Improving nitrogen efficiency in lettuce production
All fields selected had at least 20 PPM soil NO$_3$-N prior to first sidedress (≈ 80 lb NO$_3$-N / acre)
2009 field trials of Pre-sidedress Soil Nitrate Testing (PSNT)

Only the first sidedress modified
What percentage of fields tested qualified for the program?

- more than half of first crop fields
- all second crop fields
18 field trials:
- 13 head lettuce
- 5 romaine
- 14 sprinkler irrigated
- 4 drip irrigated

Grower and PSNT plots sampled every 7-10 days:
- soil NO$_3$-N
- plant biomass and N content
- plant canopy size
Plant canopy development to estimate irrigation requirements:
Harvest data:

- Hand harvest from UCD subplots
- Commercial yields from Dole crews
Crop N uptake:

Summer, north Salinas

![Graph showing the relationship between Biomass N (lb/acre) and Days after planting. The graph includes a line of best fit with the equation y = 3.7x - 109 and r² = 0.86.]
Crop N uptake:

Summer, north Salinas

average daily uptake was 3.7 lb N/day over last 4-5 weeks

\[ y = 3.7x - 109 \]

\[ r^2 = 0.86 \]
Crop N uptake:

Average daily uptake was 3.7 lb N/day over last 4-5 weeks.

Summer, north Salinas

Summer, Soledad
Crop N uptake:

y = 3.7x - 109

\( r^2 = 0.86 \)

Grower’s first sidedress from 48 - 127 lb N/acre
Averaged across fields:

<table>
<thead>
<tr>
<th></th>
<th>Yield (lb / acre)</th>
<th>Total fresh wt (UCD harvest)</th>
<th>Dole harvest weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grower</td>
<td>88,700</td>
<td></td>
<td>37,300</td>
</tr>
<tr>
<td>PSNT</td>
<td>88,100</td>
<td></td>
<td>37,400</td>
</tr>
<tr>
<td>PSNT as a % of grower</td>
<td>99</td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>
2008 Dole trials showed PSNT yields 98% of grower yield across 18 fields.
What about plant color?
What about plant color?

<table>
<thead>
<tr>
<th></th>
<th>Head</th>
<th>Romaine</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSNT</td>
<td>82</td>
<td>223</td>
</tr>
<tr>
<td>Grower</td>
<td>84</td>
<td>230</td>
</tr>
</tbody>
</table>

PSNT as a % of grower

97  97
What about N effects on product quality?
What about N effects on product quality?

No evidence that lower N rate reduced postharvest shelf life
Range of grower N applications:
High of 233 lb/acre seasonal total, low of 73 lb/acre

Range of PSNT applications:
High of 127 lb/acre seasonal total, low of 0 lb/acre
N application:

![Bar chart showing seasonal N application (lb/acre) for Grower and PSNT trials across different fields.]

- Grower 129 lb
- PSNT 57 lb

In perspective …

- In 1996-2000 PSNT trials, growers averaged 213 lb N/acre
- In 2004-05 field survey, growers averaged 164 lb N/acre
## Crop N uptake:

<table>
<thead>
<tr>
<th>Field</th>
<th>Grower PSNT</th>
<th>Seasonal crop N uptake (lb/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>139 lb</td>
<td>139 lb</td>
</tr>
<tr>
<td>3</td>
<td>132 lb</td>
<td>132 lb</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>132 lb</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>132 lb</td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>132 lb</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>132 lb</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>132 lb</td>
</tr>
<tr>
<td>15</td>
<td></td>
<td>132 lb</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td>132 lb</td>
</tr>
<tr>
<td>Ave</td>
<td></td>
<td>132 lb</td>
</tr>
</tbody>
</table>

- Grower: 139 lb
- PSNT: 132 lb
Nitrogen balance:

In pounds per acre:

<table>
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<tr>
<th></th>
<th>N applied</th>
<th>N uptake</th>
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<tbody>
<tr>
<td>Grower</td>
<td>129</td>
<td>139</td>
</tr>
<tr>
<td>PSNT</td>
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<td>132</td>
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‘extra’ N comes from:

- Soil residual N
- Soil organic matter mineralization
- Irrigation water
## Nitrogen balance:

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Extra N applied in grower plots was *highly inefficient*.

Nitrogen balance:

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<th>N removed in harvest</th>
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<tbody>
<tr>
<td>Grower</td>
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<td>139</td>
<td>70</td>
</tr>
<tr>
<td>PSNT</td>
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about half of biomass N remains as residue
Nitrogen balance:

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<td>Grower</td>
<td>129</td>
<td>70</td>
<td>+ 59</td>
</tr>
<tr>
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<td>66</td>
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- in a double crop system even conservative fertilization can lead to significant N loss potential
- non-fertilizer N must be considered when formulating fertility plans
Higher N application leads to higher residual soil $\text{NO}_3^{-}$-N
Irrigation requirements:

Irrigation requirements average $\approx 8 - 11$ inches per lettuce crop
Irrigation efficiency varies widely:

![Bar chart showing irrigation efficiency](chart.png)
N efficiency is tied to irrigation efficiency:

Each inch of in-season leaching can carry a significant amount of NO$_3$-N / acre out of the root zone.
Fertilizer cost savings:

✓ average fertilizer cost reduction of about $60/acre for PSNT approach
In summary:

✓ Lettuce N uptake is predictable, and a large sidedressing at thinning is the least efficient way to apply N
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- Irrigation requirement is predictable, but field irrigation management is highly variable.
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In summary:

✓ Lettuce N uptake is predictable, and a large sidedressing at thinning is the least efficient way to apply N
✓ Irrigation requirement is predictable, but field irrigation management is highly variable
✓ Uptake efficiency of sidedress N diminishes quickly once crop need is met
✓ N balance is always going to be negative, the trick is to minimize the difference
How can PSNT best be used?

✓ Skip sidedress at thinning, retest later
✓ Half rate sidedress at thinning if no retest and no second sidedress