Nutrient management
irrigated corn

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Nitrogen rate response trials

- Purdue and farmer fields
- 4-6 N rates replicated 4-6 times
- Calibrated yield monitor
- Yield response fit with equation to determine opt. N rate and yield
Irrigated corn response to N

Michigan

Indiana

2008CS

2008CC

2008CC2

2013CS

2014CC

2014CW

2015CS

Grain yield, bu/ac

Total N fertilizer rate, lb/ac
Economic optimum N rate varies

Yield, bu/a

<table>
<thead>
<tr>
<th>Yield, bu/a</th>
<th>207</th>
<th>226</th>
<th>213</th>
<th>228</th>
<th>199</th>
<th>183</th>
<th>258</th>
</tr>
</thead>
</table>

Econ. Opt. total N fertilizer rate, lb/ac

- $3.50/bu
- $0.50/lb N

These 2 MI trials skew the results a bit.
I have an email into Wisconsin to see if this was corn after soybean or corn after corn. The N rate calculator gives the same result regardless of whether C/S or C/C is chosen.

<table>
<thead>
<tr>
<th>Finding the Maximum Return To N and Most Profitable N Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Regional (Corn Belt) Approach to Nitrogen Rate Guidelines</td>
</tr>
<tr>
<td>State: Wisconsin – Irr. Sands</td>
</tr>
<tr>
<td>Number of sites: 4</td>
</tr>
<tr>
<td>Rotation: Corn Following Soybean</td>
</tr>
<tr>
<td>Non-Responsive Sites Not Included</td>
</tr>
<tr>
<td>Nitrogen Price ($/lb): 0.50</td>
</tr>
<tr>
<td>Corn Price ($/bu): 3.50</td>
</tr>
<tr>
<td>Price Ratio: 0.14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MRTN Rate (lb N/acre): 186</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profitable N Rate Range (lb N/acre): 175 - 197</td>
</tr>
<tr>
<td>Net Return to N at MRTN Rate ($/acre): $283.00</td>
</tr>
<tr>
<td>Percent of Maximum Yield at MRTN Rate: 98%</td>
</tr>
<tr>
<td>UAN (28% N) at MRTN Rate (lb product/acre): 664</td>
</tr>
<tr>
<td>UAN (28% N) Cost at MRTN Rate ($/acre): $93.00</td>
</tr>
</tbody>
</table>

Most profitable N rate is at the maximum return to N (MRTN). Profitable N rate range provides economic return within $1/acre of the MRTN.
Yield varied between 180 and 200 bu/acre for these 4 trials.
EONR for IN&MI and WI trials combined

Number of trials in category

<table>
<thead>
<tr>
<th>Economic Optimum N rate, lb/acre</th>
<th>Number of trials</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;175</td>
<td>1</td>
</tr>
<tr>
<td>175-200</td>
<td>4</td>
</tr>
<tr>
<td>200-225</td>
<td>3</td>
</tr>
<tr>
<td>225-250</td>
<td>2</td>
</tr>
<tr>
<td>&gt;250</td>
<td>1</td>
</tr>
</tbody>
</table>
IN&MI aggregated data

• Based on the 6 responsive sites (I need to know more about 2014 C/W and 2015 C/S)
• Economic optimum N rate is between 195 and 225 lb N/acre with the calculated optimum at 205 lb N/acre
• >$9/acre losses occur at <185 lb N/acre and >255 lb N/acre
• Based on a very limited data set if I grew corn I would apply around 205-225 lb N/acre to avoid the downside risk
### N uptake rates

#### Vegetative Growth Stages
- Days after planting: 4, 7, 8, 10, 15
- Date: 35, 43, 49, 57, 68

#### Reproductive Growth Stages
- Days after planting: 1, 2, 3, 4, 6
- Date: 77, 88, 97, 109, 144

<table>
<thead>
<tr>
<th>Date</th>
<th>N uptake rates (lb N/a/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/26</td>
<td>1.7</td>
</tr>
<tr>
<td>6/4</td>
<td>2.5</td>
</tr>
<tr>
<td>6/10</td>
<td>4.7</td>
</tr>
<tr>
<td>6/18</td>
<td>4.0</td>
</tr>
<tr>
<td>6/29</td>
<td>2.4</td>
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<tr>
<td>7/8</td>
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<td>7/19</td>
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<td>7/28</td>
<td></td>
</tr>
<tr>
<td>8/9</td>
<td></td>
</tr>
<tr>
<td>9/13</td>
<td></td>
</tr>
</tbody>
</table>

