Fertilizer Use for High Yield Corn

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High Yield Corn: Topics

• Economically optimal N rates
• N use efficiency
• P, K, S
• Implications of 2012 drought
34 site-years (13 on-station, 21 on-farm), all irrigated

corn following soybean  16
corn following corn  13
corn following dry bean  5
No-till: 11, Ridge-till: 9, Conv. Till.: 14
Max. treatment mean = 240 bu/ac

NSFP sites 2002-2004
# NSFP Treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Ib N/acre</th>
<th>Ib P(_2)O(_5)/acre</th>
<th>Ib K(_2)O/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C-C</td>
<td>C-S</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>N(_0)P(_1)K(_1)</td>
<td>0</td>
<td>41</td>
</tr>
<tr>
<td>2</td>
<td>N(_3)P(_0)K(_1)</td>
<td>200</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>N(_3)P(_1)K(_0)</td>
<td>200</td>
<td>41</td>
</tr>
<tr>
<td>4</td>
<td>N(_1)P(_1)K(_1)</td>
<td>100/125 50/75</td>
<td>41</td>
</tr>
<tr>
<td>5</td>
<td>N(_2)P(_1)K(_1)</td>
<td>150/175 100/125</td>
<td>41</td>
</tr>
<tr>
<td>6</td>
<td>N(_3)P(_1)K(_1)</td>
<td>200/225 150/175</td>
<td>41</td>
</tr>
<tr>
<td>7</td>
<td>N(_4)P(_1)K(_1)</td>
<td>300</td>
<td>41</td>
</tr>
<tr>
<td>8</td>
<td>N(_4)P(_2)K(_2)</td>
<td>300</td>
<td>82</td>
</tr>
<tr>
<td>9</td>
<td>UNL</td>
<td>75-235</td>
<td>0-40</td>
</tr>
<tr>
<td>10-12</td>
<td>10-12</td>
<td>optional</td>
<td></td>
</tr>
</tbody>
</table>

**Abbreviations:**
- C-C: Application rate
- C-S: Application rate
- Ib: Ibuprofen

**Notes:**
- 10-12 optional
- UNL: Upper Limit
- 75-235: Application rate
- 0-175: Application rate
- 0-40: Application rate
Response to applied N is a typically curvilinear-plateau response.
Mean N uptake with no N applied was 160 lb/ac with 2.7% SOM!

Mean N uptake in Uganda was 40 lb/ac with 2.7% SOM!!

Vigorous plant (root) growth
Return of crop residues
Nature of SOM
N response: soybean - corn

Corn following soybean

Relative yield (% of max. yield)

N rate (lb/acre)

East
Northeast
South-Central

Relative yield (% of max. yield)

N rate (lb/acre)
N response at 5 N:grain price ratios for corn following corn

The mean economically optimal N rate (EONR) for a N:maize price ratio of 7 was 158 lb/ac N.

At EONR, mean yield was 237 bu/ac, fertilizer N recovery was 66%, and 49 lb/ac residual soil nitrate-N remained after harvest.
N response at 5 N:grain price ratios for corn following soybean

The mean economically optimal N rate (EONR) for a N:maize price ratio of 7 was 111 lb N/ac.

At EONR, mean yield was 231 bu/ac, fertilizer N recovery was 76%, and 57 lb/ac residual soil nitrate-N remained after harvest.
EONR distribution

Corn-corn, 12 site-yr
- Mean = 156 lb/ac N
- Minimum = 91
- Maximum = 240
- Low 25% ≤ 114
- Top 25% ≥ 171

Soy-corn, 16 site-yr
- Mean = 111 lb/ac N
- Minimum = 72
- Maximum = 150
- Low 25% ≤ 93
- Top 25% ≥ 128

Can we predict EONR for individual fields?
UNL Nitrogen Corn Recommendation

N Rate (lb/acre) = 35 + (1.2 x EY) – (8 x NO₃-N) – (0.14 x EY x OM).

