Nitrogen Fertilizer Management In Intensive Cropping Systems

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N Fertility Studies at AVRC to be discussed

- Onion \( N^{15} \) Study in 1998
- Corn \( N^{15} \) Study in 1999
- Chile Pepper (Sonora) N rate study in 2004 following corn.
- Onion N rate study in 2005 following chile pepper.
- Corn N rate study in 2006 and 2007 (recovery of residual N fertilizer by corn following chile pepper and onion in rotation).

Problem Being Addressed:

• High levels of residual soil NO$_3$-N in irrigated cropland in Arkansas River Valley.

• High NO$_3$-N levels in groundwater in Arkansas River Valley of Colorado.

• Contributing factors:
  – High rates of N fertilizer applied to vegetable crops
  – Shallow rooting depths of vegetable crops
  – Inefficient use of applied N fertilizer by crops.
  – Example, N fertilizer use efficiency (NFUE) by onion at AVRC was only 15%.
Results of $^{15}$N Study (1998-1999)

- N Fertilizer use efficiency (NFUE) by onion:
  - 11% for the fertilizer applied May 20$^{th}$
  - 19% for the fertilizer applied June 13$^{th}$
  - Only 15% of the N applied to onion in 1998 was utilized by the onions.
- Corn in 1999 used an additional 12% of the fertilizer N applied to onion in 1998.
- Total NFUE was about 27% for the two crops.

Halvorson, USDA-ARS, Fort Collins, CO
Corn N Rate Study following 5 years of alfalfa and watermelon in 1999 (no N applied)

Yield Maximized at 122 lb N/a

Halvorson, USDA-ARS, Fort Collins, CO

Yield vs. Soil N (0-3ft) + Fertilizer N (lb N/A)

Y = 81.9 + 1.09X - 0.0023X^2

r^2 = 0.87

Maximum Yield with 237 lb N/A

Halvorson, USDA-ARS, Fort Collins, CO
Chile Pepper in 2004 following 4-yr of Corn
(Same N plots used for corn)
2004 Chile Pepper N Study, Rocky Ford

\[ Y = 1142 + 8.61X - 0.0276X^2 \]
\[ r^2 = 0.96 \]
(20 Sept 04 Harvest)

\[ Y = 1205 + 8.96X - 0.0298X^2 \]
\[ r^2 = 0.96 \]
(20 Sept + 5 Oct 04 Harvest)

Halvorson, USDA-ARS, Fort Collins, CO
2004 Chile Pepper N Study, Rocky Ford

Y = 12046 + 89.58X - 0.298X²
r² = 0.96

Y = 9637 + 71.67X - 0.239X²
r² = 0.96

Retail @ $10/bu

Whole Sale @ $8/bu

Gross Income ($/a)

N Fertilizer Rate (lb N/a)

Halvorson, USDA-ARS, Fort Collins, CO
2004 N Study on Chile Pepper, Rocky Ford

(Uptake data for 150 lb/a N rate)

N Uptake (lb N/a)

Whole Plant

Stems & Leaves

Peppers

Day-Of-Year

June 7

June 16

July 8

July 22

August 5

August 24

Sept. 1

Sept. 20

Halvorson, USDA-ARS, Fort Collins, CO
Onion in 2005 following Chile Pepper in 2004

Halvorsen, USDA-ARS, Fort Collins, CO
2005 Nitrogen & Irrigation Study on Onion

- N rates: 0, 40, 80, 120, 160, 200 (lb N/a)

- N Source: Polymer-coated urea (Duration Type III fertilizer with a 120 day release period; provided by Agrium)

- Applied February 22, 2005
Irrigation Methods Used

- Furrow Irrigation (normal practice)
- Drip Irrigation (alternative practice)

Water Applied to Onions:
- Furrow Irrigation = 96 inches
- Drip Irrigation = 27 inches
Total Marketable Onions in 2005 at Rock Ford, CO

![Graph showing the relationship between N fertilizer applied and onion yield.](image)

- **Drip**
  - Equation: \( Y = 1657 + 1.853X - 0.0072X^2 \)
  - \( r^2 = 0.46 \)

- **Furrow**
  - Equation: \( Y = 1248 + 4.744X - 0.0114X^2 \)
  - \( r^2 = 0.92 \)

Drip maximized at 129 lb N/a and Furrow at 208 lb N/a.
Onion Market Classes:
- Colossal (>4” diam.)
- Jumbo (3-4” diam.)
- Medium (2-3” diam.)
- Packers (<2” diam.)
Onion Market Class (2005 Rocky Ford, CO)

Fresh Onion Yield (bags/a)

N Fertilizer Rate (lb N/a)

0 40 80 120 160 200 240

0 200 400 600 800 1000 1200 1400 1600

Jumbo

Colossal

Medium

Drip

Furrow Drip

Furrow

Halvorson, USDA-ARS, Fort Collins, CO
Gross Return - Production Costs (N, Water, Drip system)

