Irrigation and Nitrogen Management
Web-Based Software for Lettuce Production

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Acknowledgements

- California Department of Food and Agriculture, Fertilizer Research and Education Program
- UC ANR Communication Services
- Grower participants
- Chiquita FreshExpress
Nitrate is part of CA Central Coast Agricultural Water Quality Regulations
Change in Nitrate Concentration
1993 to 2007
(Nitrate as NO3)

Legend
- Blue: 51 - 75 mg/L Decrease since 1993
- Light blue: 1 - 50 mg/L Decrease since 1993
- No Change since 1993
- Yellow triangle: 1 - 50 mg/L Increase since 1993
- Orange triangle: 51 - 100 mg/L Increase since 1993
- Red triangle: 101 - 200 mg/L Increase since 1993
- Dark purple triangle: 201 - 256 mg/L Increase since 1993
- Magenta triangle: 257 - 295 mg/L Increase since 1993

- Blue: Rivers / Water bodies
- Pink: Cities
- Gray: EAST SIDE
- Brown: PRESSURE
- Lilac: FOREBAY
- Yellow: UPPER VALLEY
- Pale yellow: MONTEREY CO
- Pale blue: PACIFIC OCEAN

Note: The scale and configuration of all information shown herein are approximate and are not intended as a guide for design or survey work.

Map Date: June 22, 2009

n = 96
regulatory compliance will require management changes

- use nitrogen fertilizer more efficiently
- account for all sources contributing to crop uptake of N
- improve irrigation management
- record keeping and reporting
- document improvements in water quality
Tools for Managing Water and Nitrogen Fertilizer in Lettuce

- Quick nitrate soil test
  (20 ppm NO$_3$-N = 70 to 80 lbs of N/acre/ft)
- Weather-based irrigation scheduling
Commercial Lettuce Nitrogen Fertilizer Trials

Difference
66 lbs/A
@ 0.60/lb N
=$40/A
Commercial Yield

97% of Grower

Boxes/Acre

Field

GR
BMP
Applied Water as Percentage of Crop ET (Lettuce)

Avg Applied Water = 176% of Crop ET
# Irrigation Trials in Lettuce

<table>
<thead>
<tr>
<th>Trial Site</th>
<th>Total Applied Water (inches)</th>
<th>Estimated Crop ETc (inches)</th>
<th>Irrigation requirement (^1) (inches)</th>
<th>Water use reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>King City</td>
<td>17.7</td>
<td>14.7</td>
<td>10.1</td>
<td>13.4</td>
</tr>
<tr>
<td>S. Salinas</td>
<td>9.9</td>
<td>8.7</td>
<td>7.6</td>
<td>8.9</td>
</tr>
<tr>
<td>San Ardo</td>
<td>19.4</td>
<td>11.9</td>
<td>6.7</td>
<td>8.7</td>
</tr>
<tr>
<td>N. Salinas</td>
<td>10.7</td>
<td>10.4</td>
<td>7.0</td>
<td>8.4</td>
</tr>
<tr>
<td>S. Salinas 2</td>
<td>10.9</td>
<td>10.1</td>
<td>6.1</td>
<td>7.6</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>13.7</strong></td>
<td><strong>11.2</strong></td>
<td><strong>7.5</strong></td>
<td><strong>9.4</strong></td>
</tr>
</tbody>
</table>

1. Irrigation requirement = ETc/distribution uniformity
Weather-based Irrigation Scheduling

Converting Reference ET to Crop ET:

\[ \text{ET}_{\text{crop}} = \text{ET}_{\text{ref}} \times K_{\text{crop}} \]

\( K_c \) can vary from 0.1 to 1.2
Estimated Kc of Lettuce

Average Kc = 0.33 during germination with sprinklers

Crop Coefficient (Kc)

Days after Planting

Sprinkler irrigation events

Sprinkler - Blue
Drip - Dashed

Average Kc = 0.33 during germination with sprinklers
Other factors for determining an irrigation schedule:

- Soil water holding capacity
- Crop rooting depth
- Irrigation system application rate
- Irrigation system application uniformity
- Leaching fraction (water salinity)
- Crop development stage
How can water and N management tools be useful for large vegetable growing operations?

