
5th Annual Nitrogen: Minnesota’s Grand Challenge & Compelling Opportunity Conference

Sessions 9:05 a.m.-3:40 p.m.

**GENERAL SESSION**

8:15 a.m.  Registration
9:00 a.m.  Welcome
  Tom Rotherman  University of Minnesota
9:05 a.m.  Lessons Learned in 2018, Opportunities for 2019
  Brad Carlson  University of Minnesota Extension
  Dave Nicolai  University of Minnesota Extension
  Brandon Fast  Minnesota Corn Research & Promotion Council
9:55 a.m.  An Industry Perspective on Nitrogen: Beginning with 4R Nutrient Stewardship
  Dr. Tai Maaz  International Plant Nutrition Institute
10:50 a.m.  Break
11:05 a.m.  NUE and Potential Environmental Outcomes Associated with N Application Timing
  Dr. Carrie Laboski  University of Wisconsin-Madison
12:00  Lunch

**BREAKOUT SESSION #1**

1:00 p.m.  Managing Corn for High Yield and Environmental Stewardship While Controlling Costs
  Dr. Jeff Coulter  University of Minnesota
1:55 p.m.  N loss from Midwest cropping systems: What can we do about it?
  Dr. Dan Jaynes  USDA ARS, Ames, IA
2:50 p.m.  Urea Fertilizer Do’s and Don’ts
  Dr. Fabián Fernández  University of Minnesota

**BREAKOUT SESSION #2**

1:00 p.m.  Improving Nitrogen Mineralization Predictions
  Dr. Jason Clark  South Dakota State University
1:55 p.m.  Soil Healt and Implications for Nitrogen Management
  Dr. Anna Cates  University of Minnesota
2:50 p.m.  Nitrogen Management with Manure
  Dr. Melissa Wilson  University of Minnesota
3:40 p.m.  Adjourn

Thank you to all of our Supporters!

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Managing Corn for High Yield & Environmental Stewardship While Controlling Costs

Jeff Coulter, Ph.D. – Extension Corn Agronomist

jeffcoulter@umn.edu
Overview

- Row width
- Planting rate
- N management
- New innovations
Growers are adopting greater planting rates

- Optimum planting rates tend to be greater in high-yield environments

- Often no yield penalty for too high of planting rate
Narrow rows can reduce competition among plants when high planting rates.

30-inch rows
47,000 seeds/acre

22-inch rows
47,000 seeds/acre
1) Similar yield for both row widths

2) Similar response to plant population for both row widths

3) Yield was maximized at 34,300 plants/ac or greater
30-inch rows

22-/8-inch twin rows

Photos: Liz Stahl (Univ. of MN)
Yield differences in 1 of 5 trials in southern MN

Wilmont, MN - 2010

Corn grain yield (bu/ac)

Planting rate (1,000 seeds/ac)

Data from Liz Stahl (Univ. of MN)
Yield & optimum planting rate were greater with 22-inch rows in 1 of 4 trials in northwestern MN.

Polk County, 2010

Avg. of 3 hybrids

Planting rate (1,000 seeds/ac)
Nitrogen

- Often the most limiting nutrient for corn

- Application in excess of corn requirements reduces risk of yield loss, but with economic & environmental consequences
N use efficiency (NUE)

- NUE can be increased by:
  - Greater corn uptake of applied N
  - Reduced N losses

- Synchrony between N supply & corn N uptake is key to optimizing yield, profit, & environmental protection

Cassman et al. (2002)

Source: IPNI
Nitrogen Uptake by Corn

(Adapted from How a Corn Plant Develops, Special Report 48. Iowa State University)

Hoeft et al. (2000)
N supply

- Applied N

- Soil N (variable & difficult to predict)
  - Nitrate & ammonium
  - Mineralization from soil organic matter & crop residues
N rate x timing study

Objectives

- Determine whether yield & NUE can be increased with split applications of N

- Determine whether split applications can allow less N to be used without reducing yield
N rate x timing study, 2014–2016

- Lamberton (loam soil)
- Waseca (clay loam soil)
- Continuous corn

Fertilizer
- Fall N = SuperU
- Preplant & in-season N = urea
- All other nutrients supplied at non-limiting levels