#### Above-ground plant N, lb/acre

- Growing Degree Days: 0, 500, 1000, 1500, 2000, 2500, 3000

- At-planting N
- V7 Sidedress
- V15 Sidedress
- None

Miller, Nielsen, Camberato, 2010
Nitrogen fertilization to feed the crop

• Provide N early
  • N accumulated rapidly during vegetative growth, about 5 lb N/ac/day
  • Normally 2/3 of total

• Ensure N availability late
  • N accum. at similar rate per GDD as during veg. growth
  • Normally about 1/3 of total
  • Crop can accum. N faster if crop is N deficient
Irrigated corn N suggestions

• pH, P, K, S, and micronutrients and everything else provided at sufficient levels

• Minimize preplant N

• Use starter N – 25-40 lb N/ac, 10-15 lb P₂O₅/ac, plus S or Zn if needed (K?)
Irrigated corn N suggestions

• If 3 or more applications are planned
  • Sidedress V4-V7 to target N rate minus 30-50 lb N/acre
  • Include strip at target +30 in several fields

• Apply remainder of N with irrigation by V12-V14
Other essential nutrients

• Based on a representative recent soil test
  • pH, magnesium - Mg
  • Zinc - Zn
  • Phosphorus - P
  • Potassium - K
• Sulfur – S
• Boron
Proper pH is fundamental

• Should add lime to keep soil pH
  • 6.0-6.5 in mineral soils
  • 5.2-5.5 in organic soils
• If magnesium is low use dolomitic limestone, otherwise base on quality and price
Magnesium Deficiency

- Yellow to white interveinal striping or beaded streaking of dead, round spots.
- Older leaves may become reddish purple and tips and margins may die.
Conditions favoring Mg deficiency

- **Soil test** Mg < 50 ppm (<100 lb/a) and/or low %Mg (5-10% of CEC)
- Sandy soils - low CEC and OM content
- Often occurs at low soil pH, but may occur at high pH with calcitic lime or hen manure
- High Ca, K, and anhydrous ammonia application can exacerbate Mg deficiency
Zinc deficiency

Conditions favoring zinc deficiency

- High soil pH and calcareous soils
- Low soil OM, eroded areas
- High soil P induces Zn def. when Zn avail. marginal
- Cloudy cool weather
Soil test Zn and pH determine sufficiency

Soil test Zn and pH determine sufficiency.
Recommendations are for band applications of soluble inorganic Zn sources. >40-50% WS Synthetic Zn chelates may be used at one-fifth this rate. EDTA 2-5x more effective For broadcast applications, use 5 to 10 lb Zn/acre.

**Table 28. Zinc Fertilizer Recommendations for Responsive Crops Grown on Mineral and Organic Soils.**

<table>
<thead>
<tr>
<th>Soil test Zn² ppm</th>
<th>6.6</th>
<th>6.8</th>
<th>7.0</th>
<th>7.2</th>
<th>7.4</th>
<th>7.6+</th>
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<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
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<td>2</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
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<td>0</td>
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<td>2</td>
<td>3</td>
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<td>10</td>
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<td>1</td>
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<td>12</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

EDTA 2-5x more effective
### Zinc Fertilizer Recommendations for Responsive Crops Grown on Mineral and Organic Soils

#### Rate recommendations are for band applications
- Synthetic chelates may be used at 1/5\textsuperscript{th} rate
- Broadcast applications use 5 to 10 lb Zn/acre

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Recommendations are for band applications of soluble inorganic Zn sources. >40-50% WS Synthetic Zn chelates may be used at one-fifth this rate. EDTA 2-5x more effective For broadcast applications, use 5 to 10 lb Zn/acre.
Sulfur deficiency

- General yellowing of foliage (more so in new foliage than with N deficiency)
- Partially mobile in plant?
- Striping may occur
Conditions favoring S deficiency

- Low soil S
- Sandy, low organic matter soils
- Cold, wet, no-tillage fields, C/C
- Areas of low atmospheric S dep.
- Soil supply may vary with depth – transient deficiency
Sulfur fertilizer rate and timing