2005 Onion Crop at Rocky Ford

Drip maximized at 130 lb N/a; Furrow at 206 lb N/a; Average at 177 lb N/a

Drip: \( Y = 12600 + 17.22X - 0.0663X^2 \)
\( r^2 = 0.50 \)

Furrow: \( Y = 9447 + 43.86X - 0.1062X^2 \)
\( r^2 = 0.93 \)

Average: \( Y = 11023 + 30.55X - 0.0864X^2 \)
\( r^2 = 0.91 \)
2006 Nitrogen & Irrigation Onion Study at Rocky Ford  
(new plot area, soybean in 2005)

No significant response to N fertilization or N x irrigation interactions

<table>
<thead>
<tr>
<th>Yield and Economics</th>
<th>Drip</th>
<th>Furrow</th>
<th>Difference Drip-Furrow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Marketable Onion Fresh Yield (cwt/a)</td>
<td>722.00</td>
<td>648.71</td>
<td>73.29</td>
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<tr>
<td>Colossal size onion (cwt/a)</td>
<td>8.92</td>
<td>0.77</td>
<td>8.15</td>
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<tr>
<td>Jumbo size onion (cwt/a)</td>
<td>603.61</td>
<td>394.83</td>
<td>208.78</td>
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<tr>
<td>Medium size onion (cwt/a)</td>
<td>159.47</td>
<td>253.11</td>
<td>-93.64</td>
</tr>
<tr>
<td>Packers (discards) (cwt/a)</td>
<td>4.86</td>
<td>9.08</td>
<td>-4.22</td>
</tr>
<tr>
<td>Total Gross Market Value ($/a)</td>
<td>$17,288</td>
<td>$13,547</td>
<td>$3,741</td>
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<tr>
<td>Colossal value ($/a) @ $28/cwt</td>
<td>$ 250</td>
<td>$ 22</td>
<td>$ 228</td>
</tr>
<tr>
<td>Jumbo value ($/a) @ $24/cwt</td>
<td>$14,487</td>
<td>$ 9,476</td>
<td>$ 5,011</td>
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<tr>
<td>Medium size value ($/a) @ $16/cwt</td>
<td>$ 2,552</td>
<td>$ 4,050</td>
<td>-$1,498</td>
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</tbody>
</table>

Halvorson, USDA-ARS, Fort Collins, CO
N uptake of Onion averaged over years (2005-2006), N rates, and irrigation systems at AVRC.
Drip Irrigation
(Minimal soil erosion)

Furrow Irrigation
(Major soil erosion)
Corn in 2006 following 2005 Onion Study

Residual Soil N levels following Onion

N Management I Study at AVRC, Rocky Ford, CO

April 4, 2006 (0 - 6 ft depth)

05 Drip Onion Plots

05 Furrow Onion Plots

Initial Soil NO3-N level in Feb. 2005

2006 Corn Fertilizer N Rate (lb N/a)

Soil NO3-N (lb N/a)
2006 Corn yields on 2005 Onion plots

Corn Grain Yield (bu/a)

Soil NO$_3$-N (0-3ft) + Fertilizer N (lb N/a)

$Y = 134.76 + 0.722X - 0.00092X^2$

$r^2 = 0.73$

Note: Yields near maximum with 250-300 lb N/a

Corn was furrow irrigated in 2006

Halvorson, USDA-ARS, Fort Collins, CO
2006 Corn following 2005 Onions, Rocky Ford

Y = 206.3 + 1.41x - 0.0076X^2
r^2 = 0.98

05 Drip Onion plots

Y = 165.4 + 1.31X - 0.0040X^2
r^2 = 0.995

05 Furrow Onion Plots

Note: 2006 Corn crop was furrow irrigated

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Residual Soil N following 2006 Corn crop and before fertilizing the 2007 corn crop and after harvest

![Graph showing residual soil NO$_3$-N following 2005 onion and 2006 Corn crops, with 2007 Fertilizer N Rate on x-axis and Residual Soil NO$_3$-N on y-axis. Data points indicate average DI & FI 16 Oct 07.](image-url)
2007 Grain yield following Corn in 2006 and Onion in 2005 at Rocky Ford, CO

Soil NO$_3$-N (0-3ft) + Fertilizer N (lb N/a)

Corn Grain Yield (bu/a)

Y = 40.54 + 1.31X - 0.0021X$^2$

r$^2$ = 0.90

Corn was furrow irrigated in 2007

Halvorson, USDA-ARS, Fort Collins, CO
Grain yield of 2007 Corn crop (furrow irrigated)

Fertilizer N Rate (lb N/a)

Corn Grain Yield (bu/a)

2007, 2nd Year of Corn on 2005 Onion Plots at Rocky Ford

'05 DI plots

'05 FI plots

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## N Management I Study at AVRC, Rocky Ford, CO

