CropManage: an online decision support tool for irrigation and fertilization

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Acknowledgements

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- Chiquita FreshExpress
- Tanimura and Antle
- Dole Vegetables
Lower Salinas Nutrient TMDL

Salinas Valley Basin Plan

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 section 13267 and 13269, which authorize the California Regional Water Quality Control Board, Central Coast Region (hereafter Central Coast Water Board) to require preparation and submittal of technical and monitoring reports. Water Code section 13268 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: Nitrate 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: Annual Compliance Form;
Part 5: Photo Monitoring (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: 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 7: 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);

Addressing Nitrate in California’s Drinking Water
With a Focus on Tulare Lake Basin and Salinas Valley Groundwater

SWRCB SBX2 1

Ag Order

Change in Nitrate Concentration 1993 to 2007 (Nitrate as NO₃)
Tools for Managing Water and Nitrogen Fertilizer in Vegetables

- Soil nitrate quick test
- 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
Web-based Irrigation and N management software for lettuce

https://ucanr.edu/cropmanage
Integrate information from multiple sources

Database Driven Web Application

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

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

Decision support using crop models
Steps to Using CropManage

1. Establish User Login
2. Assign to Ranch or start New Ranch
3. View Planting within Ranch or Add New Planting
4. View or enter soil tests, fertilizer, or irrigation events
Current crops supported

Vegetables:
- Romaine (40 and 80-inch wide beds)
- Iceberg (40 and 80-inch wide beds)
- Broccoli (summer and winter plantings)
- Cauliflower (summer and winter plantings)
- Cabbage (red and green)
- Spinach*
- Celery*
- Onions*

Berries:
- Strawberry
- Raspberry*
- Blackberry*
How is N fertilizer rate determined from the quick nitrate test?

Recommended
Fertilizer N = Future Crop N uptake

– (Quick Test N - threshold NO₃-N)

– Soil mineralization N

– Plant residue N
N uptake rate by head lettuce (40 inch-wide beds)
Nitrogen Fertilizer Recommendation

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

Soil NO$_3$-N (ppm)

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>
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</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>
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<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>
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<td>31.90</td>
<td>UAN28</td>
<td>56.7</td>
<td>19.0 gal/acre</td>
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<td>86.9</td>
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<td>96.5</td>
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<td>Fertilizer Name</td>
<td>Formulation</td>
<td>Percentage N</td>
<td>Pounds Per Gallon (Liquid Formulation Only)</td>
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<tr>
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<td>--------------</td>
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</tr>
<tr>
<td>0-0-24</td>
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<td>12</td>
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<tr>
<td>0-0-50</td>
<td>Dry</td>
<td>0%</td>
<td>0</td>
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<tr>
<td>1.3-3.5-.05</td>
<td>Liquid</td>
<td>1.3%</td>
<td>8.6</td>
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<tr>
<td>1.4-3.89-0.06</td>
<td>Liquid</td>
<td>1.4%</td>
<td>8.6</td>
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<td>15-8-4</td>
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<td>10.4</td>
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<td>18-18-18</td>
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<td>18%</td>
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<td>20%</td>
<td>10.5</td>
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<td>27-0-0-4.8</td>
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<td>27%</td>
<td>10.9</td>
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<td>28-0-0-5</td>
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<td>28%</td>
<td>11.05</td>
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<td>3-5-10</td>
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<td>10.4</td>
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<td>3.5-12-14</td>
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<td>3.5%</td>
<td>11.63</td>
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<td>5-20-3-1</td>
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<td>10.7</td>
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<td>6-16-0-1.94S</td>
<td>Liquid</td>
<td>6%</td>
<td>8.6</td>
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Days after Planting

Canopy Cover (%)

Iceberg lettuce canopy cover

Canopy Cover (%)

Days after Planting
<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>
</tr>
</thead>
<tbody>
<tr>
<td>7/8/12</td>
<td>Sprinkler</td>
<td>1.6</td>
<td>0.48 in</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>
<tr>
<td>7/13/12</td>
<td>Sprinkler</td>
<td>2.8</td>
<td>0.47 in</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 in</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 in</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 in</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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<td>8/4/12</td>
<td>Drip</td>
<td>8.2</td>
<td>0.46 in</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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<td>8/7/12</td>
<td>Drip</td>
<td>7.6</td>
<td>0.26 in</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>8/10/12</td>
<td>Drip</td>
<td>4.9</td>
<td>0.44 in</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 in</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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<tr>
<td>8/18/12</td>
<td>Drip</td>
<td>4.1</td>
<td>0.82 in</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>
<td></td>
<td></td>
<td>5.36 in</td>
<td>29.70 hrs</td>
<td>6.03 in</td>
<td></td>
<td></td>
<td></td>
<td>4.38 in</td>
</tr>
</tbody>
</table>
How much water was applied?
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

