Nutrient Management Update for Vegetables

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Nitrogen Management of Leafy Vegetables

• Nitrogen management of vegetables in the coastal production districts has come under scrutiny due to regulations that have been issued by the Central Coast Regional Water Quality Control Board
Nitrogen Management of Leafy Vegetables

• To help growers comply, we have been evaluating various aspects of nitrogen management:
  ▪ Nitrogen uptake by vegetables
  ▪ Evaluation of residual soil nitrogen
  ▪ Fertilizer technology to improve nitrogen use efficiency (NUE)
  ▪ Strategies to better utilize nitrogen deeper in the soil profile
Nitrogen Management of Leafy Vegetables

- Nitrogen management in leafy vegetables needs to be looked at on a crop by crop basis.
- But it should also be looked at on a yearly cycle basis in which we monitor and utilize residual N mineralized from prior crop residues and nitrate deeper in the soil profile.
Nitrogen Management of Leafy Vegetables

• The main difficulty is that nitrate is highly mobile and can be pushed downwards with excess irrigation/rain beyond the reach of vegetables such as lettuce and spinach.
Nitrogen Dynamics of Spinach
Spinach Nitrogen Dynamics

• Spinach needs adequate N nutrition to produce well, but also to meet stringent quality standards

• The deep green color demanded by the market often goes beyond the agronomic need to optimize crop yield
Spinach Nitrogen Dynamics

- Spinach is probably one of the most difficult crops to achieve good nitrogen use efficiency:
  - All sprinkler irrigation
  - High N demand
  - Shallow rooted
Nitrogen Uptake by Spinach Products

lbs N/A

Baby  
Teenage  
Bunch
Spinach Root Distribution

Two Examples

[Bar charts showing root distribution across different depth ranges (0-4, 4-8, 8-12, 12-16, 16-20, 20-24 inches) with bars indicating number of roots per square inch (roots/in²).]
Spinach Nitrogen Uptake

- **11 lbs N/A** in first 2 wks
- **5.1 lbs N/A/d** from 13 d to harvest
- **7.3 lbs N/A/d** in the week prior to harvest

Graph:
- Equation: $y = 5.1x - 66.8$
- $R^2 = 0.74$
Inefficiencies with sprinkler irrigation on 80 inch beds
Spinach Nitrogen Evaluations
Spinach Fertilization

• Spinach uptake in the first two weeks is low: 10-15 lbs N/A
• There is intensive competition between the spinach plants and good levels of N are essential
• However, Spinach needs 20-25 ppm nitrate-N in the top foot of soil throughout the crop cycle to optimize yield
Soil Nitrate-N First Crop Spinach

Days After Planting

0  6  13  18  27  35

0         6           13          18         27        35

0  20  40  80 lbs N/A

0.00  5.00  10.00  15.00  20.00  25.00  30.00  35.00

20.00

2.00

0.00
Yield of First Crop Spinach
Mean of Two Trials

![Graph showing yield of first crop spinach in various conditions. The x-axis represents different treatments (0, 20, 40, 80, standard 80), and the y-axis represents fresh tons per acre (Tons/A). The standard 80 condition shows the highest yield.]
Spinach Fertilization

• We are interested in testing ways to effectively put on amounts of N on spinach that are closer to the amounts taken up by the crop.

• Fertilizer technologies such as controlled release fertilizers show promise for moving us closer to this goal.
2012 Controlled Release Fertilizer Evaluation Spinach

120 CR at planting
80 CR at planting
80 topdress

Standard 182 lbs N/A

Untreated
2013 Spinach Evaluations - Castroville

Average of Two Trials

Graph showing the average of two trials for various spinach varieties and treatments.
Fertilizer Technology for High Density Short-term Crops

• Results with controlled release fertilizers have not been as consistent in the south end of the Salinas Valley where it is hotter

• We still have a great deal to learn about how they work and how best to use them
Nitrogen Over the Cropping Season

