Lessons Learned from Iowa On-Farm Studies
Testing Manure Nitrogen Availability

Heartland Animal Manure Management Workshop

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ISA On-Farm Network®

- On-Farm Network organizes farmers to use precision ag. technologies to evaluation management practices in crop production.
- We work with about 300-400 farmers in Iowa every year.
Outline

1. Manure N availability: “Agronomic fertilizer equivalency of manure” vs “Fair market manure value”.

2. Examples of estimating “Agronomic N fertilizer equivalency of manure”.

3. Feedback based on-farm evaluations to improve manure management.
“Available forms of nutrient are those whose variations in amount are responsible for significant variation in yield or yield response.

The availability of these forms, however, involves not only their chemical and physical nature but also the ability of the plant to forage for them with its root system”.

Roger Bray, Soil Science, 1954
• “Available nutrients are (1) the amount of a soil nutrient in chemical forms accessible to plant roots or compounds likely to be converted to such forms;

• (2) the contents of legally designed available nutrients in fertilizers determined by specified laboratory procedures, which in most states constitute the legal basis for guarantees.

Soil Science Society of America, 1997
The 1997 definition of nutrient availability is more focused on “potential fertilizer equivalency” to estimate a fair trade of the fertilizer value of manure.”

Bray’s definition suggests to consider:
1. the position of nutrient relative the roots;
2. time and period when nutrient is accessible for plant uptake;
3. potential N losses due to leaching or denitrification
4. potential plant competition with soil microorganisms for N; i.e. the direction of N mineralization and immobilization cycle.
Manure Carbon Study in 2004

1. Urea
2. UAN
3. Spring-injected swine manure
4. Ground corn grain
5. Soybean straw

Soybean straw

Ground corn grain

Advancing Agricultural Performance®
Manure Carbon Study-2004

Spring-Injected Liquid Swine Manure

Manure and UAN plots

Carbon plots

UAN
Agronomic N Fertilizer Equivalency

<table>
<thead>
<tr>
<th>N source</th>
<th>UAN equivalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid urea</td>
<td>98</td>
</tr>
<tr>
<td>Swine manure</td>
<td>58</td>
</tr>
<tr>
<td>Corn grain</td>
<td>44</td>
</tr>
<tr>
<td>Soybean straw</td>
<td>-5</td>
</tr>
</tbody>
</table>

-6 121 187 202 55 78

Corn yield (bu/acre)

N rate (lb N /acre)

2004
Agronomic Fertilizer Equivalency of Manure
Agronomic Fertilizer Equivalency of Manure

ST2009001A:

Swine Manure, late fall
Total N=125 lb N/acre

Yield Average by Fertilizer Rate

Econ. Opt. N Rates

Nitrogen Rate (lbs N/a)
- Fertilizer Only
- Manure + Fertilizer
Agronomic N Fertilizer Equivalency of Manure

ST2009183A:

**Beef Manure not Incorporated, spring**

**Total N=200 lb N/acre**

![Yield Average by Fertilizer Rate Graph](image)

- **Grain Yield (Bu/a)** vs. **Nitrogen Rate (lbs N/a)**
- **Fertilizer Only** vs. **Manure + Fertilizer**
- **Fertilizer Only** graph is red, **Manure + Fertilizer** graph is blue.
- Data points:
  - 67 lb N/acre: 77 Bu/a
  - 110 lb N/acre: 110 Bu/a
  - 142 lb N/acre: 142 Bu/a
  - 150 lb N/acre: 150 Bu/a

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**Advancing Agricultural Performance**

**Iowa Soybean Association**

**On-Farm Network**
Fertilizer Equivalency Methods

**Chicken (layer) manure, spring**

100 lb N/acre of total N

<table>
<thead>
<tr>
<th>Rate of fertilizer N (lb/acre)</th>
<th>Corn yield (bu/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>50</td>
<td>13</td>
</tr>
<tr>
<td>100</td>
<td>20</td>
</tr>
<tr>
<td>150</td>
<td>23</td>
</tr>
<tr>
<td>200</td>
<td></td>
</tr>
<tr>
<td>210</td>
<td></td>
</tr>
<tr>
<td>220</td>
<td></td>
</tr>
</tbody>
</table>

No manure

With manure

- 12 bu/acre
- 13 bu/acre
- 20 bu/acre
- 23 bu/acre
On-farm studies with manure often show

1. A combination of manure and commercial N does not decrease the optimal N rates to maximize yields or return to N because of the so-called additive effect of manure and commercial N.

