Irrigation Management Tools for Developing Orchards

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Tehama, Glenn, Colusa, and Shasta Counties
Growing Walnuts in the northern Sacramento Valley

- 14 – 24 inches annual rainfall
- 3 – 6 inches of rain may fall after leafout
- Later leafing varieties (Chandler, Howard, Tulare)
- 80 percent of fruit and nut crops irrigated with rotator mini sprinklers, fan jets, drip, or buried drip methods
- Growing walnuts on soils once deemed unsuitable and more challenging
What is irrigation management?

- Making decisions about when to irrigate and how much water to apply
  - Understanding how well an irrigation system is performing and fixing it as needed
  - Attention to water placement, infiltration, and drainage
  - Choosing among different tools and applying at least one of them to help with management decisions
Why focus on developing orchards?

Data: Lampinen et. al. 2012

Yield (tons/acre)

Midday PAR interception (%)
Learning Opportunity in Tehama County (2009-2012)
Opportunity to assess irrigation needs in developing orchards

- 1\textsuperscript{st} leaf – 2 repetitions
- 2\textsuperscript{nd} leaf – 3 repetitions
- 3\textsuperscript{rd} leaf – 3 repetitions
- 4\textsuperscript{th} leaf – 3 repetitions
- 5\textsuperscript{th} leaf – 3 repetitions
- 6\textsuperscript{th} leaf or older – 4 repetitions
Extent of soil variability
Tools used to learn about irrigation of developing orchards
Evaluating soil moisture with a soil auger

Wetter

Drier

Sandier  More

Clay

More

Clay
Plant camera
Weekly measurement of orchard water status (pressure chamber, midday SWP)
A working knowledge of the pressure chamber and Stem Water Potential concepts and guidelines

Midday stem water potential (SWP) - bars

<table>
<thead>
<tr>
<th>Pressure Chamber Reading (- bars)</th>
<th>WALNUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to -2.0</td>
<td>Not commonly observed</td>
</tr>
<tr>
<td>-2.0 to -4.0</td>
<td>Fully irrigated, low stress, commonly observed when orchards are irrigated according to estimates of real-time evapotranspiration (ETc), long term root and tree health may be a concern, especially on California Black rootstock.</td>
</tr>
<tr>
<td>-4.0 to -6.0</td>
<td>Low to mild stress, high rate of shoot growth visible, suggested level from leaf-out until mid June when nut sizing is completed.</td>
</tr>
<tr>
<td>-6.0 to -8.0</td>
<td>Mild to moderate stress, shoot growth in non-bearing and bearing trees has been observed to decline. These levels do not appear to affect kernel development.</td>
</tr>
<tr>
<td>-8.0 to -10.0</td>
<td>Moderate to high stress, shoot growth in non-bearing trees may stop, nut sizing may be reduced in bearing trees and bud development for next season may be negatively affected.</td>
</tr>
<tr>
<td>-10.0 to -12.0</td>
<td>High stress, temporary wilting of leaves has been observed. New shoot growth may be sparse or absent and some defoliation may be evident. Nut size likely to be reduced.</td>
</tr>
</tbody>
</table>

Growth not expected. Lag time to stimulate growth.

Average monthly growth of pruned shoots (cm)
Weekly measurement of soil moisture depletion (Neutron Probe Moisture Meter)
A working knowledge of soil moisture depletion concepts

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Field capacity</th>
<th>Wilting Point</th>
<th>Available Water Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Inches/ft of soil)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sandy loam</td>
<td>2.0</td>
<td>0.6</td>
<td>1.4</td>
</tr>
<tr>
<td>Fine sandy loam</td>
<td>2.6</td>
<td>0.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Loam</td>
<td>3.2</td>
<td>1.2</td>
<td>2.0</td>
</tr>
<tr>
<td>Silt loam</td>
<td>3.5</td>
<td>1.4</td>
<td>2.1</td>
</tr>
<tr>
<td>Clay loam</td>
<td>3.8</td>
<td>1.8</td>
<td>2.0</td>
</tr>
<tr>
<td>Clay</td>
<td>4.0</td>
<td>2.6</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Soil water content (in/ft)

Soil texture and water capacity:
- Sandy loam: Field capacity 2.0, Wilting point 0.6, Available water capacity 1.4
- Fine sandy loam: Field capacity 2.6, Wilting point 0.8, Available water capacity 1.8
- Loam: Field capacity 3.2, Wilting point 1.2, Available water capacity 2.0
- Silt loam: Field capacity 3.5, Wilting point 1.4, Available water capacity 2.1
- Clay loam: Field capacity 3.8, Wilting point 1.8, Available water capacity 2.0
- Clay: Field capacity 4.0, Wilting point 2.6, Available water capacity 1.4
Soil moisture monitoring and young trees
Flow meters and rain gauges
Kept irrigation records (a water budget)

- **Water supplies**
  - Dormant season soil storage
  - In-season rainfall
  - Irrigation