• Thus far we have discussed managing nitrogen on a crop by crop basis

• However, is there a way to manage sources of N other than from fertilizer, such as N mineralized from crop residue, soil organic matter and N that may be deeper in the soil profile
Nitrogen in Crop Residue

70 lbs N in lettuce residue

>225 lbs N in broccoli residue

80 lbs N in celery residue

55 lbs N in spinach residue
CropManage
Integrating Irrigation and Residual Soil Nitrate Managements

• The nitrate quick test is the best measure of the pool of available soil nitrate that is available from all sources:
  ▪ Fertilizer
  ▪ Residual fertilizer
  ▪ Mineralized organic matter and crop residue
Retrieving Nitrate Deeper in the Soil Profile

• In many cropping systems in other parts of the world, growers can utilize rotational crops that are deeper rooted and can utilize nitrate that has been leached to deeper in the soil profile

• In our area, given the economics of production, we have lost many of these important rotational crops
Nitrogen Uptake by Broccoli, Cauliflower and Cabbage
## Fates of Nitrogen in Cole Crops Production and Harvest Summer

<table>
<thead>
<tr>
<th>Crop</th>
<th>Fertilizer applied</th>
<th>Crop Uptake</th>
<th>Scavenged from soil</th>
<th>Removed in harvest</th>
<th>Residue after harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broccoli</td>
<td>181</td>
<td>329</td>
<td>149</td>
<td>87</td>
<td>243</td>
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<tr>
<td>Cauliflower</td>
<td>260</td>
<td>281</td>
<td>21</td>
<td>52</td>
<td>230</td>
</tr>
<tr>
<td>Cabbage</td>
<td>215</td>
<td>330</td>
<td>115</td>
<td>188</td>
<td>142</td>
</tr>
</tbody>
</table>
Nitrate Distribution in Spinach Beds at Harvest
Soil Nitrate Distribution in Lettuce

Plant row
Drip tape
Bed width (inches)
Depth (inches)
Nitrate-N (ppm)

Nitrate-N (ppm)
Fates of Nitrogen in Cole Crops Production and Harvest Winter

<table>
<thead>
<tr>
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<th>Fertilizer applied</th>
<th>Crop Uptake</th>
<th>Scavenged from soil</th>
<th>Removed in harvest</th>
<th>Residue after harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broccoli</td>
<td>272</td>
<td>249</td>
<td>23+</td>
<td>94</td>
<td>156</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>351</td>
<td>274</td>
<td>78+</td>
<td>70</td>
<td>175</td>
</tr>
</tbody>
</table>
End of Season Nitrogen Management

• The quantity of nitrogen in the soil at the end of the production season will affect the quantity of N that is subject to leaching losses during the winter rainy season

• Ways to address this issue are:
  ▪ Manage the final crop of the season to draw down soil nitrates to low levels
  ▪ Use cover crops take up residual soil nitrate and sequester in the crop biomass
End of Season N Management

• Careful use of the nitrate quick test can help guide fertilizer applications and avoid over application of N

• Studies conducted on numerous fields have shown that use of the quick test can reduce N application resulting in lower levels of nitrate in the soil at the end of the season
Residual Soil Nitrate at End of Growth Cycle
Evaluation of 16 Commercial Fields
End of Season N Management

• The bottom line is that efforts to utilize residual soil nitrate in place of applying additional fertilizer reduces the load of nitrate in the soil at the end of the season and can reduce the quantity of nitrate moved downward during the fallow period and rainy season.
Cover Crops

• Cover crops provide the best means of sequestering the end-of-season residual soil nitrate

• Unfortunately, they cannot be used on a high percentage of acreage
Summary

• Nitrogen management for leafy vegetable production to safeguard yield and reduce nitrate losses to the environment is complicated

• It can be achieved, but requires taking into consideration available residual soil nitrate and making fertilizer decisions accordingly