Managing fertilization and irrigation for water quality protection
# Nitrogen Budget in Coastal Vegetable Production

<table>
<thead>
<tr>
<th></th>
<th>Pepper</th>
<th>Lettuce</th>
<th>Celery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical seasonal N application</td>
<td>250</td>
<td>190</td>
<td>275</td>
</tr>
<tr>
<td>Crop uptake</td>
<td>200</td>
<td>120</td>
<td>200</td>
</tr>
<tr>
<td>Removal in harvest</td>
<td>80</td>
<td>80</td>
<td>140</td>
</tr>
<tr>
<td>Fertilizer ‘unaccounted for’</td>
<td>&gt; 150</td>
<td>&gt; 100</td>
<td>&gt; 100</td>
</tr>
</tbody>
</table>

With 2 crops per year the ‘unaccounted for’ N is very high.
N budget:

Fate of ‘unaccounted for’ N:
- tied up in soil organic N
  
  \textit{(minimal on an annual basis)}
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- remain in root zone as NO$_3$-N
  *(unlikely with irrigation and winter rain)*
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  *(minor loss in most fields)*
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  (unlikely with irrigation and winter rain)

- lost through denitrification
  (minor loss in most fields)

- lost through leaching or runoff
  (the fate of the majority of ‘unaccounted for’ N)
Typical annual cycle of soil NO$_3$-N availability:

- **Soil NO$_3$-N (PPM)**
  - Jan: 0
  - Feb: 10
  - Mar: 20
  - Apr: 30
  - May: 40
  - Jun: 50
  - Jul: 60
  - Aug: 70
  - Sep: 80
  - Oct: 90
  - Nov: 100
  - Dec: 110

- **Soil NO$_3$-N (lb/acre in top foot)**
  - Jan: 0
  - Feb: 10
  - Mar: 20
  - Apr: 30
  - May: 40
  - Jun: 50
  - Jul: 60
  - Aug: 70
  - Sep: 80
  - Oct: 90
  - Nov: 100
  - Dec: 110

- **Month**
  - Jan
  - Feb
  - Mar
  - Apr
  - May
  - Jun
  - Jul
  - Aug
  - Sep
  - Oct
  - Nov
  - Dec

- **Plant**
- **Harvest**
Environmental standards are very tough:

Federal drinking water standard is 10 PPM NO$_3$-N
How tough is the 10 PPM NO$_3$-N standard?

- An annual leaching loss of 120 lb N / acre would require > 4 feet of annual leaching volume to average 10 PPM NO$_3$-N
- To average 10 PPM NO$_3$-N in leachate, soil would need to average < 3 PPM
Relationship between soil $\text{NO}_3^-\text{-N}$ and leachate $\text{NO}_3^-\text{-N}$:

- All $\text{NO}_3^-\text{-N}$ is in the soil solution, not attached to soil particles.
- Soil solution only 20-30% the weight of soil.

<table>
<thead>
<tr>
<th>Soil $\text{NO}_3^-\text{-N}$ (PPM)</th>
<th>$\text{NO}_3^-\text{-N}$ in soil solution (PPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy loam</td>
<td>Sandy loam</td>
</tr>
<tr>
<td>10</td>
<td>50</td>
</tr>
</tbody>
</table>
2002-04 drain tile sampling in the Salinas Valley:
Bottom line:

- water leaving vegetable fields will likely exceed 10 PPM NO$_3$-N
- reducing groundwater NO$_3$-N loading requires:
  - reduced fertilizer application, and better timing
  - improved irrigation efficiency to minimize leaching volume
More efficient fertilizer use:
- reduced fertilizer application
- improve fertilizer timing
Reevaluate general crop nitrogen requirements:

- A lettuce crop contains about 100-120 lb N/acre at harvest, yet some growers commonly apply much more N.

2004-05 survey of 70 commercial lettuce fields:
What happens when excess fertilizer is applied?