With Paulo Pagliari, Ben Davies, & Jeff Vetsch (Univ. of MN)
- Greatest yield at both locations with 225 lb N/ac preplant
- Greatest yield also with 225 lb N/ac in fall at Lamberton or 180 lb N/ac in 2 or 3 splits at Waseca

<table>
<thead>
<tr>
<th>N application time</th>
<th>N rate</th>
<th>Lamberton</th>
<th>Waseca</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lb N/ac</td>
<td>-----------bu/ac----------</td>
<td></td>
</tr>
<tr>
<td>Fall</td>
<td>180</td>
<td>219 ab</td>
<td>186 b</td>
</tr>
<tr>
<td>Fall</td>
<td>225</td>
<td>234 a</td>
<td>191 ab</td>
</tr>
<tr>
<td>Preplant</td>
<td>180</td>
<td>225 ab</td>
<td>197 ab</td>
</tr>
<tr>
<td>Preplant</td>
<td>225</td>
<td>232 a</td>
<td>206 a</td>
</tr>
<tr>
<td>Preplant + V6</td>
<td>135</td>
<td>208 b</td>
<td>191 ab</td>
</tr>
<tr>
<td>Preplant + V6</td>
<td>180</td>
<td>225 ab</td>
<td>203 a</td>
</tr>
<tr>
<td>Preplant + V6 + tasseling</td>
<td>135</td>
<td>208 b</td>
<td>184 b</td>
</tr>
<tr>
<td>Preplant + V6 + tasseling</td>
<td>180</td>
<td>218 ab</td>
<td>203 a</td>
</tr>
</tbody>
</table>

3-year average

LSD (0.05)
Planting rate x N rate study

Questions addressed:

- What are the optimum planting rates in high-yield environments?
- Do greater planting rates require more N?
Planting rate x N rate study, 2012–2015

- Lamberton (loam soil)
- Waseca (clay loam soil)
- Rochester (silt loam soil)

Managed for maximum yield:
- Corn followed soybean
- All nutrients other than N supplied at non-limiting levels
- 10-34-0 in-furrow
- 103 RM hybrid
Planting rate x N rate study

- 3 planting rates (30,000, 36,000, 42,000 seeds/ac)
- 4 N rates (65, 110, 155, 200 lb N/ac)

<table>
<thead>
<tr>
<th>N fertilizer applied (lb N/ac)</th>
<th>Total</th>
<th>Preplant MAP</th>
<th>Preplant urea</th>
<th>Starter (10-34-0)</th>
<th>Sideress at V6 (28-0-0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>65</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>5</td>
<td>40</td>
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<tr>
<td>110</td>
<td>10</td>
<td>55</td>
<td>10</td>
<td>5</td>
<td>40</td>
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<tr>
<td>155</td>
<td>10</td>
<td>100</td>
<td>10</td>
<td>5</td>
<td>40</td>
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<tr>
<td>200</td>
<td>10</td>
<td>145</td>
<td>10</td>
<td>5</td>
<td>40</td>
</tr>
</tbody>
</table>
Average of 4 years & 4 N rates

Corn yield (bu/ac)

<table>
<thead>
<tr>
<th>Location</th>
<th>30,000</th>
<th>36,000</th>
<th>42,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamberton</td>
<td>b</td>
<td>a</td>
<td>a</td>
</tr>
<tr>
<td>Waseca</td>
<td>b</td>
<td>ab</td>
<td>a</td>
</tr>
<tr>
<td>Rochester</td>
<td>b</td>
<td>a</td>
<td>a</td>
</tr>
</tbody>
</table>

LSD (0.05)

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Corn following soybean

Average of 4 years & 3 planting rates

LSD (0.05)
Summary – planting rate x N rate study

- Greater planting rates never required more N

- On average, greatest yield with:
  - 155 lb N/ac or more at Lamberton & Waseca
  - 110 lb N/ac or more at Rochester (silt loam soil)
  - 36,000 seeds/ac or more at all locations
Summary – planting rate x N rate study

- Compared to 155 lb N/ac + 36,000 seeds/ac:
  - Increasing only the planting rate to 42,000 seeds/ac increased net return in 3 of 12 trials
  - Increasing only the N rate to 200 lb N/ac increased net return in 2 of 12 trials
Continuous corn intensification study

Questions addressed:

- What yield levels are possible?
- How far are current yields from these levels?
- Is standard fertilizer management capable of attaining yields at levels close to yield potential?
Continuous corn intensification study

- **Waseca** (2013 – present)
  - Nicollet clay loam
  - Patterned tile drainage
  - Continuous corn

- **Becker** (2014 – present)
  - Irrigated
  - Hubbard-Mosford loamy sand
  - Continuous corn
- **Continuous corn**
  - Requires top management for high yields
  - Greater risk of nutrient losses

- **Irrigated sands**
  - High yield potential
  - Greater risk of crop nutrient deficiency
  - Greater risk of nutrient losses
‘Systems’ treatments developed & updated over time:

- Crop advisors, industry agronomists, farmers
## Agronomic treatments – Waseca

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Normal</th>
<th>Intensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn stover harvested (%)</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>Hybrid maturity (CRM)</td>
<td>101</td>
<td>105</td>
</tr>
<tr>
<td>Planting rate (seeds/acre)</td>
<td>36,000</td>
<td>41,000</td>
</tr>
<tr>
<td>Fungicide at tasseling</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
## Fertilizer treatments – Waseca

<table>
<thead>
<tr>
<th></th>
<th>Standard</th>
<th>Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>S</strong></td>
<td>20 lb SO(_4)/ac</td>
<td>20 lb SO(_4)/ac</td>
</tr>
<tr>
<td><strong>P</strong></td>
<td>U of M guidelines</td>
<td>50% grain removal</td>
</tr>
<tr>
<td><strong>K</strong></td>
<td>U of M guidelines</td>
<td>100% grain removal</td>
</tr>
<tr>
<td><strong>10-34-0 in furrow</strong></td>
<td>4 gal/ac</td>
<td>4 gal/ac</td>
</tr>
<tr>
<td><strong>Surface-banded starter</strong></td>
<td>---</td>
<td>7 gal/ac 28-0-0 + 2 gal/ac 12-0-0-26</td>
</tr>
<tr>
<td><strong>(2&quot; x 0&quot;)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pre-plant N (urea)</strong></td>
<td>175 lb N/ac</td>
<td>111 lb N/ac</td>
</tr>
<tr>
<td><strong>V6 N (28-0-0, injected)</strong></td>
<td>---</td>
<td>40 lb N/ac</td>
</tr>
<tr>
<td><strong>V14 N (28-0-0, Y-DROPs)</strong></td>
<td>---</td>
<td>40 lb N/ac</td>
</tr>
<tr>
<td><strong>Total N</strong></td>
<td>180 lb N/ac</td>
<td>220 lb N/ac</td>
</tr>
</tbody>
</table>
- Yield gap = 16 to 64 bu/ac (average = 35 bu/ac)
- Greatest yield = advanced fertilizer mgt. + intensive agronomics
- Moderate yield = advanced fertilizer mgt. or intensive agronomics

<table>
<thead>
<tr>
<th>Agronomic management</th>
<th>Normal</th>
<th>Normal</th>
<th>Intensive</th>
<th>Intensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilizer management</td>
<td>Standard</td>
<td>Advanced</td>
<td>Standard</td>
<td>Advanced</td>
</tr>
<tr>
<td>2013</td>
<td>193 c</td>
<td>215 b</td>
<td>210 b</td>
<td>233 a</td>
</tr>
<tr>
<td>2014</td>
<td>92 c</td>
<td>121 b</td>
<td>124 b</td>
<td>156 a</td>
</tr>
<tr>
<td>2015</td>
<td>203 c</td>
<td>220 b</td>
<td>234 a</td>
<td>242 a</td>
</tr>
<tr>
<td>2016</td>
<td>214 c</td>
<td>220 b</td>
<td>233 a</td>
<td>239 a</td>
</tr>
<tr>
<td>2017</td>
<td>209 c</td>
<td>230 b</td>
<td>228 b</td>
<td>238 a</td>
</tr>
<tr>
<td>2018</td>
<td>213 b</td>
<td>224 a</td>
<td>218 b</td>
<td>229 a</td>
</tr>
<tr>
<td>6-year average</td>
<td>187 c</td>
<td>205 b</td>
<td>208 b</td>
<td>223 a</td>
</tr>
</tbody>
</table>
- Net return increased with intensive agronomics in 2 of 6 years

