Fertilization Trials on Spinach and Nitrogen Fertilizer Technology Update

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Background

- Spinach is an “at risk” crop with regards to proposed regulations by the Central Coast Water Quality Control Board.
- Due to non-agronomic quality demands from the market place (e.g. deep green color), it is going to be difficult to hit the proposed 1.0 nitrogen balance factor.
- This is especially true for the first crop.
2011 Trials

- Four fertilizer trials were conducted:
  - Two first crop sites with low residual soil nitrate (one light and one heavier soil type)
  - Two second crop sites with high residual soil nitrate (one medium and one heavier soil type)
First Crop vs Second Crop

- **First crop** – Low residual soil nitrate following winter fallow
- **Second crop** – Higher residual soil nitrate from residual fertilizer, soil mineralization, crop residue mineralization
First Crop Spinach Fertilizer Trial
First Crop Spinach on Sandy Loam Soil Yield (T/A)

- At planting treatments (ammonium sulfate):
  - 0, 20, 40 & 80 lbs N/A
- Top dress applications:
  - 18 DAP  63 lbs N/A
  - 25 DAP  39 lbs N/A
  - 29 DAP  32 lbs N/A
  - 134 lbs N/A
Soil Nitrate-N Over the Growth Cycle
Soil Nitrate-N + Ammonium-N Over the Growth Cycle
Yield of First Crop Spinach
Mean of Two Trials

![Bar chart showing yield of first crop spinach across different treatments](chart.png)
Second Crop Spinach

• Following lettuce and cole crops
• High residual soil nitrogen
• Better growing conditions
Second Crop Spinach on Loam Soil Yield (T/A)

- At planting treatments:
  - None were applied due to high residual soil nitrate
- Top dress applications applied at 17 DAP:
  - 0, 25, 50, 75, 105 lbs N/A
Soil Nitrate in the Treatments over the Growth Cycle
Yield of Second Crop Spinach
Mean of Two Trials

- zero
- 1
- 2
- 3
- standard
# Comparison of Spinach vs Lettuce Biomass and N Uptake

<table>
<thead>
<tr>
<th>Lettuce</th>
<th>Clipped Spinach</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dry Biomass (lbs/A)</strong></td>
<td><strong>Dry Biomass (lbs/A)</strong></td>
</tr>
<tr>
<td>3000 to 5000</td>
<td>1200 to 2400</td>
</tr>
<tr>
<td><strong>N Uptake (lbs/A)</strong></td>
<td><strong>N Uptake (lbs/A)</strong></td>
</tr>
<tr>
<td>120 to 140 or more</td>
<td>80 to 100</td>
</tr>
<tr>
<td><strong>Percent N at harvest</strong></td>
<td><strong>Percent N at harvest</strong></td>
</tr>
<tr>
<td>Generally 3.0 to 3.5</td>
<td>4.5 to 6.4</td>
</tr>
<tr>
<td><strong>Overall N Uptake/day</strong></td>
<td><strong>Overall N Uptake/day</strong></td>
</tr>
<tr>
<td>3.5 to 4.5 lbs/A/day</td>
<td>4.2 to over 7.0 lbs/A/day</td>
</tr>
</tbody>
</table>
Spinach Nitrogen Nutrition Evaluations

| • These evaluations dealt with the early-season applications of N for spinach |
| • This is an area where we can explore the agronomic aspects of spinach production |
| • The top dress applications should also be evaluated, but they are more problematic because of application methods |
| • They also are under non-agronomic demands for color |
Spinach Nitrogen Nutrition Evaluations

- First crop spinach on light ground are going to be difficult to effectively cut back on at planting N applications, even though the crop only takes up 15-20 lbs N/A in the first 2 weeks

- Second crop spinach will be much easier to come closer to the 1.0 nutrient balance ration proposed by the CCRWQCB
  - Knowledge of the levels of residual soil nitrate will be very important (nitrate quick test)
Enhanced Nitrogen Fertilizer Technology

- Nitrification inhibitors
- Foliar fertilizers
Nitrification Inhibitors

• These chemicals disrupt the activity of *Nitrosomonas* and *Nitrobacter* bacteria

