Making Manure Work in a Crop Nutrient Program

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2005 Crop Pest Management Shortcourse
November 22, 2005
Origin of the word - “Manure”

✓ Manure came from Middle English “manuren” meaning “to cultivate land”

✓ Initially from a French phrase meaning “hand work”
Historical use of manure

- Greek writings from 2,000-3,000 years ago
  - Manuring of vineyards and abundant manuring of thin soils
  - Classification of the richness of manure
    - Human > swine > goat > sheep > cow > oxen > horse
- Romans learned from the Greeks and transferred this information throughout their empire
20th Century Practices
Livestock Manure...Crop Nutrient or a Waste Product?
Recent MN Results Using Manure for Growing Corn After Soybeans

<table>
<thead>
<tr>
<th>County, Year</th>
<th>Corn Yield (bu/acre)</th>
<th>Fertilizer</th>
<th>Swine Manure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nicollet, 93</td>
<td>120</td>
<td>124</td>
<td></td>
</tr>
<tr>
<td>Nicollet, 94</td>
<td>193</td>
<td>206</td>
<td></td>
</tr>
<tr>
<td>Waseca, 96</td>
<td>153</td>
<td>147</td>
<td></td>
</tr>
<tr>
<td>Waseca, 97</td>
<td>165</td>
<td>175</td>
<td></td>
</tr>
<tr>
<td>Dakota, 97</td>
<td>164</td>
<td>170</td>
<td></td>
</tr>
</tbody>
</table>

Fertilizer = Spring applied 120-150 lbs. N/acre
Swine Manure = Spring applied 3,000-4,000 gal./acre

Source: *Hog Manure: Gunk or Gold?*, Gyles Randall
2005 Growing Season Results for Corn After Soybeans

Dairy Manure, Winona County

<table>
<thead>
<tr>
<th>Nitrogen Fertilizer Rates</th>
<th>Yield (bu./acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 N</td>
<td>220</td>
</tr>
<tr>
<td>80 N</td>
<td>230</td>
</tr>
<tr>
<td>120 N</td>
<td>235</td>
</tr>
<tr>
<td>160 N</td>
<td>240</td>
</tr>
</tbody>
</table>

Source: Manure Rate Demonstration Project

Swine Manure, Steele County

<table>
<thead>
<tr>
<th>Nitrogen Fertilizer Rates</th>
<th>Yield (bu./acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 N</td>
<td>150</td>
</tr>
<tr>
<td>80 N</td>
<td>180</td>
</tr>
<tr>
<td>120 N</td>
<td>210</td>
</tr>
<tr>
<td>160 N</td>
<td>230</td>
</tr>
</tbody>
</table>

Source: Manure Rate Demonstration Project
Issues to Overcome When Using Manure as a Crop Nutrient

✔ Variability in the manure product
✔ Variability in the rate of manure application
✔ Variability in the crop available nutrients after application
Manure Variability

✓ Solid vs. Liquid
✓ Livestock specie differences
  ■ Ruminant vs. non-ruminant
✓ Livestock, feed and manure systems management
✓ Manure nitrogen characteristics
  ■ Organic N and inorganic N
## Variability of Nutrients in Manure in Southeast MN, 1990-92

<table>
<thead>
<tr>
<th>Specie</th>
<th>Nutrient</th>
<th>Average</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy</td>
<td>N</td>
<td>29</td>
<td>10 - 47</td>
</tr>
<tr>
<td></td>
<td>P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;</td>
<td>15</td>
<td>6 - 28</td>
</tr>
<tr>
<td></td>
<td>K&lt;sub&gt;2&lt;/sub&gt;O</td>
<td>24</td>
<td>11 - 38</td>
</tr>
<tr>
<td>Swine</td>
<td>N</td>
<td>48</td>
<td>7 - 107</td>
</tr>
<tr>
<td></td>
<td>P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;</td>
<td>28</td>
<td>3 - 64</td>
</tr>
<tr>
<td></td>
<td>K&lt;sub&gt;2&lt;/sub&gt;O</td>
<td>21</td>
<td>7 - 51</td>
</tr>
</tbody>
</table>

It’s important to test the individual farm’s manure!
# Manure Nitrogen Characteristics