<table>
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<tr>
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<td>Fertilizer management</td>
<td>Standard</td>
<td>Advanced</td>
<td>Standard</td>
<td>Advanced</td>
</tr>
<tr>
<td>Added inputs ($/ac)</td>
<td>---</td>
<td>77 &amp; 54</td>
<td>18 &amp; 33</td>
<td>95 &amp; 87</td>
</tr>
<tr>
<td>year</td>
<td></td>
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<td></td>
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<tr>
<td>2013</td>
<td>---</td>
<td>-8</td>
<td>-3</td>
<td>-8</td>
</tr>
<tr>
<td>2014</td>
<td>---</td>
<td>6</td>
<td>64</td>
<td>80</td>
</tr>
<tr>
<td>2015</td>
<td>---</td>
<td>-22</td>
<td>45</td>
<td>-4</td>
</tr>
<tr>
<td>2016</td>
<td>---</td>
<td>-56</td>
<td>6</td>
<td>-49</td>
</tr>
<tr>
<td>2017</td>
<td>---</td>
<td>-14</td>
<td>-6</td>
<td>-43</td>
</tr>
<tr>
<td>2018</td>
<td>---</td>
<td>-27</td>
<td>-54</td>
<td>-68</td>
</tr>
<tr>
<td>6-year average</td>
<td>---</td>
<td>-19</td>
<td>10</td>
<td>-13</td>
</tr>
</tbody>
</table>
### Agronomic treatments – Becker (irrigated)

<table>
<thead>
<tr>
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<th>Intensive</th>
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<tbody>
<tr>
<td>Hybrid maturity (CRM)</td>
<td>96</td>
<td>103</td>
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<td>36,000</td>
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## Fertilizer treatments – Becker (irrigated)

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<td>4 gal/ac</td>
<td>4 gal/ac</td>
</tr>
<tr>
<td>V2 N (urea)</td>
<td>40 lb N/ac</td>
<td>40 lb N/ac</td>
</tr>
<tr>
<td>V6 N (urea)</td>
<td>185 lb N/ac</td>
<td>70 lb N/ac</td>
</tr>
<tr>
<td>V12 N (urea)</td>
<td>---</td>
<td>70 lb N/ac</td>
</tr>
<tr>
<td>VT N (urea)</td>
<td>---</td>
<td>45 lb N/ac</td>
</tr>
<tr>
<td>Total N</td>
<td>230 lb N/ac</td>
<td>230 lb N/ac</td>
</tr>
</tbody>
</table>
- Yield gap = 38 to 59 bu/ac (average = 46 bu/ac)
- Greatest yield = advanced fertilizer mgt. + intensive agronomics
- Moderate yield = advanced fertilizer mgt. or intensive agronomics

<table>
<thead>
<tr>
<th>Agronomic management</th>
<th>Normal</th>
<th>Normal</th>
<th>Intensive</th>
<th>Intensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilizer management</td>
<td>Standard</td>
<td>Advanced</td>
<td>Standard</td>
<td>Advanced</td>
</tr>
<tr>
<td>2014</td>
<td>159 c</td>
<td>192 ab</td>
<td>180 b</td>
<td>205 a</td>
</tr>
<tr>
<td>2015</td>
<td>163 d</td>
<td>183 c</td>
<td>197 b</td>
<td>222 a</td>
</tr>
<tr>
<td>2016</td>
<td>190 c</td>
<td>189 c</td>
<td>209 b</td>
<td>229 a</td>
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<tr>
<td>2017</td>
<td>169 c</td>
<td>192 b</td>
<td>171 c</td>
<td>224 a</td>
</tr>
<tr>
<td>2018</td>
<td>169 c</td>
<td>207 a</td>
<td>190 b</td>
<td>190 b</td>
</tr>
<tr>
<td>5-year average</td>
<td>178 c</td>
<td>200 b</td>
<td>201 b</td>
<td>217 a</td>
</tr>
</tbody>
</table>
- Greatest net return with advanced fertilizer mgt. in 3 of 5 years & advanced fertilizer mgt. + intensive agronomics in 2 of 5 years

- Net return increased with advanced fertilizer mgt. or intensive agronomics in 4 of 5 years

