Past Advances in Almond Irrigation and Future Opportunities

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Symposium: Water and Energy Efficiency Across Food Systems: Innovations in Water Technologies
May 22, 2014
The Scope of the Almond Growing in California

- Spanning 500 miles throughout the Central Valley
- 100% of U.S. production
- ~ 6,500+ growers, 100 “handlers”
  - 50% of growers have 50 A or less
  - 90%+ are family owned & run
- Over 80% of worldwide production – 70% of production
- Top U.S. horticultural crop in export value
- 2012 farm gate value $4.8 billion

- ABC is a grower-enacted “Federal Marketing Order” established in 1950
  - Represents growers and handlers (processors)
- Operates under supervision of USDA
Bearing Acreage Increasing, More Efficient Production

- Average yield has doubled over the last 20 years (1,390 vs. 2,390 kernel lbs/ac)
- Water use (rain-fed + applied) has increased (40 vs. 48 inches per acre)
- Almond growers now use 33% less water to produce a pound of almonds due to advances in management practices and irrigation is major contributor.
Advances and Practices in Almond Irrigation Documented by Almond Sustainability Report

- 25 years of ABC-funded research has been a key to success
  - Advances in micro-irrigation and irrigation scheduling have been a major contributor
  - Micro-irrigation – Now 70% of almond acreage
  - 83% of growers use different technologies to schedule their irrigation based on:
    - Weather / ET (43% usage)
    - Tree needs / Stem water potential
    - Soil conditions / Soil monitoring

- Irrigation grower practices conserve water while protecting the environment (2014 Almond Sustainability Report)
  - Integrated fertilization and irrigation (fertigation)
  - Demand-based irrigation
  - Optimized irrigation infrastructure
Advances & Current Practices

Flood and impact sprinkler advance to micro-sprinklers and drip.
Advances & Current Practices:
The 3 things that you need to know about scheduling

The WEATHER
The PLANT
The SOIL

• Scheduling based on weather conditions: Weather/Evapotranspiration
• Etc (Specific crop) = Eto (reference grass pasture) x Kc (crop coefficient)
• Real time ET can be calculated from CIMIS data or Wateright http://www.cimis.water.ca.gov/ http://www.wateright.org/
• Grower weather stations
“Normal” season almond ET

Average weekly almond ET for Modesto, CA

<table>
<thead>
<tr>
<th>Month</th>
<th>Inch/week ET</th>
</tr>
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<tbody>
<tr>
<td>JAN</td>
<td>0.12</td>
</tr>
<tr>
<td>FEB</td>
<td>0.19</td>
</tr>
<tr>
<td>MAR</td>
<td>0.40</td>
</tr>
<tr>
<td>APR</td>
<td>0.81</td>
</tr>
<tr>
<td>MAY</td>
<td>1.25</td>
</tr>
<tr>
<td>JUN</td>
<td>1.70</td>
</tr>
<tr>
<td>JUL</td>
<td>1.86</td>
</tr>
<tr>
<td>AUG</td>
<td>1.69</td>
</tr>
<tr>
<td>SEP</td>
<td>1.29</td>
</tr>
<tr>
<td>OCT</td>
<td>0.69</td>
</tr>
<tr>
<td>NOV</td>
<td>0.32</td>
</tr>
<tr>
<td>DEC</td>
<td>0.12</td>
</tr>
</tbody>
</table>
Measure tree needs with pressure chamber

- Done at mid-day
- Labor intensive
- Very few trees can be sampled: very site specific

Pressure applied to the leaf forces water out of the xylem. Amount of pressure determines water status.
Advances & Current Practices: There are many methods to measuring soil moisture for scheduling.

From simple and cheap.................................to complex and expensive

All have one key limitation: only a small fraction of the root zone can be measured.

The solution – measure many locations and depths, 24/7.
Advances & Current Practices: Why each of the 3 things are *partial solutions* for scheduling

WEATHER:
Tells you **how much**, but not **when**.

PLANT:
Tells you that something is **wrong**, but not **why**.

SOIL:
Tells you about the **supply**, but only for a **small portion** of the root zone.

Therefore, WEATHER, PLANT and SOIL monitoring should be integrated.
Future Opportunities – Current Research

- Defining a Central Valley Almond ET / Almond Production Function
- Mobile Platform to Measure Canopy Light Interception and Water Stress
- Precision Canopy and Water Management Through Sensor-Based Decision Making
1. What is the ROI for high-priced water: Water applied vs. production increase?
2. Can we develop region specific evapotranspiration estimates (ETs)?
3. Can we develop canopy size specific evapotranspiration estimates (Ets)?

<table>
<thead>
<tr>
<th>Midday PAR interception</th>
<th>Applied plus stored water (inches)</th>
<th>Yield potential (kernel lbs/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>7 \times 71 = 500</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>14</td>
<td>1000</td>
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<tr>
<td>30</td>
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<td>3000</td>
</tr>
<tr>
<td>70</td>
<td>49</td>
<td>3500</td>
</tr>
</tbody>
</table>
Is there an alternative to stem water potential and pressure chambers to determine tree water status?
Future Opportunities – Key Questions and Objectives

How do we develop irrigation systems that are account for spatial variability better for production efficiency and water/environmental stewardship?
Future Opportunities – Key Questions and Objectives

How do we develop irrigation systems that are account for spatial variability better?

Arbuckle Veris Eca map zones and soil sampling sites

Arbuckle long term yields according to zones
Future Opportunities – Key Questions and Objectives

How do we integrate the pieces together in a decision support and operating system?

- Simple and robust
  - Eliminate most in-field wiring
  - Mesh network extends range and reliability
  - Low power for agriculture
- Monitoring and control
  - Soil moisture, weather, water meters
  - Irrigation valves, pump relays
- Data and decisions
  - Local or web
  - Charts and alerts
  - Disease models