Tools for Improving Irrigation Management of Vegetables

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Nitrate is part of the Agricultural Discharge Waiver

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
CENTRAL COAST REGION
ORDER No. R3-2012-0011

CONDITIONAL WAIVER OF WASTE DISCHARGE REQUIREMENTS
FOR
DISCHARGES FROM IRRIGATED LANDS

The California Regional Water Quality Control Board, Central Coast Region finds that:

1. The Central Coast Region has approximately 435,000 acres of irrigated land and approximately 3,000 agricultural operations, which may be that falls into the category of discharges of waste from irrigate

2. The Central Coast Region has more than 17,000 miles of streams/runs and approximately 4000 square miles of gar are, or may be, affected by discharges of waste from irrigated

3. The State Water Resources Control Board (State Water Boa Quality Control Boards (Regional Water Boards) are the pri with primary responsibility for the coordination and control of to the Porter-Cologne Water Quality Control Act (Porter-C Water Code Division 7). The legislature, in the Porter-C

Total Nitrogen Reporting for Tier 2 and Tier 3 Dischargers with farms/ranches with High Nitrate Loading Risk

70. By October 1, 2014 and by October 1 annually thereafter, Tier 2 and Tier 3 Dischargers with a farm/ranch with High Nitrate Loading Risk must record and report total nitrogen applied in the Annual Compliance Form, electronically in a format specified by the Executive Officer, per MRP Order No. R3-2012-0011-02 and MRP Order No. R3-2012-0011-03, respectively.

71. As an alternative to reporting total nitrogen applied in the electronic Annual Compliance Form, Tier 2 and Tier 3 Dischargers with a farm/ranch with High Nitrate Loading Risk may propose an individual discharge groundwater monitoring and reporting program (GMRP) plan for approval by the Executive Officer. The GMRP plan must evaluate waste discharge to groundwater from each ranch/farm or nitrate loading risk unit with a High Nitrate Loading Risk.
Tools for Managing Nitrogen Fertilizer in Lettuce

- Quick nitrate soil test
  
  (20 ppm NO$_3$-N = 70 to 80 lbs of N/acre/ft)
How much does irrigation management matter for optimizing nitrogen fertilizer?
Nitrogen fertilizer and irrigation interactions

### Field 1

- **Grower practice**
- **Quick Nitrate Test**

94% of Crop ET (5.1 inches)

#### Treatment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Applied N fertilizer (lb/Acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grower</td>
<td>192</td>
</tr>
<tr>
<td>QNT</td>
<td>135</td>
</tr>
</tbody>
</table>

### Field 2

- **Grower practice**
- **Quick Nitrate Test**

198% of Crop ET (17.4 inches)

#### Treatment

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Applied N fertilizer (lb/Acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grower</td>
<td>302</td>
</tr>
<tr>
<td>QNT</td>
<td>160</td>
</tr>
</tbody>
</table>
What’s new in irrigation management?

- Soil moisture sensors
- Flow meters
- Crop ET
- Irrigation and N management software for vegetables
Dataloggers improve ease of data collection:

- View trends in data
- Interface with multiple sensors
- Built in connectivity
Data Connectivity has improved:

- Radio
- Cell phone
- Satellite
- Internet
Data Connectivity: Commercial services

• Hortau
• ClimateMinder
• Ranch Systems
• Puresense
• CropSense (John Deere)
• Decagon
• Irrometer
• Onset Computer
• Spectrum Technology
Coastal crops: berries and vegetables

Moderate soil moisture deficits can cause yield loss
Tensiometers monitor the matric potential (tension) of the soil

Measurement of soil moisture that is most related to water status in a plant
Logging tensiometers improves interpretation of readings

Electronic gauge
Hortau tensiometer system
Watermark granular matrix blocks:
Soil moisture tension: 0 to 200 cbars
Don’t give up your soil probes and shovels yet:

- Soil moisture sensors monitor a few locations within a field
- Soil moisture sensors are probably not affordable to use in every field
- Ground truthing is still needed
Volumetric soil moisture sensors

- Many manufacturers and models
- Most interface with dataloggers
- Most useful for evaluating relative changes in soil moisture
Decagon 10HS
Volumetric Soil Moisture Sensor
Where should soil moisture sensors be located?