- **Water losses**
  - Evapotranspiration (ETc)
  - Inefficiencies
Experience with the pressure chamber and 1st leaf orchards
Results with 1st leaf orchards

- Two 1.0 gph emitters per tree
- From planting in March to late May, relied on rainfall or occasional irrigation, six hour set,

Midday Stem Water Potential

-orchard Readings — Fully Irrigated Baseline
Results with the pressure chamber in 1st leaf orchards

- Two 1.0 gph emitters per tree
- Beginning late May irrigated 1.0 hour each day, 4 or 5 days per week, skipping Sundays
Experience with 1st leaf orchards

- Two 1.0 gph emitters per tree
- Continued irrigating 4 or 5 days per week, skipping Sundays. Gradually increased run time up to 2.0 hours per day.
Experience with 1st leaf orchards

- Two 1.0 gph emitters per tree
- Continued irrigating 5 days each week, skipping Sundays. Gradually increased run time up to 3 hours per day.
Experience with 1st leaf orchards

- Purposely began to reduce irrigation frequency in September
- Goal: Use deep stored water and develop deeper root system
- Goal: Harden off green shoots
Experience with monitoring soil moisture depletion in 1st leaf orchards
Soil moisture levels in two foot soil profile

Soil moisture levels in five foot soil profile
Lessons learned with 1st leaf trees

- Terrace soils, lower quality, less forgiving
- Placement of water important when root is small
- After planting, trees more responsive to higher frequency, shorter irrigation sets
- As trees grow, root system expands
  - Better use of deeper soil moisture in latter half of season #1, placement not as critical

Progression with irrigation methods and placement of water
## Estimated water use (ETc) for 1st Leaf Walnuts

<table>
<thead>
<tr>
<th>Year</th>
<th>In-season Rainfall (in.)</th>
<th>Drip Irrig. (in.)</th>
<th>Soil Moisture Depletion (in.)</th>
<th>Total (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011 (Rep I)</td>
<td>4.3</td>
<td>3.3</td>
<td>7.5</td>
<td>15.1</td>
</tr>
<tr>
<td>2011 (Rep II)</td>
<td>4.3</td>
<td>3.1</td>
<td>7.0</td>
<td>14.4</td>
</tr>
</tbody>
</table>
Experience in 2\textsuperscript{nd} to 4\textsuperscript{th} leaf orchards
Experience in 2nd to 4th leaf orchards

1st Leaf ~
- 7.2 % PAR (+/- 1.8 %)
- 14 to 15 inches of water use (Not all from irrigation)
- 2 to 45 % of ETc for a mature orchard

2nd Leaf ~
- 16-23 % PAR (+/- 2.4 %)
- 21.2 inches of water use (Not all from irrigation)
- 35 to 60 % of ETc for a mature orchard

3rd Leaf ~
- 29 - 35 % PAR (+/- 5.0 %)
- 38.0 inches of water use (Not all from irrigation)
- 70-100 % of ETc for a mature orchard
- Influenced by irrigation method and orchard floor vegetation

4th Leaf ~
- 48 -50 % PAR (+/- 5.0 %)
- 42.0 inches of water use (Not all from irrigation)
- Approaching 100 % of ETc for a mature orchard
- Influenced by irrigation method and orchard floor vegetation
Approximate ETc of newly planted walnut trees. Expressed as a percentage of ETc for mature trees and as inches of ETc in two week intervals.

<table>
<thead>
<tr>
<th>DATE</th>
<th>First Leaf %</th>
<th>First Leaf (inches)</th>
<th>First Leaf (gal/tree/day)</th>
<th>Second Leaf %</th>
<th>Second Leaf (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr 1-15</td>
<td>15</td>
<td>0.1</td>
<td>1.7</td>
<td>35</td>
<td>0.3</td>
</tr>
<tr>
<td>Apr 16-30</td>
<td>20</td>
<td>0.3</td>
<td>4.3</td>
<td>40</td>
<td>0.6</td>
</tr>
<tr>
<td>May 1-15</td>
<td>25</td>
<td>0.5</td>
<td>7.8</td>
<td>45</td>
<td>0.9</td>
</tr>
<tr>
<td>May 16-31</td>
<td>30</td>
<td>1.0</td>
<td>14.8</td>
<td>45</td>
<td>1.5</td>
</tr>
<tr>
<td>June 1-15</td>
<td>30</td>
<td>1.0</td>
<td>15.2</td>
<td>50</td>
<td>1.6</td>
</tr>
<tr>
<td>June 16-30</td>
<td>35</td>
<td>1.3</td>
<td>19.6</td>
<td>50</td>
<td>1.9</td>
</tr>
<tr>
<td>July 1-15</td>
<td>40</td>
<td>1.8</td>
<td>27.7</td>
<td>55</td>
<td>2.5</td>
</tr>
<tr>
<td>July 16-31</td>
<td>40</td>
<td>2.1</td>
<td>31.0</td>
<td>60</td>
<td>3.1</td>
</tr>
<tr>
<td>Aug 1-15</td>
<td>45</td>
<td>1.8</td>
<td>27.1</td>
<td>60</td>
<td>2.4</td>
</tr>
<tr>
<td>Aug 16-31</td>
<td>45</td>
<td>1.6</td>
<td>24.4</td>
<td>60</td>
<td>2.2</td>
</tr>
<tr>
<td>Sept 1-15</td>
<td>40</td>
<td>1.2</td>
<td>17.7</td>
<td>55</td>
<td>1.6</td>
</tr>
<tr>
<td>Sept 16-30</td>
<td>40</td>
<td>0.9</td>
<td>14.1</td>
<td>55</td>
<td>1.3</td>
</tr>
<tr>
<td>Oct 1-15</td>
<td>35</td>
<td>0.7</td>
<td>10.7</td>
<td>50</td>
<td>1.0</td>
</tr>
<tr>
<td>Oct 16-31</td>
<td>30</td>
<td>0.3</td>
<td>4.1</td>
<td>45</td>
<td>0.4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>----</td>
<td><strong>14.6</strong></td>
<td>----</td>
<td>----</td>
<td><strong>21.3</strong></td>
</tr>
</tbody>
</table>