- Large growing operations have multiple decision makers.
- One farm manager may be responsible for >200 fields during a season.
- Other responsibilities besides water and fertilizer N management.
Web-based Irrigation and N management software for lettuce

https://ucanr.org/cropmanage
CropManage Web-based Tool:

Assist growers in making decisions on irrigation and nitrogen fertilizer management

✓ Intuitive, simple, quick to use.
✓ Accessible from smart phone, tablet computer, desktop computer
✓ Guide irrigation schedules using CIMIS weather data.
✓ Guide nitrogen fertilization decisions using quick nitrate test data.
✓ Maintain and share irrigation, fertilizer, and soil test records for multiple fields and farms.
Integrate information from multiple sources

Soil and Ranch base info
CIMIS ETo
Soil nitrate test
Field sensors

Crop ET model
Watering Recommendation
Crop N model
N fertilizer Recommendation
Record display and data export

Database driven web application

Decision support using crop models
How is N fertilizer rate determined from the quick nitrate test?

Fertilizer N Rate = Future Crop N uptake

- (Quick Test N - threshold NO$_3$-N)
- predicted soil mineralization N
- predicted plant residue N
Iceberg lettuce canopy cover over (%)

Days after Planting

Predicted Canopy Cover (%)

Observed Canopy Cover (%)

Canopy\textsubscript{obs} = 1.01 \times \text{Canopy}\textsubscript{pred} - 0.69

R^2=0.99
Available moisture depends on soil type and rooting depth.
Spatial CIMIS ETo Reporting
How much water was applied?
Evaluate and document water management

Cumulative Applied Water (inches) vs. Days after Planting

- **CropManage Recommendation**
- **Grower Application**

- Days after Planting:
  - 0
  - 10
  - 20
  - 30
  - 40
  - 50
  - 60
Ranch List

Select a Ranch to work in from the list below.

- Bondesen
- Bryon's Test
- Calla Roberts Ranch
- Chualar
- Corey
- East Garlinger Ranch
- Fanoe
- Gabilan Ranch
- Hess
- Hilltown
- Home
- Hunter Lane
- Ikeda Bros Ranch 37
- J Pettit
- Los Coches
- Martella UC trial
- Molera
Plantings

Showing ALL Plantings

<table>
<thead>
<tr>
<th>Planting</th>
<th>Wet Date</th>
<th>Lot</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taylor Lettuce M 20</td>
<td>3/31/2012</td>
<td>20</td>
<td>edit planting</td>
</tr>
<tr>
<td>Romaine 24 standard</td>
<td>8/11/2012</td>
<td>24</td>
<td>edit planting</td>
</tr>
<tr>
<td>Romaine 24 UC</td>
<td>8/11/2012</td>
<td>24</td>
<td>edit planting</td>
</tr>
</tbody>
</table>

- New Planting
- View Current Plantings
- Import Export Options

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**Ranch/Field:** South Mortensen Ranch, Lot 24, loam  
**Planting:** Romaine 24 standard, 9.1 acres  
**Crop:** Romaine 5 row, 80 inch bed, 8/11-10/17/12

## Planting

### Soil Summary

<table>
<thead>
<tr>
<th>Sample Date</th>
<th>Sample Reading (ppm)</th>
<th>Crop Stage</th>
<th>Sample Depth (ft)</th>
<th>Sample Analysis</th>
<th>Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/18/12</td>
<td>200</td>
<td>2nd drip fertigation</td>
<td>1</td>
<td>Quick Strip</td>
<td>95.2</td>
</tr>
<tr>
<td>9/18/12</td>
<td>100</td>
<td>2nd drip fertigation</td>
<td>2</td>
<td>Quick Strip</td>
<td>47.6</td>
</tr>
<tr>
<td>10/4/12</td>
<td>200</td>
<td>3rd drip fertigation</td>
<td>1</td>
<td>Quick Strip</td>
<td>95.2</td>
</tr>
</tbody>
</table>
### Soil Summary