EY = Expected yield (bu/acre)
NO₃-N = Root zone residual nitrate-N (ppm)
OM = Soil organic matter (%)

Additional credits for legumes, manure and irrigation water subtracted from basic algorithm.

Adjustment for fertilizer:grain price
Adjustment for time of application
Corn Nitrogen Rate Calculator

Finding the Maximum Return To N and Most Profitable N Rate
A Regional (Corn Belt) Approach to Nitrogen Rate Guidelines

This web site provides a process to calculate economic return to N application with different nitrogen and corn prices and to find profitable N rates directly from recent N rate research data. The method used follows a newly developed regional approach for determining corn N rate guidelines that is being implemented in several Corn Belt states.

Regional Corn N Rate Publication

Choose state

Iowa
Illinois - North
Illinois - Central
Illinois - South
Minnesota
Wisconsin - VH/HYP Soils
Wisconsin - M/LYP Soils
Wisconsin - Irr. Sands

Choose rotation pattern(s)
- Corn following soybean
- Corn following corn

Include non-responsive sites

Set corn and nitrogen prices

Anhydrous Ammonia (82% N) 360.80 ($/Tcn)
Nitrogen price 0.22 ($/lb N)
Corn price 2.20 ($/bu)

Calculate Reset

More Info How to Use
Why the components in Nebraska N equation?

- Yield goal: varies from <50 to >250 bu/ac in NE but maybe 140 to 220 bu/ac in IA
- Residual soil nitrate-N: less likely to be lost in NE to leaching and denitrification compared with IA, especially where rainfall is less
- SOM: varies from 0.5 to >3% in NE but maybe 2.0 to >3% in IA
Prediction with the UNL algorithm

• On average, it was very close
  • Within 5 lb/ac N for S:C
  • About 12 lb/ac over for C:C

• However, much site-year variation in N effect on yield and N uptake
  • predicted and actual EONR not well-related
  • components of algorithm were not well related to yield and N uptake response to N rate

• In-season assessment and application probably needed to approach EONR
Nitrogen use efficiency:

more bu/lb and less loss;

is high NUE compatible with high yield?
Nitrogen use efficiency

Corn produced per lb applied N has doubled since 1960.

y = 0.7153x - 1372.9

\( R^2 = 0.7081 \)
**Nitrogen Losses**

**Volutilization:** surface applied manure or fertilizer ammonium N may convert to ammonia gas and be lost to atmosphere.

**Runoff:** causes N loss and water contamination.

**Denitrification:** reduction of nitrate-N to N\(_2\) or nitrous oxide under low O\(_2\) conditions.

**Leaching** of nitrate-N below the rooting zone.

Runoff: causes N loss and water contamination.
Fertilizer N recovery efficiency

National average is less than 0.4 lb/lb

Corn-corn

Soybean-corn
Drought Implications for Nitrogen Management

Charles Wortmann
• What are the implications of the 2012 drought for nitrogen management in 2013?
• Do fertilizer rates need to be adjusted?
• Is the soybean credit still valid?
• How was the release of manure N affected?
N management

• Residual soil nitrate levels
  – often unusually high
    • rainfed and irrigated fields
    • following soybean as well as corn
  – Several contributing factors relating to 2012 weather conditions.
High residual soil nitrate levels

- High soil organic N mineralization because of high temperatures.
- Reduced yield ~ reduced N uptake
- Less leaching and denitrification losses
- Early crop maturity, less robust plants, a warm fall, & more soil N resulted in more decomposition of crop residue, especially soybean leaves, for more N release.

- High residual soil nitrate following soybean and corn.
Taking stock of residual nitrate-N

• Deep sampling, at least to 24” but 0-8” depth especially important for 2013

• UNL algorithm credits 50-60% of nitrate-N found but give more credit if low soil water, especially if
  – used with in-season diagnosis
    • pre-sidedress nitrate test
    • reading the crop canopy reflectance
What is the soybean N credit? Will it be affected?

