Irrigation effects on Nitrogen Management of Lettuce

Michael Cahn, Richard Smith, Barry Farrara, Aaron Heinrich
UCCE, Monterey County
Tim Hartz and Tom Bottoms, Plant Sciences, UC Davis
Saving on Nitrogen Fertilizer Costs

Source: Agricultural Prices, National Agricultural Statistics Service, USDA.
Quick Nitrate Test: Soil nitrate status

(20 ppm NO$_3$-N = 65 to 75 lbs of N/acre/ft)
2010 Nitrogen Fertilizer Trials

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

Boxes/Acre

Field

1 2 3 4 5 Avg

GR BMP

97% of Grower
How much does irrigation management matter for optimizing nitrogen fertilizer?
Lbs of N lost by leaching depends on soil nitrate concentration and drainage

<table>
<thead>
<tr>
<th>Soil Nitrate-N content (ppm)</th>
<th>Drainage (inches)</th>
<th>Nitrate-N leached (lbs of N/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>1</td>
<td>34</td>
</tr>
<tr>
<td>15</td>
<td>4</td>
<td>34</td>
</tr>
<tr>
<td>40</td>
<td>4</td>
<td>103</td>
</tr>
</tbody>
</table>
Total Water Applied to Lettuce

Avg = 12.6 inches
Days after Planting

Canopy Cover (%)

Crop ET = 1 to 3.5 inches
Crop ET = 3.5 to 7.5 inches
Applied Water as Percentage of Crop ET

Avg Applied Water = 176% of Crop ET
Applied N and soil nitrate (site 1)

Soil NO₃-N ppm

DAP

Grower practice

BMP

Lbs N/A

192

135
Applied Water and Crop ET (site 3)
Applied N and soil nitrate (site 3)
Pre-thinning Water Applied to Lettuce

Avg prethinning water = 5.5 inches
Potential N losses during crop establishment:

- Evaporation and transpiration losses during first 2 weeks of a lettuce crop < 2 inches

<table>
<thead>
<tr>
<th>Management</th>
<th>Crop and Evaporation losses</th>
<th>Germination water amount</th>
<th>N loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced irrigation</td>
<td>1.2</td>
<td>2.4</td>
<td>31</td>
</tr>
<tr>
<td>Normal irrigation</td>
<td>1.2</td>
<td>3.5</td>
<td>50</td>
</tr>
</tbody>
</table>
First irrigation after thinning can contribute to N losses

- Crop ET is low
- Soil nitrate levels are often high
- Roots are concentrated in upper foot
- Irrigations amounts are often in excess of water holding capacity of soil
Amount of water applied during a single irrigation can contribute to nitrate losses

<table>
<thead>
<tr>
<th>Irrigation method</th>
<th>establishment avg</th>
<th>max</th>
<th>post-thinning avg</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>sprinkler</td>
<td>0.5 - 1.1</td>
<td>0.9 - 1.4</td>
<td>0.5 - 1.5</td>
<td>1.1 - 2.2</td>
</tr>
<tr>
<td>drip</td>
<td>0.6</td>
<td>0.9</td>
<td>0.5 - 1.0</td>
<td>0.7 - 1.7</td>
</tr>
<tr>
<td>furrow</td>
<td>--</td>
<td>--</td>
<td>1.5</td>
<td>3.9</td>
</tr>
</tbody>
</table>
Soil Moisture Tensions > 30 cbars slows lettuce growth
## Soil Moisture Available for Lettuce Growth

<table>
<thead>
<tr>
<th>Days after Planting</th>
<th>15</th>
<th>30</th>
<th>45</th>
<th>60</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root depth (ft)</td>
<td>0.5</td>
<td>1.25</td>
<td>1.75</td>
<td>2</td>
</tr>
<tr>
<td>Silty clay</td>
<td>0.2</td>
<td>0.5</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>Silty clay loam</td>
<td>0.2</td>
<td>0.5</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Loam</td>
<td>0.2</td>
<td>0.6</td>
<td>0.8</td>
<td>0.9</td>
</tr>
</tbody>
</table>
Low Distribution Uniformity increases Irrigation Requirement and Drainage
### Average irrigation intervals in Lettuce

<table>
<thead>
<tr>
<th>crop stage</th>
<th>sprinkler</th>
<th>drip</th>
<th>furrow</th>
</tr>
</thead>
<tbody>
<tr>
<td>pre-thinning</td>
<td>3.3</td>
<td>2.0</td>
<td>--</td>
</tr>
<tr>
<td>post-thinning</td>
<td>8.0</td>
<td>6.0</td>
<td>7.5</td>
</tr>
</tbody>
</table>
## Effect of irrigation interval on N management

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Irrigation interval (days)</th>
<th>% Crop ET</th>
<th>N fertilizer management</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 day</td>
<td>4</td>
<td>102%</td>
<td>Quick N test</td>
</tr>
<tr>
<td>7 day</td>
<td>7</td>
<td>142%</td>
<td>Quick N test</td>
</tr>
<tr>
<td>Grower</td>
<td>Grower decision (7 days)</td>
<td>Grower decision (134%)</td>
<td>Grower decision</td>
</tr>
</tbody>
</table>
Soil Nitrate and Applied N of Irrigation Treatments

Days after planting:
30 40 50 60

Cumulative N fertilizer (lbs N/acre):
0 50 100 150

Soil Nitrate-N (ppm of N):
0 20 40 60 80 100

4-day interval
7-day interval
Grower standard

Cumulative N fertilizer (lbs N/acre):
0 50 100 150 200

Days after planting:
30 40 50 60

253
127
Did the irrigation treatments affect nitrate leaching?
Estimated Drainage of Irrigation Treatments