2. Due to many factors involved, agronomic fertilizer N equivalency of manure is very difficult to describe by using one number or even a range of numbers.
A process of evaluating, adjusting and improving management practices by:

- conducting feedback information about manure management performance;
- sharing and discussing results with other farmers, agronomists, crop consultants, and scientists;
- and using evaluation results to make adjustments for the future.
Late-Season Feedback in Corn N Status

• Tools to collect feedback in N status:
  1. Digital aerial imagery.
  2. Corn stalk nitrate test (CSNT).
  3. On-farm replicated strip trials (RST).
  4. Aggregate data analyses and result interpretations.

Iowa State Univ. PM 1584
All Results of On-Farm Evaluations Are On-Line

Imagery Guided Stalk Nitrate Survey

2013 Stalk Nitrate Results

GSS2013/ACD018

Two-Treatment Replicated Strip Trials

Strip Trial Summary Statistics

<table>
<thead>
<tr>
<th>Soil Map Unit</th>
<th>Percent of Trial</th>
<th>Yield (Bu/Ac)</th>
<th>Yield Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washedill Loam, 0 to 2% slope</td>
<td>77.1</td>
<td>167.6</td>
<td>153.6</td>
</tr>
<tr>
<td>Washedill Loam, 0 to 2% slope</td>
<td>91.3</td>
<td>144.5</td>
<td>130.5</td>
</tr>
<tr>
<td>Outlayer Loam, 0 to 2% slope</td>
<td>248</td>
<td>109.2</td>
<td>75.6</td>
</tr>
<tr>
<td>Baseline Loam, 2 to 5% slope</td>
<td>171</td>
<td>158.4</td>
<td>141.0</td>
</tr>
<tr>
<td>Average Yield</td>
<td>153.3</td>
<td>141.0</td>
<td>2.3</td>
</tr>
</tbody>
</table>

*Yield difference calculated for the strip units that have statistically small areas not included.

Yield By Treatment and Soil Map Unit

<table>
<thead>
<tr>
<th>Yield Average by Individual Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>High N Rate</td>
</tr>
<tr>
<td>Low N Rate</td>
</tr>
<tr>
<td>Yield Difference</td>
</tr>
</tbody>
</table>

*GeoMean ppm NO3:

- Low (<250 ppm)
- Marginal (250-760 ppm)
- Optimal (760-2000 ppm)
- High (>2000 ppm)

Rainfall (in.)

- March: 1.8
- April: 4.8
- May: 9.6
- June: 6.2
- July: 2.3
- August: 2.6

*GeoMean ppm of NO3-N includes points 1, 2, 3, but not targeted deficient point 4.
Analysis of Historical Data: 2006-2013

3430 corn fields from 2006 through 2013
Nitrogen Management Categories

Predominant N forms and timing of application:

1. **AA Fall**: fall-applied anhydrous ammonia.
2. **Swine Fall**: fall-injected swine manure.
3. **AA Spring**: spring-applied anhydrous ammonia.
4. **UAN Spring**: spring-applied UAN.
5. **SD UAN/AA**: sidedress UAN or AA

2011. JSWC. 66:373-385
N Rates Resulted in Optimal Corn N Status

Distribution of N rates that resulted in corn optimal N status within 166 corn after corn and 465 corn after soybean fields.
Differences Between N Management Categories

For Optimal N Status, fields with Fall-Injected Liquid Swine Manure required about 10-20% higher N rates than those with commercial N.

Potential reasons:

- Increased yield potentials and higher demand for N;
- Uncertainty in amount of N applied or higher N losses.
- Large uncertainty in manure N availability because of the presence of organic forms or delayed N availability;
Because of a limited number of fields for Spring Manure, we could not confirm that the differences were primary due to timing manure application.
N Rates resulted in optimum corn N status within 65 corn after corn fields and 229 corn after soybean fields from 2006 through 2013.
Verifying Corn Stalk Nitrate Test Calibration

125 on-farm trials with 2 N rates, farmers’ “Normal rate” plus or minus 50 lb N/acre.
In the deficient range, probability of profitable yield response (YR) to additional N ranged from 60 to 70%.
In the excessive range, probability of profitable YR ranged from 40 to 10%.
The optimal range for fields with Fall Manure was \(~1500\) ppm larger than those for fields with different sources and timing of commercial N.
Agronomic Risk of Managing Manure

Compared with commercial N fertilizers, manure management is more risky because of

1. Large within-field variability and common application errors.

2. Uncertainty in amount of N applied.

3. Uncertainty in N availability because the presence of carbon and difficulty to predict N losses.

4. Uncertainty in quantifying manure residual effects.
On-Line Database of Replicated Strip Trial Summaries

On-Farm Network® Replicated Strip Trial Database

Instructions

Limit trial results as desired by selecting one or more Years, Crop, Trial Type, Trial Detail, Watershed and County. Hold the CTRL key and click to select multiple items. After making all of your selections click Display Results.