Calculate

Drip Application Rate

- Bed width (inches): 40
- Number of drip lines per bed: 1
- Tape Discharge Rate (gallons/minute/100ft): 0.45

Calculate
Interface with UCD SoilWeb Tool

**Soil Name:**
Elder sandy loam, 0 to 2 percent slopes

**Soil Series:**
Elder

**Soil Texture:**
sandy loam

<table>
<thead>
<tr>
<th>Soil Depth</th>
<th>Silt (%)</th>
<th>Sand (%)</th>
<th>Clay (%)</th>
<th>Organic (%)</th>
<th>Density (g/cm³)</th>
<th>Soil Tension (cbar)</th>
<th>Mineralization Rate (lb N/acre/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ft</td>
<td>19.6%</td>
<td>67.4%</td>
<td>13%</td>
<td>2.5%</td>
<td>1.6</td>
<td>7</td>
<td>0.2</td>
</tr>
<tr>
<td>2 ft</td>
<td>19.6%</td>
<td>67.4%</td>
<td>13%</td>
<td>2.5%</td>
<td>1.6</td>
<td>5.8</td>
<td>0.2</td>
</tr>
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</table>
## Replicated Irrigation Trial for Iceberg Lettuce

<table>
<thead>
<tr>
<th>Treatment</th>
<th>head wt</th>
<th>carton yield</th>
<th>CFR&lt;sup&gt;1&lt;/sup&gt; 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>

<sup>1</sup> Cored for region
Using weather based irrigation scheduling for broccoli

<table>
<thead>
<tr>
<th>Irrigation Treatment</th>
<th>Applied water</th>
<th>Crown</th>
<th>Bunch</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grower Standard (150% ET)</td>
<td>20.4 inches</td>
<td>6797</td>
<td>8289</td>
<td>15086</td>
</tr>
<tr>
<td>CropManage (100% ET)</td>
<td>14.2 inches</td>
<td>6747</td>
<td>9522</td>
<td>16269</td>
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<tr>
<td>LSD(_{0.05})</td>
<td>NS</td>
<td>1052</td>
<td>1061</td>
<td></td>
</tr>
</tbody>
</table>
Summary of Commercial Lettuce Strip Trials (2012-2013)

33% (57 lbs N/Ac) less N applied following CropManage
Clientele interest

> 550 users
> 250 Ranches
> 6700 visits to CM blog since Dec 2013
Demonstration trials with growers
The road ahead...
New version of CropManage under development

- Dedicated programmer for CM
- Better user-interface
- Faster speed
- More flexibility to support different types of commodities
- Web-service for partnering
- Usage reporting
Expanding CropManage demonstrations and development to other regions of the state

- Imperial
- Ventura
- Santa Barbara
- Santa Clara
- Tehama

- ANR Strategic Initiative
- CDFA-FREP
- CDFA-SCBG
- DWR Prop. 50
Soil moisture monitoring

Soil Moisture Data

- Mid For 8 inches (kPa)
- Mid For 18 inches (kPa)
- Mid Aft 8 inches (kPa)
- Mid Aft 18 inches (kPa)
- SW For 8 inches...
- SW For 18 inches...
- SW Aft 8 inches...
- SW Aft 18 inches...

Dates:
- Apr 27
- Apr 29
- May 1
- May 3
- May 5
- May 7
- May 9
- May 11
- May 13
- May 15
- May 17
- May 19
Opportunities to partner with commercial companies by developing CM into a web service (API):

Steinbeck Country Produce, Inc.
Cheaper and better satellite imagery in the future
Summary

- Web applications can be useful for repackaging research results into simple to use decision support tools

- *CropManage* has been a useful tool for helping growers improve water and N management and for assisting with research studies.

- Opportunities exist for expanding CM to additional commodities and adding in new features and data sources.