The “4R” Strategies for Nitrogen Management

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4R Nutrient Management

Applying the “RIGHT”…….

S Rate
S Source
S Timing
S Placement

Not just aimed at N

S Applicable to all nutrient applications

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4R Nutrient Management Outcomes

ENVIROMENTAL

Source Rate

Time Place

ECONOMIC

SOCIAL

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CROPPING SYSTEM OBJECTIVES

ECONOMIC

- Net profit
- Yield
- Nutrient balance
- Soil erosion
- Resource use efficiencies: Energy, Labor, Nutrient, Water

ENVIRONMENTAL

- Healthy environment
- Yield quality
- Nutrient loss
- Water & air quality
- Soil productivity
- Biodiversity
- Ecosystems services
- Farm income
- Working conditions
- Stability

SOCIAL

- Adoption
- Source
- Rate
- Place
- Time
- Durability
- Profitability
- Productivity

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Distractions

Goal: Plant health and balanced nutrient, chemical, water inputs

Distracted by:
- Latest sales pitch/products
- Stressful growing conditions
- Foliar vs. Granular feeds; Micro’s; Fertilizer enhancers

In stressful times, distractions deviate our vision of plant health
- Precision and Principles
- Remember the soil ecosystem is a fairly well buffered, resilient environment
## 2015 MRTN Suggested N Rates for Corn

<table>
<thead>
<tr>
<th>Soil Productivity Potential¹</th>
<th>Previous Crop</th>
<th>Suggested N Rate (lbs. N/acre)</th>
<th>N: Corn Price Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.05</td>
</tr>
<tr>
<td>High/Very High</td>
<td>Corn</td>
<td>175</td>
<td>155</td>
</tr>
<tr>
<td></td>
<td></td>
<td>160-190²</td>
<td>140-170</td>
</tr>
<tr>
<td></td>
<td>Soybean³ and</td>
<td>150</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>small grains⁴</td>
<td>135-165</td>
<td>115-140</td>
</tr>
<tr>
<td>Medium/Low</td>
<td>Corn</td>
<td>145</td>
<td>135</td>
</tr>
<tr>
<td></td>
<td></td>
<td>135-160</td>
<td>125-150</td>
</tr>
<tr>
<td></td>
<td>Soybean³ and</td>
<td>120</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>small grains⁴</td>
<td>105-135</td>
<td>90-115</td>
</tr>
<tr>
<td>Loamy Sands and Sands (CEC &lt; 8.0)</td>
<td>Irrigated – all crops</td>
<td>215</td>
<td>195</td>
</tr>
<tr>
<td></td>
<td></td>
<td>200-230</td>
<td>180-210</td>
</tr>
</tbody>
</table>

1. **Low**: average yield = < 135 bu/A; **Medium**: average yield = 136 to 165 bu/A; **High**: average yield = 166 to 195 bu/A; **Very High** = more than 196 bu/A; (average yield is the five-year running average disregarding unusual highs and lows).

2. Range approximates ± $1 of the maximum return to N (MRTN) rate.

3. When the previous crop is soybean, the nitrogen credit is built into the recommendation. Do not take any additional nitrogen credit. Nitrogen credits for previously applied manure need to be subtracted from the N recommendations.

4. Refers to small grains interseeded with leguminous cover crop species. Small grains not interseeded with leguminous cover crop species should default to previous crop corn.

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Effectiveness of N Sources

If handled correctly, there is no difference in nitrogen sources

- Anhydrous ammonia (82-0-0)
  - More efficient when sidedressed than other sources of N
  - More dangerous than other sources of N
  - Injected, more resistant to N loss mechanisms, microbial toxicity

- Urea
  - Highest %N of the dry’s
  - Least desirable for surface applications

- UAN
  - Can be injected, surface applied, fertigated, mixed with other chemical applications

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N is N but you got to get it there!!
N Application Timing and Placement

Placement/Timing
Tied together through infrastructure to deliver N

Goal of N Fertilization
To provide an adequate amount of N in a manner that N recovery by the crop is maximized, and N loss to the environment (leaching, denitrification, immobilization, volatilization) is minimized.