Mean of 11 commercial lettuce trials in which one or more N sidedressings were skipped:

![Graph showing Seasonal N application vs Crop N uptake for Grower N and Reduced N.

Conclusion:

- Most excess fertilizer is not even taken up by the plant; it remains in the soil, at risk of leaching.
Crop N uptake pattern:

Lettuce N uptake (lb/acre/week):

- Weeks after planting:
  - 0 lb N/acre
  - 5 lb N/acre
  - 10 lb N/acre
  - 15 lb N/acre
  - 20 lb N/acre
  - 25 lb N/acre
  - 30 lb N/acre

Celery N uptake (lb/acre/week):

- Weeks after transplanting:
  - 100 - 120 lb N/acre at harvest
  - 180 - 220 lb N/acre at harvest
Weeks after transplanting Pepper N uptake (lb/acre)

180-220 lb N/acre seasonal total
Limit N application until plants can use it:
Take advantage of residual soil N:

Not all crop N uptake comes from fertilizer:

2004-05 survey of commercial lettuce fields, thinning stage
Value of Presidedress Soil Nitrate Testing (PSNT) in lettuce production:

In 25 commercial lettuce field trials:
- First sidedressing was skipped in 75% of fields.
- Overall N application reduced by > 40%.
- No loss of yield or quality.
Controlling irrigation to limit leachate is critical

... and drip irrigation is the ideal tool
Leaching during stand establishment a particular problem
Irrigation requirement can be predicted by canopy size and ET₀:

Efficient seasonal drip irrigation volume ≈ 80 – 120 % of ET₀.
Average daily ET₀ for Morro Bay:

Daily evapotranspiration (ET₀)
Irrigation management varies greatly among growers:

Drip-irrigated lettuce fields in the Salinas Valley
Assume summer conditions, sandy loam soil:

- If field 5 applied 5 inches of water with drip, then field 14 applied 10 inches.
- If soil is 10 PPM $\text{NO}_3^{-}\text{-N}$, field 14 lost $\approx 50$ lb N/acre in leaching!
2007 lettuce fertigation trials:

<table>
<thead>
<tr>
<th>Field</th>
<th>Lettuce type</th>
<th>Soil NO$_3$-N at start of fertigation (PPM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>head</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>head</td>
<td>27</td>
</tr>
</tbody>
</table>
2007 lettuce fertigation trials:

<table>
<thead>
<tr>
<th>Field</th>
<th>Reference evapotranspiration ($ET_o$, inches)</th>
<th>Drip irrigation applied (inches)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.2</td>
<td>4.9</td>
</tr>
<tr>
<td>2</td>
<td>6.5</td>
<td>4.7</td>
</tr>
</tbody>
</table>
Days after planting

N fertigation (lb/acre)

Days after planting

127 lb N fertigated
169 lb N total

153 lb N fertigated
171 lb N total
Reduced N treatment created by eliminating some N fertigation:

- **Field 1**
  - 50 lb N fertigated
  - 92 lb N total

- **Field 2**
  - 46 lb N fertigated
  - 64 lb N total
## Results:

<table>
<thead>
<tr>
<th>Field</th>
<th>Treatment</th>
<th>lb N / acre</th>
<th>Mean plant wt (lb)</th>
<th>Crop N uptake (lb / acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>total</td>
<td>fertigated</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Grower</td>
<td>169</td>
<td>127</td>
<td>2.29</td>
</tr>
<tr>
<td></td>
<td>Reduced N</td>
<td>92</td>
<td>50</td>
<td>2.31</td>
</tr>
<tr>
<td>2</td>
<td>Grower</td>
<td>171</td>
<td>153</td>
<td>2.16</td>
</tr>
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<td></td>
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<td>64</td>
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What about winter?

- Leave as little NO$_3$-N in the profile as possible after fall crop
- Employ winter cover crop where practical
Cover crops:
- consistently reduce sediment loss
- inconsistently reduce nutrient loss