• If S is needed:
  • 15 – 30 lb S/acre
  • Applied in the spring especially on sandy soils because the sulfate-S will leach out of the profile if fall-applied
<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>Sulfur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium thiosulfate</td>
<td>26%</td>
</tr>
<tr>
<td>Ammonium sulfate</td>
<td>24%</td>
</tr>
<tr>
<td>K-mag or Sul-po-mag</td>
<td>23%</td>
</tr>
<tr>
<td>Gypsum</td>
<td>20%</td>
</tr>
<tr>
<td>Potassium sulfate</td>
<td>18%</td>
</tr>
</tbody>
</table>
Starter fertilizer

• Frequently increase early growth
• Accelerate development rate
• Most likely to increase yield in:
  • irrigated, high yield environment
  • no-till, heavy residue
  • early planting
  • low nutrient soils
• Hastens maturity 7-10 days (lower grain moisture at harvest)
Starter fertilizer

• 2x2 placement gives most consistent benefits
• 30-40 lb N/acre is likely optimum for yield
• 10-20 lb P$_2$O$_5$/acre is enough for starter response
• Maybe S, Zn, B, and/or K may be beneficial
Boron Deficiency

Leaf tissue boron >4-10 ppm is adequate
Conditions for B deficiency

• Boron can be limiting with high yield corn particularly in sandy low organic matter soils with high pH and when irrigated
Role of B in plants

• Cell division in growing points
• Pollination and seed development
  • Poor tassel emergence, spikelet deformation, absence of anthers, barrenness
• Germination of pollen and growth of pollen tubes
Boron-deficiency symptoms

• Normal plant growth requires a continuous supply of B - B is not translocated from old to new tissue
• Therefore, B-deficiency symptoms are first expressed in young tissue and growing points
Boron fertilization

- Soil applied B - 0.5-1.0 lb B/acre
- Post-planting applications are better than pre-plant applications, foliar applications of 0.1-0.3 lb B/acre
Nutrient uptake patterns over time

200 bu/acre
2 hybrids, 4 site-years

Phosphorus uptake over time

Phosphorus (P$_2$O$_5$)

P$_2$O$_5$, lb/acre

Thermal time (°C)

Phenological Growth Stages

V$_5$  V$_{10}$  V$_{15}$  R1  R3  R6

Potassium uptake over time

Phenological Growth Stages
V₅  V₁₀ V₁₅ R1  R3  R6

Potassium (K₂O)

90%

K₂O, lb/acre

Thermal time (°C)
General findings

• “Modern” compared to “old” hybrids
  • Accumulate more nutrients (yield more)
  • Take up proportionally more nutrients during grainfill (maintain leaf tissue later into grainfill period)
What does it all mean?

• Do “modern” compared to “old” hybrids require:
  • Higher soil test levels or higher rates of fertilization to reach potential
  • Different timing of nutrient application (does the optimum timing differ among nutrients)
Amount of roots changes substantially throughout season

From: Nielsen-AGRY97-07, 2000 based on: Mengel-AGRY95-08, 1995

P3369A, 21,700 pl/ac, 204 bu/ac, roots to a depth of 30"
Uptake per unit root root diminishes during the season

Mengel and Barber, 1974, AJ 66:399-402.

Fig. 3. The relation between root length and plant age for corn grown in 1971.

Fig. 4. The relation between P flux into the root per unit root length and plant age for corn grown in 1970 and 1971.
Soil test P levels for corn and soybean

- Build-up soil
- Maintain soil test
- Draw-down soil test

Fertilizer Recommendation Objective:
- Critical level: 15
- Maintenance Range: 15 to 30
- Maintenance limit: 30 to 40

Soil Test Level, ppm:
- Low
- High
Soil test K levels for corn and soybean

<table>
<thead>
<tr>
<th>Fertilizer Recommendation Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Build-up soil</td>
</tr>
<tr>
<td>Maintain soil test</td>
</tr>
<tr>
<td>Draw-down soil test</td>
</tr>
</tbody>
</table>

- Critical level
- Maintenance Range
- Maintenance limit
- +30
- +50
- 75+2.5 CEC
Soil test K levels at CEC=10

Fertilizer Recommendation Objective

- Build-up soil
- Maintain soil test
- Draw-down soil test

Soil Test Level, ppm

- Low
- Critical level: 100
- Maintenance Range: 100 to 130
- Maintenance limit: 130
- High: 150

Fertilizer Rate

- None
- High
P and K fertilization

• Existing critical levels should be sufficient for high yielding irrigated corn
• Application rates should be set to maintain soil test levels in the mid-to high-maintenance range
Questions?