Nutrient and Water Use of Fresh Market Spinach

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Spinach Production Challenges

- Eighty-inch wide beds present a particular challenge for managing nitrogen and water.
- Densely planted with 24 - 32 seedlines across the wide bed top using 2 to 4 million seed per acre.
- It is fast maturing, shallow rooted and exclusively sprinkler irrigated.
- These characteristics create difficulties for achieving high N-use efficiency.
- Growers are under pressure to meet strict quality standards and comply with water quality regulations.
Nitrogen Uptake of Spinach

Most active uptake 15-30 days

6.0 lbs N/A/day
Nitrogen Uptake by Spinach by Product Type

- Baby
- Teenage
- Bunch

Lbs N/A
Spinach Nitrogen Uptake and Application Rates

- **Total N applied (lbs N/A)**: 175 lbs N/A
- **Biomass N (lbs N/A)**: 93 lbs N/A

175 lbs N/A applied
93 lbs N/A uptake
Effect of Residual Soil Nitrate on Spinach Yield

Initial Soil Nitrate-N = 5.8 ppm

Initial Soil Nitrate-N = 28.0 ppm
## Phosphorus and Potassium Uptake

<table>
<thead>
<tr>
<th>Crop</th>
<th>Percent P at harvest</th>
<th>P uptake lbs/A</th>
<th>Percent K at harvest</th>
<th>K uptake lbs/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spinach</td>
<td>0.7</td>
<td>15.0</td>
<td>9.3</td>
<td>203</td>
</tr>
</tbody>
</table>
In the first 15 days of the crop cycle, the roots only reached to 10 inches.
Rooting Depth of Spinach

88% of all roots found in top 12” of soil at harvest

![Bar chart showing rooting depth of spinach across different soil depth intervals. The chart indicates that the majority of roots are found in the top 12” of soil.](chart)
Nitrate Distribution in Spinach Beds After Harvest

Most Active Roots

Zone of efficient crop N removal

Nitrate leached past root zone

NO₃-N (mg/kg soil)
### Spinach Water Use Survey

<table>
<thead>
<tr>
<th>Applied water inches</th>
<th>Crop ET inches</th>
<th>Applied water/ETc</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.7</td>
<td>3.1</td>
<td>245</td>
</tr>
</tbody>
</table>

Growers need to avoid water patterns in fields and to keep the crop growing fast with high quality and this drives water applications.
Improving Nitrogen Use Efficiency

• Water management is key to keeping nitrate in the shallow rootzone

• The use of nitrogen fertilizer technology is another idea that has potential
  ▪ Controlled release fertilizers can protect nitrate in the coated prill from leaching losses
  ▪ Nitrification inhibitors can reduce nitrate movement by keeping N as ammonium
Materials Tested

• Controlled release materials:
  ▪ Coated Urea – Duration
  ▪ Triazone - NSure

• Nitrification inhibitors:
  ▪ Nitrapyrin - Instinct
  ▪ DMPP - Novatec
  ▪ DCD – Super U
Shallow root system and high water use makes it difficult to keep a high percent of soil nitrate in the area of active roots.
Nitrification inhibitor: Keeps ammonium from converting to nitrate for a brief period of time.
Controlled Release: Urea encapsulated in a plastic prill

4-12 inches area of active root system
2013 Trial

* Material sprayed over spread ammonium sulfate and then mulched into bed
Yield of Romaine
Drip Applied UN32 with Fertilizer Additives
Spence, 2014

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (lbs N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>0</td>
</tr>
<tr>
<td>Standard</td>
<td>155</td>
</tr>
<tr>
<td>Moderate</td>
<td>105</td>
</tr>
<tr>
<td>Nitrapyrin</td>
<td>105</td>
</tr>
<tr>
<td>NSURE</td>
<td>105</td>
</tr>
<tr>
<td>Novatec</td>
<td>105 lbs N</td>
</tr>
</tbody>
</table>
Spinach to Be Added to CropManage

CropManage web based decision support Program to assist water and N management

- Irrigation management decisions based on crop ET
- Nitrogen management decisions based on soil residual nitrate and crop demand
Acknowledgements

California Leafy Greens Research Board

CDFA Fertilizer Research and Education Program