<table>
<thead>
<tr>
<th>Sample Date</th>
<th>Sample Reading (ppm)</th>
<th>Crop Stage</th>
<th>Sample Depth (ft)</th>
<th>Sample Analysis</th>
<th>Soil Nitrate-N (ppm)</th>
<th>Soil Mineral N (lb/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/18/12</td>
<td>200</td>
<td>2nd drip fertigation</td>
<td>1</td>
<td>Quick Strip</td>
<td>95.24</td>
<td>387.67</td>
</tr>
<tr>
<td>9/18/12</td>
<td>100</td>
<td>2nd drip fertigation</td>
<td>2</td>
<td>Quick Strip</td>
<td>47.62</td>
<td>193.83</td>
</tr>
<tr>
<td>10/4/12</td>
<td>200</td>
<td>3rd drip fertigation</td>
<td>1</td>
<td>Quick Strip</td>
<td>95.24</td>
<td>387.67</td>
</tr>
<tr>
<td>10/4/12</td>
<td>150</td>
<td>3rd drip fertigation</td>
<td>2</td>
<td>Quick Strip</td>
<td>71.43</td>
<td>290.75</td>
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<td>10/8/12</td>
<td>90</td>
<td>4th drip fertigation</td>
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<td>42.86</td>
<td>174.45</td>
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<td>10/8/12</td>
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<td>4th drip fertigation</td>
<td>2</td>
<td>Quick Strip</td>
<td>95.24</td>
<td>387.67</td>
</tr>
</tbody>
</table>

### Fertilizer Summary

<table>
<thead>
<tr>
<th>Fertilizer Date</th>
<th>Soil NO₃-N (ppm)</th>
<th>Crop Stage</th>
<th>Fertilizer N Recommended (lb N/acre)</th>
<th>Cumulative N Uptake</th>
<th>Fertilizer</th>
<th>Applied N (lb N/acre)</th>
<th>Applied Fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>8/28/12</td>
<td>N/A</td>
<td>Post-thinning</td>
<td>N/A</td>
<td>4.74</td>
<td>28-0-0-5</td>
<td>92.8</td>
<td>30.0 gallons/acre</td>
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<tr>
<td>9/13/12</td>
<td>N/A</td>
<td>1st drip fertigation</td>
<td>N/A</td>
<td>16.50</td>
<td>28-0-0-5</td>
<td>30.9</td>
<td>10.0 gallons/acre</td>
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<tr>
<td>9/13/12</td>
<td>47.62</td>
<td>2nd drip fertigation</td>
<td>0.0</td>
<td>23.09</td>
<td>28-0-0-5</td>
<td>30.9</td>
<td>10.0 gallons/acre</td>
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<tr>
<td>9/24/12</td>
<td>N/A</td>
<td>3rd drip fertigation</td>
<td>N/A</td>
<td>34.05</td>
<td>NPhuric 15-0-0-49</td>
<td>9.5</td>
<td>5.0 gallons/acre</td>
</tr>
</tbody>
</table>
## Watering Summary Table

