CropManage: On-line Decision Support Tool for Managing Water and Nitrogen of Vegetables

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Acknowledgements

- Tim Hartz, Richard Smith
- California Department of Food and Agriculture, Fertilizer Research and Education Program
- UC ANR Communication Services, Bryon Noel
- Lee Johnson and Forrest Melton, CSUMB/NASA
- Grower participants
- Chiquita FreshExpress
- Tanimura and Antle
- California Leafy Green Research Board
TIER 3

DISCHARGERS ENROLLED UNDER
THE CONDITIONAL WAIVER OF WASTE DISCHARGE REQUIREMENTS FOR DISCHARGES FROM IRRIGATED LANDS

This Monitoring and Reporting Program Order No. R3-2012-0011-03 (MRP) is issued pursuant to California Water Code (Water Code) section 13267 and 13269, which authorize the California Regional Water Quality Control Board, Central Coast Region (hereafter Central Coast Region) operation and submittal of technical and monitoring reports. The MRP requires a waiver of waste discharge requirements to include as a condition, the performance of monitoring and the public availability of monitoring results. The Conditional Waiver of Waste Discharge Requirements for Discharges from Irrigated Lands Order No. R3-2012-0011 (Order) includes criteria and requirements for three tiers. This MRP sets forth monitoring and reporting requirements for Tier 3 Dischargers enrolled under the Order. A summary of the requirements is shown below.

SUMMARY OF MONITORING AND REPORTING REQUIREMENTS FOR TIER 3:

Part 1: Surface Receiving Water Monitoring and Reporting (cooperative or individual);
Part 2: Groundwater Monitoring and Reporting;
Part 3: Nitrates Loading Risk Factor Determination and Total Nitrogen Reporting (required for subset of Tier 3 Dischargers if farm ranch has high nitrate loading risk to groundwater);
Part 4: Individual Surface Water Discharge Monitoring and Reporting;
Part 5: Irrigation and Nutrient Management Plan (required for subset of Tier 3 Dischargers if farm ranch contains or is adjacent to a waterbody impaired for temperature, turbidity or sediment);
Part 6: Water Quality Buffer Plan (required for subset of Tier 3 Dischargers if farm ranch contains or is adjacent to a waterbody impaired for temperature, turbidity or sediment).
Tools for Managing Water and Nitrogen Fertilizer in Lettuce

- Soil nitrate quick test
  (20 ppm NO$_3$-N = 70 to 80 lbs of N/acre/ft)
- Weather-based irrigation scheduling
Weather-based Irrigation Scheduling

Converting Reference ET to Crop ET:

$$ET_{crop} = ET_{ref} \times K_{crop}$$

$K_c$ can vary from 0.1 to 1.2
Other information needs to be considered

- Rooting Depth
- Irrigation System Uniformity and Application Rate
- Soil Type
- Salinity of Water Source
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 >100 fields during a season
- Other responsibilities besides water and fertilizer N management
Web-based Irrigation and N management software for lettuce

https://ucanr.edu/cropmanage

Login

To login enter your e-mail and password below.

E-mail Address: mdcahn@ucdavis.edu

Password: Password

Login

Forgot Password
Create New Account
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

Database Driven Web Application

- Soil and Ranch
- CIMIS ET
- Soil nitrate test
- Field sensors

Crop ET model
Crop N model
Watering Recommendation
N fertilizer Recommendation
Display and export water and fertilizer records

Decision support using crop models
Steps to Using CropManage

1. Establish user login
2. Set up a ranch or request access to existing ranch
3. Add new plantings to ranch or view existing plantings
4. Enter or view soil tests, fertilizer, or irrigation events for plantings
Current crops supported

Romaine, 40-inch wide beds (2 plant rows)
Romaine, 80-inch wide beds (5/6 plant rows)
Iceberg, 40-inch wide beds (2 plant rows)
Iceberg, 80-inch wide beds (5/6 plant rows)
How is N fertilizer rate determined from the quick nitrate test?