<table>
<thead>
<tr>
<th>Year</th>
<th>Crop</th>
<th>N1</th>
<th>N2</th>
<th>N3</th>
<th>N4</th>
<th>N5</th>
<th>N6</th>
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<tbody>
<tr>
<td>2000</td>
<td>Corn</td>
<td>149.1</td>
<td>158.3</td>
<td>140.8</td>
<td>145.2</td>
<td>156.5</td>
<td>156.6</td>
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<tr>
<td>2001</td>
<td>Corn</td>
<td>95.2</td>
<td>107.7</td>
<td>111.9</td>
<td>118.3</td>
<td>123.9</td>
<td>124.7</td>
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<td>2002</td>
<td>Corn</td>
<td>68.6</td>
<td>84.3</td>
<td>91.2</td>
<td>104.8</td>
<td>108.7</td>
<td>116.3</td>
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<tr>
<td>2003</td>
<td>Corn</td>
<td>72.9</td>
<td>92.9</td>
<td>118.2</td>
<td>125.9</td>
<td>129.2</td>
<td>143.3</td>
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<tr>
<td>2004</td>
<td>Chile Pepper</td>
<td>62.6</td>
<td>69.8</td>
<td>98.1</td>
<td>90.9</td>
<td>106.7</td>
<td>105.3</td>
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<tr>
<td>2005</td>
<td>Onion</td>
<td>90.3</td>
<td>87.4</td>
<td>100.6</td>
<td>116.9</td>
<td>111.6</td>
<td>117.3</td>
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<tr>
<td>2006</td>
<td>Corn</td>
<td>76.4</td>
<td>94.4</td>
<td>108.0</td>
<td>122.9</td>
<td>129.5</td>
<td>130.7</td>
</tr>
<tr>
<td>2007</td>
<td>Corn</td>
<td>48.8</td>
<td>65.4</td>
<td>72.8</td>
<td>112.18</td>
<td>151.18</td>
<td>165.2</td>
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<tr>
<td></td>
<td>Total N removed (8 crops)</td>
<td>663.9</td>
<td>760.2</td>
<td>830.6</td>
<td>937.3</td>
<td>1017.3</td>
<td>1059.4</td>
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<tr>
<td></td>
<td>Total N added, lb N/a</td>
<td>0</td>
<td>215</td>
<td>430</td>
<td>685</td>
<td>900</td>
<td>1115</td>
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<tr>
<td></td>
<td>N Fert. Use Efficiency</td>
<td>45%</td>
<td>39%</td>
<td>40%</td>
<td>39%</td>
<td>35%</td>
<td></td>
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<tr>
<td></td>
<td>Avg N Rate, lb N/a</td>
<td>0</td>
<td>26.9</td>
<td>53.8</td>
<td>85.6</td>
<td>112.5</td>
<td>139.4</td>
</tr>
</tbody>
</table>

Halvorson, USDA-ARS, Fort Collins, CO
Rocky Ford, CO (Based on 6 Corn crops)


Average Corn Grain Yield (bu/a)

Average Fertilizer N Rate (lb N/a)

\[ Y = 163.0 + 0.848X - 0.00267X^2 \]

\[ r^2 = 0.995 \]

Halvorson, USDA-ARS, Fort Collins, CO
Rocky Ford, CO (Based on avg yield of 6 Corn crops)

Average Fertilizer N Rate (lb N/a)

Gross Returns - N Costs ($/a)

Corn Grain Price = $3.95/bu
Urea N price = $0.54 and $0.60/lb N

Halvorson, USDA-ARS, Fort Collins, CO
2007 Corn yields following 2006 Onion crop (new N study initiated in 2006)

N Management II Study at AVRC, Rocky Ford, CO

Yield Maximized at 276 lb N/a

Y = 135.98 + 0.995X - 0.0018X^2

r^2 = 0.72

Corn was furrow irrigated in 2007

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Total N Needs of Corn:
Avg = 1.14 lb N/bu

Grain N Removal by Corn:
Avg = 0.69 lb N/bu
Conclusions from Onion Studies

- Onion response to N fertilization was minimal following soybean.

- Drip Irrigation resulted in greater marketable onion yields and more large sized onions at lower N rates than the normal furrow irrigation system.

- Drip required less irrigation water.

- Drip irrigation appears to have an economic advantage over furrow irrigation.

- Drip irrigation resulted in less soil erosion.

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Strategy Tips for N Management

• Use corn as a scavenger to recover unused fertilizer N applied to vegetable crops.

• Corn can reduce residual soil NO₃-N levels.

• Reduce N fertilizer rates applied to corn following onion based on soil test.

• Reduce rates of N applied to Onion.

• Delay N application to Onion crop until late-May and Chile Pepper until mid-June.

• Use polymer-coated urea (controlled release N fertilizers).

• Use drip irrigation on onion and other high cash value vegetable crops to get more efficient use of N by reducing N rates, and a reduction in water application.

• Soil Test for residual soil N before fertilizing.

Halvorson, USDA-ARS, Fort Collins, CO
Collecting Corn and Soil Samples from N Management Study at Rocky Ford

Thanks for Listening!!

Questions???

Halverson, USDA-ARS, Fort Collins, CO