- Rule of thumb: 3 locations in field and 2 depths (e.g., 8 and 18 inches)
- Locate sensors in plant row
- Locations should represent head, middle, and tail of the field.
How much water did you apply?
Flow meters are not just for wells
Applied Water vs. Crop Evapotranspiration

- **Cumulative Crop ET (inches)**
- **Cumulative Applied Water + Rain (inches)**

**Graph Key:**
- **Crop ET** - black line
- **Applied Water** - blue dashed line

**Axes:**
- **Days after Transplanting**
- **Cumulative Crop ET (inches)**
- **Cumulative Applied Water (inches)**
Evapotranspiration

Ranch System

CIMIS weather station

Atmometer
Evapotranspiration can be estimated using CIMIS weather stations:

- Solar Radiation
- Wind Speed
- Relative Humidity
- Air Temperature

Active CIMIS Stations:
- Santa Ynez (64)
- Cuyuma (88)
- Goleta Foothills (94)
- Santa Barbara (107)
- Sisquoc (165)
- Lompoc (231)
- Santa Maria II (232)
- Nipomo (202)
- San Luis Obispo West (160)

www.cimis.water.ca.gov
Spatial CIMIS ETo Reporting
Comparison of different methods of estimated ETo (Gilroy Ca)

Spatial CIMIS

CIMIS station

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

$K_c$ can vary from 0.1 to 1.2

$ET_{crop}$ = Reference Evapotranspiration

$K_c$ = Crop Coefficient

Days after Planting

Canopy Cover (%)

0 20 40 60 80

0 20 40 60 80

0 20 40 60 80 80

Days after Planting
Web-based Irrigation and N management software for lettuce

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

Assist growers in managing water and nitrogen fertilizer using information from multiple sources

- Soil tests (quick N test)
- Weather data (CIMIS ETo)
- Soil physical characteristics
- Crop models
- Flow meter
- Soil moisture sensors
Main Uses

- Maintain and share irrigation, fertilizer, and soil test records within a farming operation.
- Manage information for multiple fields and ranches
- Guide irrigation schedule using CIMIS evapotranspiration data and crop models
- Guide nitrogen fertilization decisions based on crop uptake model and quick nitrate test
Ranch List

Select a Ranch to work in from the list below.

- Bondenson
- Bondesen
- Bryon's Test
- Calla Roberts Ranch
- Chualar
- Corey
- East Garlinger Ranch
- Fanoe
- Gabilan Ranch
- Home
- Ikeda Bros Ranch 37
- J Pettit
- Martella UC trial
- Molera
- North Garlinger
- North Mortensen Ranch
- South Mortensen Ranch
- Test Ranch
- USDA-ARS Spence
- Whalebone Ranch
### Ranch/Field
Corey, Lot 49, silty clay

### Planting
- **R R Lettuce Cy 49**, 8.0 acres
- **Crop**: Iceberg 2 row, 40 inch bed, 4/17-6/29/12

## Planting

### Soil Summary

<table>
<thead>
<tr>
<th>Sample Date</th>
<th>Crop Stage</th>
<th>Sample Reading (ppm)</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>5/1/12</td>
<td>1st sidedress</td>
<td>20</td>
<td>1</td>
<td>Quick Strip</td>
<td>10.53</td>
<td>34.28</td>
</tr>
<tr>
<td>5/19/12</td>
<td>1st drip fertigation</td>
<td>28</td>
<td>1</td>
<td>Quick Strip</td>
<td>14.74</td>
<td>47.99</td>
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<tr>
<td>5/25/12</td>
<td>2nd drip fertigation</td>
<td>45</td>
<td>1</td>
<td>Quick Strip</td>
<td>23.68</td>
<td>77.13</td>
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<tr>
<td>6/4/12</td>
<td>3rd drip fertigation</td>
<td>45</td>
<td>1</td>
<td>Quick Strip</td>
<td>23.68</td>
<td>77.13</td>
</tr>
</tbody>
</table>
# Fertilizer Summary