Irrigation Interval

- 4 day
- 7 day
- Grower

Drainage (Applied Water - Crop ET) inches

- 0.0
- 0.5
- 1.0
- 1.5
- 2.0
- 2.5
Estimated Nitrate Leaching Losses

Irrigation Interval

<table>
<thead>
<tr>
<th></th>
<th>4 day</th>
<th>7 day</th>
<th>grower</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrate-N loss (lb/acre)</td>
<td>0</td>
<td>5</td>
<td>24</td>
</tr>
</tbody>
</table>
Residual Soil Nitrate

Graph showing the relationship between depth (inches) and mineral N concentration (ppm). The graph compares the effects of different irrigation intervals on residual soil nitrate levels. The legend indicates:
- **Grower Standard Practice** (red line with black circles)
- **4 day irrigation interval** (dashed blue line with black triangles)
- **7 day irrigation interval** (dashed blue line with black inverted triangles)
## Yield Summary of Irrigation Treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Head Weight Untrimmed</th>
<th>Head Weight Trimmed</th>
<th>Plant population Marketable</th>
<th>Plant population Diseased</th>
<th>Yield Marketable</th>
<th>Yield Biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-day</td>
<td>2.493</td>
<td>1.72</td>
<td>39685</td>
<td>883</td>
<td>68350</td>
<td>98909</td>
</tr>
<tr>
<td>7-day</td>
<td>2.483</td>
<td>1.68</td>
<td>41156</td>
<td>441</td>
<td>69363</td>
<td>102243</td>
</tr>
<tr>
<td>grower</td>
<td>2.546</td>
<td>1.72</td>
<td>40241</td>
<td>343</td>
<td>69023</td>
<td>102357</td>
</tr>
</tbody>
</table>

LSD$_{0.05}$ ns ns ns ns ns ns ns
### Salinity Effects on Cool Season Vegetables

<table>
<thead>
<tr>
<th>Crop</th>
<th>EC&lt;sub&gt;e&lt;/sub&gt;</th>
<th>EC&lt;sub&gt;w&lt;/sub&gt;</th>
<th>EC&lt;sub&gt;e&lt;/sub&gt;</th>
<th>EC&lt;sub&gt;w&lt;/sub&gt;</th>
<th>EC&lt;sub&gt;e&lt;/sub&gt;</th>
<th>EC&lt;sub&gt;w&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broccoli</td>
<td>2.8</td>
<td>1.9</td>
<td>3.9</td>
<td>2.7</td>
<td>5.5</td>
<td>3.7</td>
</tr>
<tr>
<td>Cabbage</td>
<td>1.8</td>
<td>1.2</td>
<td>2.8</td>
<td>1.9</td>
<td>4.4</td>
<td>2.9</td>
</tr>
<tr>
<td>Celery</td>
<td>1.8</td>
<td>1.2</td>
<td>3.4</td>
<td>2.3</td>
<td>5.8</td>
<td>3.9</td>
</tr>
<tr>
<td>Lettuce</td>
<td>1.3</td>
<td>0.9</td>
<td>2.1</td>
<td>1.4</td>
<td>3.2</td>
<td>2.1</td>
</tr>
<tr>
<td>Spinach</td>
<td>2.0</td>
<td>1.3</td>
<td>3.3</td>
<td>2.2</td>
<td>5.3</td>
<td>3.5</td>
</tr>
</tbody>
</table>

**Yield Potential**

- **100%**
  - Broccoli: 3.9
  - Cabbage: 2.8
  - Celery: 3.4
  - Lettuce: 2.1
  - Spinach: 3.3

- **90%**
  - Broccoli: 2.7
  - Cabbage: 1.9
  - Celery: 2.3
  - Lettuce: 1.4
  - Spinach: 2.2

- **75%**
  - Broccoli: 5.5
  - Cabbage: 4.4
  - Celery: 5.8
  - Lettuce: 3.2
  - Spinach: 5.3

EC<sub>e</sub> = EC of saturated soil extract

EC<sub>w</sub> = EC of irrigation water

1. Adapted from FAO irrigation and drainage paper 29, 1985

**EC of sea water = 50- 60 dS/m**
EC and SAR effects on Biomass Yield of 2 Head Lettuce Varieties

var. Sniper

var. Salinas
How much leaching for salinity management?

- Adequate leaching usually occurs during pre-irrigation and stand establishment
- Leach Fraction > 30%, ECwater = ECsoil
- Irrigating more frequently (with drip) can offset some of the salinity effects on growth
- Do not apply N fertilizer before leaching events
How much N fertilizer credit should be taken for nitrate in well water?

Assuming 7 inches of crop ET and 80% System Uniformity:

<table>
<thead>
<tr>
<th>Nitrate-N concentration in irrigation water (ppm)</th>
<th>Nitrogen-fertilizer equivalents (lb/Acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>40</td>
<td>51</td>
</tr>
<tr>
<td>60</td>
<td>76</td>
</tr>
</tbody>
</table>
Irrigation strategies for using nitrogen fertilizer efficiently in lettuce

- Match irrigation schedule with crop ET to minimize nitrate leaching
- Assure that irrigation system has a high DU
- Minimize irrigation water for germination (< 3 inches)
- Avoid applying high amounts of water during a single irrigation (> 0.5 inch during prethinning, > 1 inch during post thinning)
- Avoid heavy irrigations after fertilizing