• There are a number of types of nitrification inhibitors, but at present, only Agrotain Plus (DCD) and Instinct™ (formerly N-serve) are available in the US, and only Agrotain Plus is available for use on lettuce
Nitrification - conversion of ammonium to nitrate

- In warm soils (>50 °F), it occurs in 2-3 weeks
Nitrification Inhibitors

• Two forms of Agrotain
  ▪ Agrotain
    • Urease inhibitor
      ▪ Only of interest where Urea is surface broadcast (not common here)
  ▪ Agrotain plus
    • Urease inhibitor + DCD
Impact of Dicyandiamide (DCD) on Nitrate Leaching

Tim Hartz, 2011

![Bar chart showing the impact of Dicyandiamide (DCD) on nitrate leaching over different weeks of incubation and soil types.](chart.png)

- **Total NO$_3$-N leached (mg/column)**
  - Soil 1
  - Soil 1 + DCD
  - Soil 2
  - Soil 2 + DCD

- **Weeks of incubation**: 2, 4, 6
Nitrification Inhibitor

Agrotain Plus in UN32

Injection Manifolds
2011 Lettuce Yield (T/A) Nitrification Inhibitor Trial

Lbs N/A

- 10
- 150
- 100
- 100 + Agrotain
- 100 + 4% DCD
- 100 + 8% DCD
Nitrification Inhibitor Summary

- Thus far we have seen significant improvement in yield with the use of Agrotain Plus in one out of five trials (trends seen in other trials)
- All the trials have been with drip application of the fertilizer
- This year we will examine applying Agrotain Plus as a sidedress with a tractor to see if applying it as a bead may change the activity of the material
# Foliar Fertilizer N Trial
First Crop Romaine 2011

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total N/A applied Lbs/A</th>
<th>Fresh yield tons/A</th>
<th>Lettuce N content % N</th>
<th>Lettuce N content lbs N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>0.0</td>
<td>30.9</td>
<td>1.9</td>
<td>81</td>
</tr>
<tr>
<td>Impact – foliar</td>
<td>29.2</td>
<td>33.7</td>
<td>2.2</td>
<td>95</td>
</tr>
<tr>
<td>Green Feed - foliar</td>
<td>29.2</td>
<td>32.0</td>
<td>2.2</td>
<td>94</td>
</tr>
<tr>
<td>Standard fertilizer</td>
<td>138.4</td>
<td>38.4</td>
<td>2.7</td>
<td>125</td>
</tr>
</tbody>
</table>
Soil Nitrate-N in Foliar Treatments

First Crop Romaine

- Untreated
- Impact foliar
- Green Feed foliar
- Standard
# Foliar Fertilizer N Trial

## Second Crop Head Lettuce 2011

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Total N/A applied Lbs/A</th>
<th>Fresh yield tons/A</th>
<th>Lettuce N content % N</th>
<th>Lettuce N content lbs N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>0.0</td>
<td>34.5</td>
<td>3.5</td>
<td>97.5</td>
</tr>
<tr>
<td>Impact – foliar</td>
<td>51.8</td>
<td>35.0</td>
<td>3.8</td>
<td>110.3</td>
</tr>
<tr>
<td>Green Feed - foliar</td>
<td>51.8</td>
<td>34.7</td>
<td>3.5</td>
<td>101.8</td>
</tr>
<tr>
<td>Nitamin - foliar</td>
<td>51.8</td>
<td>35.0</td>
<td>3.6</td>
<td>103.2</td>
</tr>
<tr>
<td>Standard fertilizer</td>
<td>108.7</td>
<td>35.4</td>
<td>3.9</td>
<td>120.3</td>
</tr>
</tbody>
</table>
Soil Nitrate-N in Foliar Treatments

First Crop Head Lettuce

- Untreated
- Impact foliar
- Green Feed foliar
- Nitamin foliar
- Standard

Graph showing the changes in soil nitrate-N over time for different foliar treatments.
Foliar Trial Summary

- In low residual soil nitrate situations that foliar N applications may give a slight increase in yield
- Foliar applications did not increase loads of soil nitrate
- This may provide a measure of added insurance to situations where you may have sufficient residual soil N, but want to make sure the plant has sufficient N without adding further N to the soil
Acknowledgements

- California Leafy Greens Research Board
- Koch Industries
- Caltec