conditions
- Laboratory analysis
  - ✓ Soil
  - ✓ Plant tissue: Petiole and Leaf blade
  - ✓ Water
# Soil Sampling

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
<th>% SP</th>
<th>units</th>
<th>dS/m</th>
<th>meq/l</th>
<th>meq/l</th>
<th>meq/l</th>
<th>meq/l</th>
<th>% T/ac-6&quot;</th>
<th>+L</th>
<th>lbs/ac-6&quot;</th>
<th>mg/l</th>
<th>mg/kg</th>
<th>mg/kg</th>
<th>mg/kg</th>
<th>mg/kg</th>
<th>mg/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0-1</td>
<td>41</td>
<td>7.6</td>
<td>1.76</td>
<td>11.1</td>
<td>4.0</td>
<td>4.3</td>
<td>2.5</td>
<td>1.1</td>
<td>++</td>
<td>0.6</td>
<td>15</td>
<td>23</td>
<td>399</td>
<td>5.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1-2</td>
<td>42</td>
<td>7.7</td>
<td>1.58</td>
<td>8.9</td>
<td>3.8</td>
<td>5.2</td>
<td>1.5</td>
<td>1.8</td>
<td>+</td>
<td>0.7</td>
<td>7</td>
<td>17</td>
<td>388</td>
<td>2.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2-3</td>
<td>41</td>
<td>7.8</td>
<td>0.94</td>
<td>3.3</td>
<td>1.7</td>
<td>4.5</td>
<td>1.4</td>
<td>2.8</td>
<td>++</td>
<td>0.6</td>
<td>5</td>
<td>8</td>
<td>303</td>
<td>0.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3-4</td>
<td>39</td>
<td>7.8</td>
<td>1.57</td>
<td>6.1</td>
<td>3.6</td>
<td>7.0</td>
<td>2.4</td>
<td>3.3</td>
<td>++</td>
<td>0.7</td>
<td>14</td>
<td>3</td>
<td>214</td>
<td>0.6</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Limits of soil analysis

- Not the sole indicator of vine nutrient needs or availability; many other factors
Grapevine Tissue Sampling

• Evaluating for fertilizer needs
• Sample at full bloom (2/3 caps fallen)
• Petioles from 60–100 vines
• Sample leaf opposite a basal cluster
Bloom N Critical Values

- Bloom petiole values*

<table>
<thead>
<tr>
<th>Level</th>
<th>Petiole Levels (NO$_3$-N, ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deficient</td>
<td>&lt; 350</td>
</tr>
<tr>
<td>Questionable</td>
<td>350 to 500</td>
</tr>
<tr>
<td>Adequate</td>
<td>500 to 2,000</td>
</tr>
<tr>
<td>Excessive</td>
<td>&gt; 2,000</td>
</tr>
<tr>
<td>Toxic</td>
<td>&gt; 8,000</td>
</tr>
</tbody>
</table>

* NO$_3$-N critical values are based solely on Thompson Seedless on own roots
Visual Assessment

• How about bloom petiole analysis under the questionable values?
N Application Timing

• Late spring or early summer
  ✓ One month after bud break
  ✓ Right after fruitset
• Post-harvest
  ✓ Intact, healthy leaf area
  ✓ > 3 weeks before leaf fall
N Application Amount

• Crop removal ≈ 30 lbs of N in 10 tons of crop which are removed from the vineyard

• Rate, lbs N/acre under *drip irrigation*:

<table>
<thead>
<tr>
<th>Rate, lbs N/acre*</th>
<th>Vine Vigor</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>High to excess vigor</td>
</tr>
<tr>
<td>10 – 20</td>
<td>High to medium</td>
</tr>
<tr>
<td>20 – 30</td>
<td>Medium</td>
</tr>
<tr>
<td>30 – 40</td>
<td>Medium to low</td>
</tr>
</tbody>
</table>

*Apply in increments over time*
Don’t Forget Irrigation!