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Nitrogen Fertilizer Timing (Options)

- Autumn *(NOT in MICHIGAN!!)*
- Spring pre-plant
- At planting (in-furrow or 2x2)
- Post-planting (PRE)
- Sidedress (early vs late)
- Fertigation

Efficient irrigation management must be combined with 4R to maximize N efficiencies
June 2015 – 8 inches rainfall
Yellow V4 Corn vs. Yellow V12 Corn?

- Greatest potential for N loss
  - 1) Wet, warm conditions
  - 2) Soil nitrate present without active crop growth
  - Application closer to peak corn uptake (V6-V12)
    - Pre-tasssel coulter inject N
    - Increases opportunity for greater yield and greater NUE
    - How? Less opportunity for env. loss

- 4R Nutrient Management

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Does Late N Application Pay Off?

Seasonal Nitrogen Uptake, %

- Early Growth
- Rapid Growth
- Maturing
- Late Loss

Sidedress

80% of requirement after V8 - 10
Does Late N Application Pay Off?

- Synchronize N availability with corn uptake
- Rate of corn N uptake increases V6
  - GDD’s
    - 5/25/16: 383
    - 5/31/16: 545
- Weather volatility

Adapted from Bender et al., 2013
# 4R Nutrient Mgmt 2015 (2 locations)

N equalized across treatments at MRTN rate

<table>
<thead>
<tr>
<th>Trt #</th>
<th>N Rate (lb/A)</th>
<th>N Placement and Timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>Untreated check</td>
</tr>
<tr>
<td>2</td>
<td>140</td>
<td>Pop-up (7 lbs N), Sidedress injected (V4)</td>
</tr>
<tr>
<td>3</td>
<td>140</td>
<td>Pop-up (7 lbs N), Sidedress injected (V4), Pre-tassel (V11)</td>
</tr>
<tr>
<td>4</td>
<td>140</td>
<td>Pop-up (7 lbs N), Pre-tassel (V11)</td>
</tr>
<tr>
<td>5</td>
<td>140</td>
<td>PPI - Urea</td>
</tr>
<tr>
<td>6</td>
<td>140</td>
<td>PPI - 75:25 split of PCU/Urea</td>
</tr>
<tr>
<td>7</td>
<td>140</td>
<td>PPI - 1 T Herbrucks, Sidedress injected (V4)</td>
</tr>
<tr>
<td>8</td>
<td>140</td>
<td>2x2 (40 lbs N), Sidedress injected (V4)</td>
</tr>
<tr>
<td>9</td>
<td>140</td>
<td>2x2 (40 lbs N), Pre-tassel (V11)</td>
</tr>
<tr>
<td>10</td>
<td>140</td>
<td>2x2 (40 lbs N), Sidedress injected (V4), Pre-tassel (V11)</td>
</tr>
</tbody>
</table>
Early Season Growth -- V6 Observations

Popups resulted in early-season plant response at Lansing and Richville, 2015. PPI's also more noticeable than 2x2's.

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V4 N vs. V10 N (June 26, 2015)

202 bu/A

181 bu/A

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4R Corn Yield 2015 (by Treatment Group)

Yield (bu/A) @ 15.5% moisture

- **Popup**
  - 201.8
  - 193.1
  - A

- **PPI**
  - 200.3
  - 183.7
  - B

- **2x2 Starter**
  - 205.0
  - 195.5
  - A

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4R Response to Pop-Up and Split N

Yield (bu/A) @ 15.5% moisture

SDV4

SDV4/V10

Sidedress Timings

Lansing  Richville

P=0.2424  P=0.0280  K. Steinke, MSU
4R Response to Pre-plant N

Yield (bu/a) @ 15.5% moisture

<table>
<thead>
<tr>
<th>Nitrogen Source</th>
<th>Yield</th>
<th>Treatment</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea</td>
<td>189.6</td>
<td>b</td>
<td>0.0545</td>
</tr>
<tr>
<td>Urea/ESN</td>
<td>190.5</td>
<td>b</td>
<td>0.1044</td>
</tr>
<tr>
<td>Herb/V10</td>
<td>220.9</td>
<td>a</td>
<td></td>
</tr>
</tbody>
</table>