If you choose just one crop you will see the average yield difference and also have the option to calculate ROI on the trials. To reset your selections click Clear Results.

## On-Line Database of Trial Summaries

<table>
<thead>
<tr>
<th>Year</th>
<th>Watershed</th>
<th>County</th>
<th>Crop</th>
<th>Trial Type</th>
<th>Trial Detail</th>
<th>Yield Difference bu/A</th>
<th>Trial ID</th>
<th>Trial Report Stalk</th>
<th>Nitrate Report</th>
<th>Scouting Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013</td>
<td>Upper Iowa</td>
<td>Hancock</td>
<td>Corn</td>
<td>Plant Nutrition - Manure + Nitrogen</td>
<td>Manure + N vs Manure</td>
<td>22.3</td>
<td>ST2013/A071A</td>
<td>View</td>
<td>View</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>Upper Iowa</td>
<td>Hancock</td>
<td>Corn</td>
<td>Plant Nutrition - Manure + Nitrogen</td>
<td>Manure + N vs Manure</td>
<td>2.0</td>
<td>ST2013/A072A</td>
<td>View</td>
<td>View</td>
<td></td>
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<tr>
<td>2013</td>
<td>Winnebago</td>
<td>Hancock</td>
<td>Corn</td>
<td>Plant Nutrition - Manure + Nitrogen</td>
<td>Manure + N vs Manure</td>
<td>2.0</td>
<td>ST2013/A070A</td>
<td>View</td>
<td>View</td>
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<tr>
<td>2013</td>
<td>Upper Iowa</td>
<td>Hardin</td>
<td>Corn</td>
<td>Plant Nutrition - Manure + Nitrogen</td>
<td>Manure + N vs Manure</td>
<td>-1.5</td>
<td>ST2013/A012A</td>
<td>View</td>
<td>View</td>
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<tr>
<td>2013</td>
<td>North Stank</td>
<td>Jasper</td>
<td>Corn</td>
<td>Plant Nutrition - Manure + Nitrogen</td>
<td>Manure + N vs Manure</td>
<td>22.8</td>
<td>ST2013/A121A</td>
<td>View</td>
<td>View</td>
<td></td>
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<tr>
<td>2013</td>
<td>Boyer</td>
<td>Monona</td>
<td>Corn</td>
<td>Plant Nutrition - Manure + Nitrogen</td>
<td>Expanded Manure</td>
<td>0.0</td>
<td>ST2013/A148A</td>
<td>View</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average Yield Difference of the 7 trials displayed: **10.2 bu/acre**.

90% Confidence Interval for the Average Yield Difference: from **2.7** to **17.7** bu/acre.

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**Return on Investment**

To calculate ROI of the selected trials, enter a market price for this crop and the cost per acre.

<table>
<thead>
<tr>
<th>Market Price:</th>
<th>Cost Per Acre:</th>
</tr>
</thead>
<tbody>
<tr>
<td>$4.5</td>
<td>$25</td>
</tr>
</tbody>
</table>

Average Return on Investment: **$20.90** per acre.

90% Confidence Interval for the Average Return on Investment: from **-$12.85** to **$54.65** per acre.
1. The need to distinguish between “Fair market manure value” vs “Agronomic N fertilizer equivalency of manure”.

2. “Manure N availability” should reflect the risk of N loss or reduced N availability and the impact of factors that commonly influence this risk.
Feedback Based Strategies to Improve Manure Management

• Simply adding more commercial N to manured fields or using the best % of N availability will not solve all problems in manure management.

Farmers can improve manure management by

1. Using in-season N diagnostic tools (i.e., soil testing, chlorophyll meters or canopy sensors)

2. And collecting post-season feedback in N status or performing the so-called “Late-Season Annual N Manure Management Check-Up”.
Late-Season N Check-Up to Adjust Future N Management

Content:
P2. Complexity of N management.
P3. Adaptive management to collect feedback.
P5. On-farm replicated strip trials.
P6. Data collection, summarization and interpretation.
P7. Verifying calibration categories of corn stalk nitrate test.
P8. Using feedback in N status to make adjustments for the future.
P11. Establishing relationship between corn N status, management and rainfall.
P11. Concerns and fears of unexpected results.
P12. Farmer group meetings.
Thank you

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