Recommended
Fertilizer N = Future Crop N uptake

- (Quick Test N - threshold NO$_3$-N)
- Soil mineralization N
- Plant residue N
N uptake rate by head lettuce (40 inch-wide beds)
Nitrogen Fertilizer Recommendation

\[ N_{\text{fert}} = 57 + 18 - 4.5 = 71 \text{ lbs N/acre} \]

N uptake = 57 lbs/acre

Soil and residue mineralization = 4.5 lbs/acre

SNQT – Threshold = -18 lbs/acre
## 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>7/1/12</td>
<td>12.50</td>
<td>Planting</td>
<td>0.0</td>
<td>0.23</td>
<td>3.5-12-14</td>
<td>15.0</td>
<td>36.9 gal/acre</td>
</tr>
<tr>
<td>7/24/12</td>
<td>15.00</td>
<td>1st drip fertigation</td>
<td>31.2</td>
<td>4.32</td>
<td>28-0-0-5</td>
<td>24.8</td>
<td>8.0 gal/acre</td>
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<tr>
<td>8/10/12</td>
<td>15.00</td>
<td>2nd drip fertigation</td>
<td>55.8</td>
<td>31.90</td>
<td>UAN28</td>
<td>56.7</td>
<td>19.0 gal/acre</td>
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<tr>
<td>Totals</td>
<td></td>
<td></td>
<td>86.9</td>
<td></td>
<td></td>
<td>96.5</td>
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</table>

**New Fertilizing**
<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>Kc</th>
<th>Canopy Cover (%)</th>
<th>Average Reference ET (inches/day)</th>
<th>Total Crop ET (inches)</th>
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</thead>
<tbody>
<tr>
<td>7/8/12</td>
<td>Sprinkler</td>
<td>1.6</td>
<td>0.48</td>
<td>1.59 hrs</td>
<td>0.60 in</td>
<td>0.48</td>
<td>0</td>
<td>0.25</td>
<td>0.36</td>
</tr>
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<td>7/13/12</td>
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<td>2.8</td>
<td>0.47</td>
<td>1.57 hrs</td>
<td>0.51 in</td>
<td>0.30</td>
<td>1</td>
<td>0.24</td>
<td>0.35</td>
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<tr>
<td>7/20/12</td>
<td>Drip</td>
<td>6.3</td>
<td>0.41</td>
<td>2.70 hrs</td>
<td>0.45 in</td>
<td>0.23</td>
<td>3</td>
<td>0.22</td>
<td>0.34</td>
</tr>
<tr>
<td>7/24/12</td>
<td>Drip</td>
<td>9.4</td>
<td>0.19</td>
<td>1.25 hrs</td>
<td>0.22 in</td>
<td>0.16</td>
<td>5</td>
<td>0.25</td>
<td>0.16</td>
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<tr>
<td>7/29/12</td>
<td>Drip</td>
<td>11.2</td>
<td>0.23</td>
<td>1.56 hrs</td>
<td>0.15 in</td>
<td>0.18</td>
<td>11</td>
<td>0.22</td>
<td>0.20</td>
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<tr>
<td>8/4/12</td>
<td>Drip</td>
<td>8.2</td>
<td>0.46</td>
<td>3.03 hrs</td>
<td>0.60 in</td>
<td>0.27</td>
<td>24</td>
<td>0.24</td>
<td>0.39</td>
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<tr>
<td>8/7/12</td>
<td>Drip</td>
<td>7.6</td>
<td>0.26</td>
<td>1.76 hrs</td>
<td>0.30 in</td>
<td>0.40</td>
<td>33</td>
<td>0.19</td>
<td>0.22</td>
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<td>Drip</td>
<td>4.9</td>
<td>0.44</td>
<td>2.95 hrs</td>
<td>0.30 in</td>
<td>0.50</td>
<td>43</td>
<td>0.25</td>
<td>0.38</td>
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<tr>
<td>8/14/12</td>
<td>Drip</td>
<td>4.3</td>
<td>0.73</td>
<td>4.90 hrs</td>
<td>0.80 in</td>
<td>0.64</td>
<td>56</td>
<td>0.25</td>
<td>0.62</td>
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<td>8/18/12</td>
<td>Drip</td>
<td>4.1</td>
<td>0.82</td>
<td>5.49 hrs</td>
<td>0.00 in</td>
<td>0.77</td>
<td>67</td>
<td>0.23</td>
<td>0.70</td>
</tr>
<tr>
<td>Totals</td>
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<td></td>
<td>5.36</td>
<td>29.70 hrs</td>
<td>6.03 in</td>
<td></td>
<td></td>
<td></td>
<td>4.38</td>
</tr>
</tbody>
</table>
Iceberg lettuce canopy cover
Spatial CIMIS ETo Reporting
Irrigation System Application Rate (inches/hr)