<table>
<thead>
<tr>
<th>Fertilizer Date</th>
<th>Crop Stage</th>
<th>Soil NO₃-N (ppm)</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>5/5/12</td>
<td>Pre-thinning</td>
<td>15.79</td>
<td>14.2</td>
<td>4.02</td>
<td>15-8-4</td>
<td>78.0</td>
<td>50.0 gallons/acre</td>
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<tr>
<td>5/22/12</td>
<td>1st drip fertigation</td>
<td>14.74</td>
<td>21.5</td>
<td>13.82</td>
<td>28-0-0-5</td>
<td>37.1</td>
<td>12.0 gallons/acre</td>
</tr>
<tr>
<td>5/27/12</td>
<td>2nd drip fertigation</td>
<td>23.68</td>
<td>4.9</td>
<td>18.88</td>
<td>28-0-0-5</td>
<td>30.9</td>
<td>10.0 gallons/acre</td>
</tr>
<tr>
<td>6/7/12</td>
<td>3rd drip fertigation</td>
<td>23.68</td>
<td>11.8</td>
<td>36.25</td>
<td>28-0-0-5</td>
<td>30.9</td>
<td>10.0 gallons/acre</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td><strong>52.4</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>176.9</strong></td>
<td></td>
</tr>
</tbody>
</table>

New Fertilizing
# Irrigation Summary

<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>
</tr>
</thead>
<tbody>
<tr>
<td>4/17/12</td>
<td>Sprinkler</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>0.94 in</td>
<td>0.00</td>
<td>0</td>
</tr>
<tr>
<td>4/19/12</td>
<td>Sprinkler</td>
<td>0.7</td>
<td>0.35 in</td>
<td>1.15 hrs</td>
<td>0.49 in</td>
<td>0.70</td>
<td>0</td>
</tr>
<tr>
<td>4/21/12</td>
<td>Sprinkler</td>
<td>0.6</td>
<td>0.40 in</td>
<td>1.34 hrs</td>
<td>0.61 in</td>
<td>0.70</td>
<td>0</td>
</tr>
<tr>
<td>4/23/12</td>
<td>Sprinkler</td>
<td>0.6</td>
<td>0.38 in</td>
<td>1.28 hrs</td>
<td>0.58 in</td>
<td>0.70</td>
<td>0</td>
</tr>
<tr>
<td>4/26/12</td>
<td>Sprinkler</td>
<td>1.3</td>
<td>0.09 in</td>
<td>0.30 hrs</td>
<td>0.28 in</td>
<td>0.48</td>
<td>0</td>
</tr>
<tr>
<td>5/6/12</td>
<td>Sprinkler</td>
<td>2.9</td>
<td>0.41 in</td>
<td>1.36 hrs</td>
<td>1.30 in</td>
<td>0.16</td>
<td>2</td>
</tr>
<tr>
<td>5/18/12</td>
<td>Drip</td>
<td>4.9</td>
<td>0.58 in</td>
<td>3.84 hrs</td>
<td>0.91 in</td>
<td>0.20</td>
<td>12</td>
</tr>
<tr>
<td>5/22/12</td>
<td>Drip</td>
<td>6.5</td>
<td>0.24 in</td>
<td>1.61 hrs</td>
<td>0.74 in</td>
<td>0.23</td>
<td>21</td>
</tr>
<tr>
<td>5/27/12</td>
<td>Drip</td>
<td>4.7</td>
<td>0.45 in</td>
<td>3.03 hrs</td>
<td>0.64 in</td>
<td>0.37</td>
<td>35</td>
</tr>
<tr>
<td>6/1/12</td>
<td>Drip</td>
<td>3.4</td>
<td>0.70 in</td>
<td>4.65 hrs</td>
<td>0.44 in</td>
<td>0.56</td>
<td>52</td>
</tr>
<tr>
<td>6/3/12</td>
<td>Drip</td>
<td>3.0</td>
<td>0.35 in</td>
<td>2.34 hrs</td>
<td>0.11 in</td>
<td>0.69</td>
<td>58</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td><strong>3.95 in</strong></td>
<td><strong>20.89 hrs</strong></td>
<td><strong>7.04 in</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

New Watering  View Flow Meter Data  View Rainfall Data
Summary

- Water management plays a critical role in managing N fertilizer in shallow rooted vegetables.
- Connectivity using radios, cell phones and the internet facilitates real-time monitoring of crop water use.
- Using a combination of ET and soil moisture monitoring is probably the best approach to evaluating irrigation scheduling in cool season vegetables.