- Less immobilization of N with soybean compared with corn crop residue
- Mineralizable soil organic N increases with soybean (exudates/nodules) but decreases with corn production
Manure N and S

• Organic N and S release
  – Less in 2012 for very dry fields but
  – Maybe more for irrigated fields because of high temperature and high microbial activity
N suggestions for 2013

• Give the 45 lb credit, even where soybean yields were low.

• Deep sample for nitrate for 2013 N management, including after soybean

• Consider N from manure applied in 2011-12

• Apply less than normal N pre-plant and sidedress or fertigate according to crop need
  • Pre-sidedress soil nitrate test
  • Apply according to canopy greenness

• Consider yield potential
In-season evaluation

• Pre-sidedress nitrate test (PSNT): Soil NO$_3$-N in 0-12” soil depth when corn is 12” tall or >1 week before planned sidedressing.
  – Most valuable with manure applied
  – Less valuable with cool spring or leaching conditions
  – 2013!!

• Leaf color, chlorophyll meters, sensors, tissue samples
Phosphorus (P), Potassium (K), Zinc (Zn)

• Where are the applied 2012 nutrients for rainfed fields? How will low 2012 uptake affect 2013 availability?

• Immobile nutrients
P-rainfed fields

• Unused 2012 P was sorbed
  – Still present
  – in equilibrium with solution and non-labile P

• Increased soil test P is expected
  – Soil test important for 2013 management but misleading for future years

• Generally less fertilizer P needed in 2013 rainfed
Potassium for rainfed fields

• Less K uptake in 2012
  – 4-8 lb K$_2$O to raise STK by 1 ppm
    • Affected by soil CEC

• However, little leaching of K from crop residue; STK can be increased by 30-40 ppm by leaching of K from crop residues
  – Less leaching from residues and lower STK?
Drought effect on soil test K

- Some evidence that ratio of exchangeable to less-exchangeable K in soil decreases with drought; therefore, reduce STK
  - Lab results may under-represent STK in 2012

<table>
<thead>
<tr>
<th>Relatively unavailable K</th>
<th>Slowly available K</th>
<th>Readily available K</th>
</tr>
</thead>
<tbody>
<tr>
<td>90–98 percent of total</td>
<td>1–10 percent of total</td>
<td>percent of total</td>
</tr>
<tr>
<td>Non exchangable K</td>
<td>Exchangable K (90 percent of 2 percent)</td>
<td>Soil Solution K (10 percent of 2 percent)</td>
</tr>
</tbody>
</table>
Potassium for rainfed fields

• High or low STK expected this spring?
• Depends on
  – K uptake
  – K leached from crop residues
  – Drought effects on representiveness of soil K test
• STK important for 2013 management but mis-leading for future years
• Probably reduced fertilizer K needed in 2013
Zinc

• Similar guidelines as for P and K
Drought and soil pH

• Soil test pH likely to be reduced
  – maybe by 0.1 to 0.3 unit
  – but soil pH can be restored to normal with ~2” of rain
  – no clear effect on buffer pH, the value used to determine lime requirement

• More lime applied with more irrigation
Grid sampling

• Delay to a more typical year
Table 1. Estimated impact on next year’s fertilizer need (drought nutrient credits) for selected harvest strategies for drought stressed corn or soybean. Assumes fertilizer applied this year was based on 150 B/A yield for corn and 50 B/A yield for soybean. Arrow down means recommended fertilizer rate for next year should decrease by the associated value.

<table>
<thead>
<tr>
<th>Harvest Management</th>
<th>Corn N</th>
<th>Phosphate</th>
<th>Potash</th>
<th>Soybean N</th>
<th>Phosphate</th>
<th>Potash</th>
</tr>
</thead>
<tbody>
<tr>
<td>No crop harvested</td>
<td>□145</td>
<td>□50</td>
<td>□40</td>
<td>0</td>
<td>□40</td>
<td>□65</td>
</tr>
<tr>
<td>Harvested as grain (40% of yield goal)</td>
<td>□70</td>
<td>□30</td>
<td>□25</td>
<td>0</td>
<td>□24</td>
<td>□40</td>
</tr>
<tr>
<td>Grazed</td>
<td>□40</td>
<td>□50</td>
<td>□40</td>
<td>0</td>
<td>□40</td>
<td>□65</td>
</tr>
<tr>
<td>Chopped and removed(^1)</td>
<td>0</td>
<td>□15</td>
<td>□60</td>
<td>0</td>
<td>□20</td>
<td>□25</td>
</tr>
</tbody>
</table>