Sprinkler Application Rate
- Sprinkler Type: Rainbird 20 JH
- Nozzle Diameter (in): 7/64
- Nozzle Pressure (psi): 50
- Lateral Pipe Spacing (ft): 33.333333333333
- Sprinkler Head Spacing (ft): 30

Drip Application Rate
- Bed width (inches): 40
- Number of drip lines per bed: 1
- Tape Discharge Rate (gallons/minute/100ft): 0.45
CropManage Overview: A web application for managing water and nitrogen fertilizer in lettuce

Author: Michael D Cahn

October 15, 2012

Cool season vegetable production requires significant inputs of water and nitrogen (N) fertilizer to maximize yield and quality. Proposed changes in water quality regulations on the Central Coast and higher fertilizer prices in recent years have prompted grower interest in increasing efficiency of nitrogen fertilizer use in lettuce. By improving water management and matching nitrogen applications to the uptake pattern of the crop, growers could potentially reduce fertilizer use and address water quality concerns.

Two tools available, the quick nitrate soil test and weather-based irrigation scheduling, have been shown to help lettuce producers better manage water and fertilizer nitrogen. Trials we conducted in commercial fields have demonstrated that soil nitrate concentrations greater than 20 ppm NO$_3$-N,
How much water was applied?
Evaluate and Document Water Management

![Graph showing cumulative applied water (inches) over days after planting, comparing CropManage Recommendation and Grower Application.](image)
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Applied N Fertilizer</th>
<th>Commercial Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grower Standard</td>
<td>211</td>
<td>19114</td>
</tr>
<tr>
<td>CropManage</td>
<td>149</td>
<td>18760</td>
</tr>
</tbody>
</table>
## Replicated Irrigation Trial for Iceberg Lettuce

<table>
<thead>
<tr>
<th>Treatment</th>
<th>head wt</th>
<th>carton yield</th>
<th>CFR yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>untrimmed</td>
<td>trimmed</td>
<td>untrimmed</td>
</tr>
<tr>
<td>Grower standard (150% ETc)</td>
<td>2.73</td>
<td>1.60</td>
<td>73903</td>
</tr>
<tr>
<td>CropManage (100% ETc)</td>
<td>2.76</td>
<td>1.61</td>
<td>75623</td>
</tr>
<tr>
<td>LSD&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
</tbody>
</table>

1. Cored for region

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LSD<sub>0.05</sub> refers to the Least Significant Difference at the 0.05 level of significance.
## Using weather based irrigation scheduling for broccoli

<table>
<thead>
<tr>
<th>Irrigation Treatment</th>
<th>Applied water inches</th>
<th>Marketable Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Grower Standard (150% ET)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CropManage (100% ET)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14.2</td>
</tr>
<tr>
<td>LSD$_{0.05}$</td>
<td></td>
<td>NS</td>
</tr>
</tbody>
</table>
The road ahead...
N contribution from irrigation water?
Final Thoughts

- Web applications can repackage complex data sets and mathematical models into simple to use decision support tools.

- Web apps can also help growers track their practices and demonstrate that they are managing nutrients and water efficiently.

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