Nitrification Inhibitors for Improving Nitrogen Use Efficiency in Lettuce Production

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Why Nitrification Inhibitor

- To improve the efficiency of applied nitrogen – Nitrogen Use Efficiency
- In order to make improvements in NUE it is important to link nitrogen supply with nitrogen demand, while minimizing nitrogen losses
Concerns over nitrogen use efficiency of lettuce production has greater urgency due to the issuance of the agricultural order by the Central Coast Regional Water Quality Control Board on November 19, 2010.
• The proposed regulations stipulate that growers must not apply more nitrogen than the crop removes:
  ▪ 1.0 factor for applied fertilizer vs what is removed by the crop for double cropped vegetables
Challenges of Improving Nitrogen Use Efficiency in Lettuce Production
Nitrogen Uptake by Head Lettuce Over Growing Season

Nearly all N uptake occurs from 30-65 days

\[ y = 3.7x - 109 \]

\[ r^2 = 0.86 \]
Intensity of Production Impact on Nitrate Losses

- Double cropping builds up levels of nitrate in soils as one crop leads to the other and leaves crop residues and unused fertilizer N
Residual Nitrate-Nitrogen in Soil Over Growing Season (two crops of lettuce)

Smith and Schulbach, 1996

Beginning of winter fallow period

20 ppm threshold

Plant 1st crop

Plant 2nd crop

Harvest

Months
## Lettuce and Winter Rotational Crops

### Acreage Trends

(Thousands of acres)

<table>
<thead>
<tr>
<th>Date</th>
<th>Lettuce</th>
<th>Small Grains</th>
<th>Sugar Beets</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950</td>
<td>68</td>
<td>63</td>
<td>24</td>
</tr>
<tr>
<td>1970</td>
<td>55</td>
<td>63</td>
<td>14</td>
</tr>
<tr>
<td>1990</td>
<td>58</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>2008</td>
<td>150</td>
<td>10</td>
<td>0</td>
</tr>
</tbody>
</table>
Irrigation Impact on Nitrogen Use Efficiency

- One inch of leached water carries 23 lbs of N/A
  - @ 100 ppm nitrate-N in the soil solution
Tools to Improve Efficiency

• Testing the soil for nitrate prior to nitrogen application provides the most dramatic and clear cut method for improving nitrogen use efficiency
Accounting for Residual Nitrogen
2010 Nitrogen Fertilizer Trials

Difference 66 lbs/A @ 0.60/lb N = $40/A
Potential of Nitrification Inhibitors to Improve Nitrogen Use Efficiency in Lettuce Production
Nitrification - conversion of ammonium to nitrate

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

- Two forms of Agrotain
  - Agrotain
    - Urease inhibitor
      - Only of interest where Urea is surface broadcast (not common here)
  - Agrotain plus
    - Urease inhibitor + DCD
Effects of Nitrification Inhibitors

• Instinct™ has been thoroughly studied over the past 30+ years in the corn belt, it has been shown to reduce nitrification for 4-6 weeks (depending on soil pH and temperature)

• Corn yields can be increased, but yield response depends on site factors
Effects of Nitrification Inhibitors

- The highest probability of yield response occurs on coarse textured soils
- Reductions in nitrate loss have been measured in these situations
- The benefits of the use of nitrification inhibitors decrease as higher amounts of N are applied
Impact of Agrotain Plus (DCD) Nitrification Inhibitor on NoTill Corn Yield, UC Davis, 2007

Mitchell and Jackson
2008 and 2010 Lettuce Nitrification Inhibitor Trials

• Three trials conducted – one on-farm and two at Hartnell East Campus

• Materials were injected in two – three applications at thinning and 7-10 days following thinning

• Agrotain Plus applied at 15 lbs/ton of UN32 (wt/wt)
Soil Nitrate – Four Dates

2008 On-Farm Trial
Clay Loam Soil, Planted March 3
Lettuce Yield
2008 On-Farm Trial

Pounds N/A

198
147
147+Agro
119
119+Agro
Untreated

1000 Lbs Lettuce/A

56
54
52
50
48
46
44
42

Pounds N/A
Soil Nitrate – Three Dates
2008 Hartnell Trial
Loam Soil, Planted June 6
2010 Hartnell Trial

Agrotain Plus in UN32

Injection Manifolds
Excellent Response to Fertilizer

Untreated  Standard
2010 Nitrification Inhibitor Impact on Nitrate in Leachate
Lettuce Yield

2010 Nitrification Inhibitor Trial

(application lbs N/A)
Why Not More Dramatic Results?
DCD banded with fertilizer is concentrated in a small volume of soil
DCD applied in drip is diluted in a greater volume of soil
Water Soluble Nature of DCD

- Urea alone
- Urea with Agrotain plus

Weeks of incubation:
- 2 weeks
- 4 weeks
- 6 weeks
- 8 weeks

mg NO₃-N leached
Summary of Nitrification Inhibitor Technology for Lettuce Production

• From the literature and from these studies, it is clear that nitrification inhibitors do reduce nitrification
• They are limited in their ability to work effectively
• They will be more effective in situations with moderate levels of nitrogen
Summary of Nitrification Inhibitor Technology for Lettuce Production

• In these trials we were not able to show clear and statistically significant differences
• Trends appear to be positive
• There may be ways to improve the efficacy of DCD in lettuce production