<table>
<thead>
<tr>
<th>Water Date</th>
<th>Irrigation Method</th>
<th>Recommended Irrigation Interval (days)</th>
<th>Recommended Irrigation Amount (inches)</th>
<th>Recommended Irrigation Time (hours)</th>
<th>Irrigation Water Applied (inches)</th>
<th>K&lt;sub&gt;c&lt;/sub&gt;</th>
<th>Canopy Cover (%)</th>
<th>Average Reference ET (inches/day)</th>
<th>Total Crop ET (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8/11/12</td>
<td>Sprinkler</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>0.49 in</td>
<td>0.00</td>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>8/14/12</td>
<td>Sprinkler</td>
<td>2.2</td>
<td>0.38 in</td>
<td>1.28 hrs</td>
<td>0.63 in</td>
<td>0.48</td>
<td>0</td>
<td>0.20</td>
<td>0.29</td>
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<tr>
<td>8/16/12</td>
<td>Sprinkler</td>
<td>1.6</td>
<td>0.35 in</td>
<td>1.17 hrs</td>
<td>0.48 in</td>
<td>0.70</td>
<td>0</td>
<td>0.19</td>
<td>0.26</td>
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<tr>
<td>8/20/12</td>
<td>Sprinkler</td>
<td>3.1</td>
<td>0.36 in</td>
<td>1.19 hrs</td>
<td>0.48 in</td>
<td>0.37</td>
<td>1</td>
<td>0.18</td>
<td>0.27</td>
</tr>
<tr>
<td>8/28/12</td>
<td>Sprinkler</td>
<td>7.4</td>
<td>0.30 in</td>
<td>1.02 hrs</td>
<td>0.94 in</td>
<td>0.20</td>
<td>2</td>
<td>0.14</td>
<td>0.23</td>
</tr>
<tr>
<td>9/13/12</td>
<td>Drip</td>
<td>9.4</td>
<td>0.60 in</td>
<td>4.03 hrs</td>
<td>0.72 in</td>
<td>0.21</td>
<td>21</td>
<td>0.16</td>
<td>0.54</td>
</tr>
<tr>
<td>9/18/12</td>
<td>Drip</td>
<td>9.0</td>
<td>0.34 in</td>
<td>2.24 hrs</td>
<td>0.78 in</td>
<td>0.40</td>
<td>36</td>
<td>0.15</td>
<td>0.30</td>
</tr>
<tr>
<td>9/24/12</td>
<td>Drip</td>
<td>7.0</td>
<td>0.57 in</td>
<td>3.82 hrs</td>
<td>0.66 in</td>
<td>0.60</td>
<td>56</td>
<td>0.14</td>
<td>0.52</td>
</tr>
<tr>
<td>9/28/12</td>
<td>Drip</td>
<td>7.2</td>
<td>0.42 in</td>
<td>2.78 hrs</td>
<td>0.63 in</td>
<td>0.77</td>
<td>67</td>
<td>0.12</td>
<td>0.38</td>
</tr>
<tr>
<td>10/3/12</td>
<td>Drip</td>
<td>5.1</td>
<td>0.79 in</td>
<td>5.27 hrs</td>
<td>0.69 in</td>
<td>0.87</td>
<td>76</td>
<td>0.16</td>
<td>0.71</td>
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<tr>
<td>10/9/12</td>
<td>Drip</td>
<td>6.8</td>
<td>0.74 in</td>
<td>4.91 hrs</td>
<td>0.90 in</td>
<td>0.94</td>
<td>81</td>
<td>0.12</td>
<td>0.66</td>
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<tr>
<td>10/17/12</td>
<td>Drip</td>
<td>8.3</td>
<td>0.81 in</td>
<td>5.41 hrs</td>
<td>0.57 in</td>
<td>0.98</td>
<td>84</td>
<td>0.09</td>
<td>0.73</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td><strong>5.66 in</strong></td>
<td><strong>33.10 hrs</strong></td>
<td><strong>7.97 in</strong></td>
<td><strong>4.89 in</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Field Validation of CropManage

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Applied N Fertilizer</th>
<th>Commercial Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>CropManage</td>
<td>149</td>
<td>18760</td>
</tr>
<tr>
<td>Grower Standard</td>
<td>211</td>
<td>19114</td>
</tr>
</tbody>
</table>
The road ahead…
Interface with UCD online Soil Survey Tool
Soil moisture monitoring

![Graph showing soil moisture tension over time for 8 inches and 18 inches depth. The graph indicates that soil moisture tension decreases over time, with a significant drop on 9-30.]
Final Thoughts

- Web-based applications can integrate complex data and models into simple to use decision support tools.

- *CropManage* is not just for growers. It is a potential tool for crop consultants to use in assisting growers with water and N management decisions.

- We will offer training workshops on CropManage beginning March 2013.