• Raisin/wine grape generally requires 2-3 acre foot of water annually, and table grape requires 4 acre foot in San Joaquin Valley.
• N content in water varies based on sources: surface water vs. well water
• Consider N input from irrigation, when budgeting the vineyard N amount.
## Irrigation Water Analysis

### Nitrogen agricultural use calculations

<table>
<thead>
<tr>
<th>Date Sampled</th>
<th>Time Sampled</th>
<th>EC dS/m</th>
<th>Ca meq/L</th>
<th>Mg meq/L</th>
<th>Na meq/L</th>
<th>SAR</th>
<th>Adj SAR</th>
<th>Cl meq/L</th>
<th>CO₃+HCO₃ meq/L</th>
<th>SO₄ meq/L</th>
<th>NO₂-N mg/L</th>
<th>Fe mg/L</th>
<th>Mn mg/L</th>
<th>pH</th>
<th>L.I.</th>
<th>TDS mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>RL</td>
<td>0.01</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td></td>
<td></td>
<td>10.0</td>
</tr>
<tr>
<td>SM</td>
<td>2510 B</td>
<td>Calc</td>
<td>Calc</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2540 C</td>
</tr>
<tr>
<td>EPA</td>
<td>200.7</td>
<td>200.7</td>
<td>200.7</td>
<td>300.0</td>
<td>300.0</td>
<td>300.0</td>
<td>200.7</td>
<td>300.0</td>
<td>200.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Analysis Date

- 9/21/18
- 9/25/18
- 9/29/18
- 9/25/18
- 9/21/18
- 9/25/18
- 9/21/18
- 9/25/18
- 9/21/18

### Analysis Time

- 16:00
- 11:15
- 11:15
- 11:15
- 11:15
- 12:45
- 16:59
- 12:45
- 17:5

### x2.73

<table>
<thead>
<tr>
<th>Date Sampled</th>
<th>Time Sampled</th>
<th>EC dS/m</th>
<th>Ca meq/L</th>
<th>Mg meq/L</th>
<th>Na meq/L</th>
<th>SAR</th>
<th>Adj SAR</th>
<th>Cl meq/L</th>
<th>CO₃+HCO₃ meq/L</th>
<th>SO₄ meq/L</th>
<th>NO₂-N mg/L</th>
<th>Fe mg/L</th>
<th>Mn mg/L</th>
<th>pH</th>
<th>L.I.</th>
<th>TDS mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Westlands</td>
<td>9/21/18</td>
<td>14:00</td>
<td>0.55</td>
<td>0.87</td>
<td>1.19</td>
<td>3.20</td>
<td>3.20</td>
<td>2.90</td>
<td>1.40</td>
<td>0.60</td>
<td>0.12</td>
<td>0.5</td>
<td>0.10</td>
<td></td>
<td></td>
<td>1.4</td>
</tr>
</tbody>
</table>

### Well 11/3/17

- 9:15
- 0.11
- 0.50
- 0.36
- 0.30
- 0.50
- 0.50
- <0.1
- 1.10
- <0.1
- <0.05
- 0.2
- 0.10
- 0.04
- 7.9
- -5.6

### Well 11/3/17

- 9:20
- 0.50
- 2.08
- 1.78
- 1.60
- 1.10
- 2.10
- 0.40
- 3.40
- 1.20
- 0.05
- 6.9
- <0.10
- <0.02
- 7.9
- 0.4

### Well 11/3/17

- 9:25
- 0.66
- 2.83
- 2.32
- 1.40
- 0.80
- 1.70
- 0.50
- 3.60
- 1.60
- <0.05
- 18.8
- <0.10
- <0.02
- 8.0
- 0.6

### Calculated from nitrate-N lbs/Ac/ft³ ft/Inch

1.4

### University of California

Agriculture and Natural Resources

Cooperative Extension
Conclusion

• Use plant tissue analysis coupled with visual assessment to determine: do I need N fertilizer?
• Budget the vineyard N based on:
  ✓ Yield: 3 lbs N of 1 ton of fresh fruit
  ✓ Irrigation: 2-3 acre foot for raisin/wine, 4 acre foot for table grape
• Yield is maximized with applied water at 80% of estimated ETc.
Acknowledgement

• Dr. Larry Williams, UC Davis
• Dr. Matthew Fidelibus, UC Davis
• Gaia Nafziger, UCCE Fresno County
• SJV wine growers and wineries
Questions?