<table>
<thead>
<tr>
<th>Agronomic management</th>
<th>Normal (Added inputs: $/ac)</th>
<th>Normal 52 &amp; 38</th>
<th>Intensive 18</th>
<th>Intensive 70 &amp; 56</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilizer management</td>
<td>Standard</td>
<td>Advanced 44</td>
<td>Standard 28</td>
<td>Advanced 101</td>
</tr>
<tr>
<td>Year</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>---</td>
<td>44</td>
<td>28</td>
<td>36</td>
</tr>
<tr>
<td>2015</td>
<td>---</td>
<td>16</td>
<td>84</td>
<td>101</td>
</tr>
<tr>
<td>2016</td>
<td>---</td>
<td>-54</td>
<td>31</td>
<td>42</td>
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<tr>
<td>2017</td>
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<td>12</td>
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<td>-17</td>
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<tr>
<td>2018</td>
<td>---</td>
<td>73</td>
<td>19</td>
<td>-17</td>
</tr>
<tr>
<td>5-year average</td>
<td>---</td>
<td>19</td>
<td>31</td>
<td>29</td>
</tr>
</tbody>
</table>

Becker (irrigated)
Conclusions

- Increases in profitability are limited in frequency & magnitude with above-normal rates of seed & other inputs

- Weather can have a much larger impact on yield than agronomic inputs & it greatly influences optimum N management

- Have back-up plans for when weather causes challenges
Be an economist, pay attention to details

- Control costs without impacting yield
- Conduct simple on-farm tests
- Be timely & site specific
- Don’t overlook the basics:
  - Crop rotation
  - Hybrid selection
  - Stand establishment
  - Weed control
New Innovations in Corn Cropping Systems

With John Baker, Rod Venterea, & Jon Alexander

(USDA-ARS & Univ. of MN)

http://z.umn.edu/corn
Corn production in kura clover living mulch

To improve water & soil quality without reducing profitability

Photo: Jon Alexander
Kura clover

- Perennial
- Spreads by rhizomes
- Deep rooted – can scavenge soil N
- Legume – can fix N
- Cold hardy
- Persistent

Photos: John Baker, USDA-ARS
Kura clover living mulch-corn systems demonstrate potential in northern Corn Belt

- Compared with standard corn systems:
  - Reduces runoff by 50% & erosion by 77% on 8-15% slope
  - Enhances soil organic carbon
  - 74% reduction in soil nitrate-N in non-fertilized corn
  - Kura clover competes with corn if not properly suppressed
  - Even with proper suppression, corn grain yield can be reduced by 5 to 21%, depending on precipitation
New research is developing ways to gain these benefits & mitigate the drawbacks
Corn production in kura clover living mulch

Step 1: Establish kura clover (photo: April 24, 2017)

Photo: John Baker, USDA-ARS
Corn production in kura clover living mulch

Step 2: Mow kura clover in spring

Photo: John Baker, USDA-ARS
Corn production in kura clover living mulch

Step 3: Rotary zone tillage with some N application
(photo: May 11, 2017)

Photo: Bill Breiter, USDA-ARS
Corn production in kura clover living mulch

Step 4: Plant glyphosate-tolerant corn on strips
(photo: May 12, 2017)
Corn production in kura clover living mulch

Vigorous re-growth 2 weeks after planting (May 25, 2017)

Photo: Jon Alexander, Univ. of MN
Corn production in kura clover living mulch

Step 5: Apply glyphosate to suppress kura clover
(photo following glyphosate application)

Photo: John Baker, USDA-ARS
Corn production in kura clover living mulch

Step 6: Sidedress additional N

(photo on June 21, 2017)

Photo: Bill Breiter, USDA-ARS
July 6: Healthy stand of clover fills in understory by mid-season

Aug 24: Canopy closes over clover by late season

Photos: Jon Alexander, Univ. of MN
Corn production in kura clover living mulch

Step 7: Harvest corn grain & stover

Step 8: Repeat on strips in spring

Photo: John Baker, USDA-ARS
Research from 2017 & 2018 for 1\textsuperscript{st}- & 2\textsuperscript{nd}-year corn in kura clover living mulch indicates:

- Yield similar to corn following soybean & corn
- Reduced N fertilizer requirement (similar to 1\textsuperscript{st} - & 2\textsuperscript{nd}-year corn following alfalfa)

Limitations:

- Kura clover seed availability & establishment
- Economic viability uncertain
Thank you!