\(^1\) Assumes most growth stopped at R1 for corn and R3/4 for soybean.
Anhydrous application with dry soil?

• Can you get it into the ground??
• Will the soil close well?
• Is soil water adequate?
  – Soil water needed for NH$_3$ to convert to NH$_4^+$ and react with soil
Ammonia Application to Soil

Ammonium (NH$_4^+$) binds rapidly to cation exchange sites on soil clay particles and soil organic matter. Hydroxyl anions effectively increase soil pH.
Anhydrous Ammonia Retention Zone

Valentine sand
CEC 3.8 meq/100g
pH 6.6

Hastings silt loam
CEC 23.5 meq/100g
pH 6.2

180 lb N/acre
30 inch knife spacing
Outlet depth 4 inches

N loss = 2.4 lb/acre (1.3%)
Anhydrous application with dry soil?

- Soil water needed for NH$_3$ to convert to NH$_4^+$ and react with SO

Stanley and Smith

Failed furrow closure
Anhydrous application with dry soil

- Most important is good furrow closure
- Soil water is generally adequate
Response to 40 lb/ac P2O5

Yield response, bu/Ac

Soil test P, Bray-1
Broadcast P recommendation based on soil test P and previous crop

Fertilizer P (lb P₂O₅/ac⁴) vs. Bray #1 P

- Corn following Corn
- Corn following Soybean

From: Shapiro et al., 2009.
Do we need high STP for consistently high yields?

- Nutrient removal will increase
- But high yield crops are expected to have healthy, well-developed roots systems efficient in nutrient uptake
- Slow to warm soils???
Slow-to-warm soils issue

- MN results show that high STP may be important in cases of slow to warm soils
  - Latitude dependent issue?? Canada, Great Britain, MN
- Study at: SCAL 8-10 yr; HAL >10 yr
- 2011-15 study at 3 locations to compare UNL P recommendations to 25 and 35 mg/kg STP
  - continuous maize
  - tilled and no-till
Reasons to consider maintaining high soil test levels

- Soil test levels vary across field; maintaining higher levels reduces risk of having low level areas
  - Minimize risk with site-specific management
- Applications can be withheld for one or two years in cases of unusually high costs
  - Depends on rental arrangements
K application often results in reduced grain and biomass yield in Nebraska

<table>
<thead>
<tr>
<th>Previous crop</th>
<th>0 kg/ha K</th>
<th>40 kg/ha K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybean</td>
<td>229</td>
<td>222*</td>
</tr>
<tr>
<td>Corn</td>
<td>235</td>
<td>232</td>
</tr>
<tr>
<td>Drybean</td>
<td>235</td>
<td>225</td>
</tr>
<tr>
<td>All</td>
<td>232</td>
<td>226*</td>
</tr>
</tbody>
</table>

Supported by findings of Miany and Olson (Miany, 1980) at UNL-ARDC and by McCallister et al. (1988) across numerous site-years.
Table VI. Potassium fertilizer suggestions.

<table>
<thead>
<tr>
<th>Potassium Soil Test, ppm K</th>
<th>Relative Level</th>
<th>Amount to Apply Annually (K₂O), lb/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Broadcast¹</td>
</tr>
<tr>
<td>0 to 40</td>
<td>Very Low (VL)</td>
<td>120</td>
</tr>
<tr>
<td>41 to 74</td>
<td>Low (L)</td>
<td>80</td>
</tr>
<tr>
<td>75 to 124</td>
<td>Medium (M)</td>
<td>40</td>
</tr>
<tr>
<td>125 to 150</td>
<td>High (H)</td>
<td>0</td>
</tr>
<tr>
<td>Greater than 150</td>
<td>Very High (VH)</td>
<td>0</td>
</tr>
</tbody>
</table>

From: Shapiro et al., 2009.
Effect of 22 kg/ha sulfur, irrigated corn

5 trials each for sandy and medium/ fine textured soil.