Note: P-values indicate statistical significance at the 0.05 level. K. Steinke, MSU
4R Response to 2x2 N with Split Apps

<table>
<thead>
<tr>
<th>Sidedress Timing</th>
<th>SDV4</th>
<th>SDV10</th>
<th>SDV4/V10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lansing</td>
<td>204.2</td>
<td>209.3</td>
<td>201.6</td>
</tr>
<tr>
<td>Richville</td>
<td>189.4</td>
<td>201.2</td>
<td>196.0</td>
</tr>
</tbody>
</table>

Yield (bu/a) @ 15.5% moisture

P = 0.2718

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Early-season corn NDVI

- Values relative to non-limiting N treatment (280 kg N ha\(^{-1}\))

- Yield potential affected early in corn vegetative growth

\[
\text{Lansing, MI: } y = 19.737x + 75.871 \quad R^2 = 0.1114 \quad P=0.004
\]

\[
\text{Richville, MI: } y = 36x + 59.348 \quad R^2 = 0.2365 \quad P<0.001
\]
Early-season corn NDVI – by Strategy Lansing, MI 2015

V6 Rel NDVI vs. Rel Yield - Lansing, MI 2015

- **Popup**
  - \( y = 34.549x + 58.847 \)
  - \( R^2 = 0.3771 \)
  - \( P=0.0338 \)

- **PPI**
  - \( y = 22.802x + 72.3 \)
  - \( R^2 = 0.0501 \)
  - \( P=0.4819 \)

- **2x2**
  - \( y = -29.126x + 124.19 \)
  - \( R^2 = 0.0723 \)
  - \( P=0.3933 \)
Take-Home Points and Impacts

- Yield expression influenced early
  - N supplied early may have impact on yield
  - Poor correlation of early growth to yield (pop ups)
  - Impact of N strategy on yield expression variable
  - Risk

- Negative yield response to late season N under reduced N loss conditions
  - Reduced grain yield potential (2014)
  - Non-sig. yield gains under N loss conditions (2015)
  - Late-season N as rescue application
Take-Home Points and Impacts

- Split N increased yield vs. single PPI under N loss conditions (2015)
- More risk involved with popups
  - Could NOT carry plant through to V10 (2015)
  - Reduced amount of N at-planting to set yield
  - Increased yield swings vs. 2x2’s from V4 to V10 SD

- 2x2 strategy more consistent grain yield response
  - Plant set to capitalize on environmental conditions

- More risk? Too much rain after early SD timing OR too little rain leading up to late SD timing??

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Pre-Season Vs. In-Season N Rec’s

**MRTN**

- Pre-season model to gauge overall N rate
- Does NOT adjust for in-season N losses BUT DOES account for N losses through many years of yield response to N rates through the database

**Computer Models and Phone Apps**

- In-season N rec’s for adjusting in-season N application
- Attempt to “track N” during the season based on variable weather patterns
Pre-Season Vs. In-Season N Rec’s

Greenseeker
- Sensor Dependent: 46 lbs N 2x2 fb weekly crop canopy sensing for V8 final N (121 total)

Adapt-N
- Computer model dependent: 46 lbs N 2x2 fb V8 final N based on rainfall data (171 total)

MRTN
- 46 lbs N 2x2 fb V4 final N at 94 lbs N (140 total)

Even with excessive June rainfall, no difference between MRTN and Adapt N
- Both statistically greater than Greenseeker
Don’t Put All of Your Eggs in One Basket!!

- Intentionally plan for 2 different N applications
  - Offset unpredictable weather (too wet or too dry)
- Be fluid with decisions
  - Avoid the corn N management cookbook
- 2x2 still attains undisputed consistencies
- Consider manure
- Have to set the plant up for success
  - Plants need to be able to capitalize on early to mid-season environmental conditions
  - Support tools often fail with this concept

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