Gallons/tree/day = (((ETc x 27,150) ÷ trees/ac) ÷ days)
Approximate ETc of newly planted walnut trees. Expressed as a percentage of ETc for mature trees and as inches of ETc in two week intervals.

<table>
<thead>
<tr>
<th>DATE</th>
<th>Third Leaf %</th>
<th>Third Leaf (inches)</th>
<th>Fourth Leaf %</th>
<th>Fourth Leaf (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apr 1-15</td>
<td>70</td>
<td>0.5</td>
<td>100</td>
<td>0.8</td>
</tr>
<tr>
<td>Apr 16-30</td>
<td>75</td>
<td>1.1</td>
<td>100</td>
<td>1.4</td>
</tr>
<tr>
<td>May 1-15</td>
<td>85</td>
<td>1.8</td>
<td>100</td>
<td>2.1</td>
</tr>
<tr>
<td>May 16-31</td>
<td>90</td>
<td>3.1</td>
<td>100</td>
<td>3.4</td>
</tr>
<tr>
<td>June 1-15</td>
<td>95</td>
<td>3.1</td>
<td>100</td>
<td>3.3</td>
</tr>
<tr>
<td>June 16-30</td>
<td>95</td>
<td>3.5</td>
<td>100</td>
<td>3.7</td>
</tr>
<tr>
<td>July 1-15</td>
<td>100</td>
<td>4.6</td>
<td>100</td>
<td>4.6</td>
</tr>
<tr>
<td>July 16-31</td>
<td>100</td>
<td>5.1</td>
<td>100</td>
<td>5.1</td>
</tr>
<tr>
<td>Aug 1-15</td>
<td>100</td>
<td>4.0</td>
<td>100</td>
<td>4.0</td>
</tr>
<tr>
<td>Aug 16-31</td>
<td>100</td>
<td>3.6</td>
<td>100</td>
<td>3.6</td>
</tr>
<tr>
<td>Sept 1-15</td>
<td>100</td>
<td>2.9</td>
<td>100</td>
<td>2.9</td>
</tr>
<tr>
<td>Sept 16-30</td>
<td>100</td>
<td>2.3</td>
<td>100</td>
<td>2.3</td>
</tr>
<tr>
<td>Oct 1-15</td>
<td>100</td>
<td>2.0</td>
<td>100</td>
<td>2.0</td>
</tr>
<tr>
<td>Oct 16-31</td>
<td>100</td>
<td>0.9</td>
<td>100</td>
<td>0.9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>----</strong></td>
<td><strong>38.5</strong></td>
<td><strong>----</strong></td>
<td><strong>40.1</strong></td>
</tr>
</tbody>
</table>
More lessons learned

- Pressure chamber, moisture sensors, and flow meters give different insights
  - Pressure chamber – Tree response to growing conditions
  - Moisture sensors and flow meters – indicators of how management may be affecting growing conditions
  - All three tools provide a point of reference to adjust management
**Benefits of irrigation management tools**

**Productivity**
- Earlier
  - Higher and more consistent
  - Better crop quality and more value
  - Improved orchard life span

**Complements other cultural practices**

**Resource stewardship**

**Water and energy conservation?**

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**2012 Survey of Almond Growers**

- Turning to more science-based information
- 53 % Use flow meters
- 43 % Irrigation uniformity
- 44 % - Water budget (ETc)
- 49 % - Soil moisture monitoring
- 28 % - Pressure Chamber, Midday SWP
THANK YOU!

More irrigation management information is available at

http://cetehama.ucanr.edu

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