No additional response to 44 kg S/ha.

<table>
<thead>
<tr>
<th>Texture</th>
<th>0 lb S</th>
<th>20 lb S</th>
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<tbody>
<tr>
<td>Sandy</td>
<td>226.2</td>
<td>232.3</td>
</tr>
<tr>
<td>Fine</td>
<td>214.8</td>
<td>214.1</td>
</tr>
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About 100 S application trials conducted for corn, sorghum, soybean since 2000; verify UNL recommend.

S application commonly results in greener crops; cost is not great; on-going verification needed. Environmental and S resource availability issues relatively minor.
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Around 100 S application trials for corn, sorghum, soybean since 2000; verify recommendation

S application commonly results in greener crops; cost is not great; on-going verification needed. Environmental and S resource availability issues relatively minor
Test irrigation water for all nutrients

1965 report: 1141 wells; approx. median/mean lb/ac-ft

- Potassium: 37; Grant Co. 190
- Calcium: 110; Grant Co. 250
- Magnesium: 37; Cheyenne 85
- Lime: 400
- Sulfur: 27; Douglas 500; Keith 300
- Boron: 0.6; Box Butte 0.75
- Chloride: 30; Dixon/Johnson 150
www.soiltest.unl.edu
Fertilizer Suggestions for Corn

Charles A. Shapiro, Richard B. Ferguson, Gary W. Hergert, and Charles S. Wortmann, Extension Soils Specialists; Daniel T. Walters, Professor of Agronomy and Horticulture

Fertilizer nutrient requirements for corn are based on expected yield and nutrient levels in the soil. This revision contains slight changes to the nitrogen (N) recommendation equation depth of 0 - 8 inches every three to five years in the fall. Most Nebraska soils supply adequate amounts of K, sulfur, zinc, and iron, but on some soils the corn crop will benefit from applying...
Corn Growers 2008

 knew how. Know now.

http://cropwatch.unl.edu/web/soils/home/
CropWatch: Corn
Nebraska Corn Production, Pest Management, and Research Information

Nebraska Corn
The latest information on corn production and management practices from the University of Nebraska-Lincoln.

Corn Planting Depth, Date, and Population Information
With these nice spring days, you may be eager to start planting, even in wet soils where planting may be difficult. Remember that many agronomic problems that occur later in the season start with how things were done at planting, particularly the planting depth you use. For more information on problems related to planting depth, click here. You can also check out the April 2, 2010 Market Journal segment on this topic by clicking here.

As corn hybrid genetics and seed treatments continue to improve, producers are often encouraged to consider increasing their plant populations and...
Lime use to amend acid soils

Determine the variability in soil pH. Is variable rate or site-specific application justified?

- management zones
- grid sampling
- on-the-go sensor mapping?
A scoop drops to collect soil sample. The scoop of soil is brought up to ion specific electrode and pH is read. Scoop is lowered for next sample. Electrode is washed. Electrical current is sent from coulter through soil to be intercepted by another coulter to measure EC at different depths.
Grid sampling vs sensor mapping of soil pH: MS field
Control of lime rate

• Lime is broadcast applied; particle size is small
  – Uniformity of application is affected by wind and slope
  – How much overlap of passes is needed?
• Can variable rate applicators respond quickly enough to detailed prescription maps?
• Alternative application
  – Pelletize ag lime, finer particle size
    • More value per ton
  – Adapt dry fertilizer boom air-flow technology for lime
The agronomics and economics of variable rate liming

Trials in Nance, Saunders, and Wayne Counties
4 treatments
2 reps
Thank you!
Questions?