<table>
<thead>
<tr>
<th>Manure Type</th>
<th>NH$_3$-N (lbs./1,000 gal. or ton)</th>
<th>Organic N</th>
<th>Total N</th>
<th>% NH$_3$-N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Swine liquid</td>
<td>33</td>
<td>17</td>
<td>50</td>
<td>66%</td>
</tr>
<tr>
<td>Beef liquid</td>
<td>8</td>
<td>21</td>
<td>29</td>
<td>28%</td>
</tr>
<tr>
<td>Dairy liquid</td>
<td>6</td>
<td>25</td>
<td>31</td>
<td>19%</td>
</tr>
<tr>
<td>Turkey solid</td>
<td>8</td>
<td>32</td>
<td>40</td>
<td>20%</td>
</tr>
</tbody>
</table>

Source: Manure Characteristics, Midwest Plan Service-18, Section 1, 2000
Manure Systems Management...
Emptying the Manure pit
Variation in manure samples from unagitated deep-pit swine buildings

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Top of pit</th>
<th>Middle of pit</th>
<th>Bottom of pit</th>
<th>Vertical Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total N</td>
<td>36</td>
<td>35</td>
<td>51</td>
<td>38</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>18</td>
<td>21</td>
<td>72</td>
<td>31</td>
</tr>
<tr>
<td>K₂O</td>
<td>28</td>
<td>22</td>
<td>25</td>
<td>27</td>
</tr>
</tbody>
</table>

Source: Manure Characteristics, Midwest Plan Service-18, Section 1, 2000
Overcoming Manure Variability

✔ Test the manure
  ■ Annually at a minimum
  ■ Build a manure test history
✔ Agitate or mix the manure prior to application

Work towards applying a uniform product
Variability in Rate of Manure Application

✓ Does the application equipment meet the needs of the situation?
✓ Can equipment be calibrated to deliver the desired rate?
✓ Are there equipment modifications available to change the rate?
Manure Rate...State and Federal Regulations

☑ Estimated available N from all sources does not exceed:
  - Crop N needs for non-legume crops or crop N removal for legume crops

☑ Phosphorus applied at a rate and/or frequency which will not allow soil P to increase over a 6-year period
  - Very high soil test P levels and close to surface water
Matching equipment to the situation

Solid manure vs. Slurry manure
Vacuum vs. non-vacuum tanks

Hydraulic-driven vs. PTO-driven pumps
Calibrating Manure Applicators

Method

✓ **Determine average load**
  - *Known volumes* - Use 90% of manufactures listed volume as average hauling load
  - *Load cells* - when volume or weight is unknown, it can be determined by weighing with load cells

✓ Calculate area spread or use loads per field
What affects the rate of manure application?

- Applicator ground speed
- Width of manure application
- Applicator/manure pump flow rate
- Water content of manure

Manure flow rate (gal/min) = Application rate
Area covered (acres/min)
Typical PTO-driven pump, tank applicator systems

✓ Pump flow rate =
  - 800-1,200 gal/min
✓ Normal field operating speeds =
  - 2-8 mph

Example
A tank with a PTO-driven pump providing 1,000 gal/min flow rate with a 12 ft applicator and operating at a maximum speed of 6 mph will result in:

A lowest application rate of 6,800 gal/acre
Hydraulic-driven pumps provide an option for reducing rates.

NOTE: Reduction in the manure flow rate may impact the uniformity of manure application to the soil.
Low manure flow can cause poor distribution of manure.
Distribution systems designed for low flow rates
Use of restrictors for reducing application rates

Restrictor plates decrease the size of the opening allowing reduced manure flow or for maintaining uniform application at slower pump speeds.

Disadvantage: Increased plugging

Placement of in-line restrictor plates
Use of flow valves and meters
Working with solid manure applicators

- Takes more management because of less technology in the equipment
- Uniformity is always an issue
- Use fertilizer N in combination with manure
The *Real World* of Manure Application Rate

8 Manure Rate Demonstration sites were established in southern MN during the Fall 2004

N recommendation goal was 120-140 lbs. N/acre

Average of the 8 sites was 124 lbs. N/acre

<table>
<thead>
<tr>
<th>Site</th>
<th>Available N from manure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site A</td>
<td>123 lbs/acre</td>
</tr>
<tr>
<td>Site B</td>
<td>189 lbs/acre</td>
</tr>
<tr>
<td>Site C</td>
<td>143 lbs/acre</td>
</tr>
<tr>
<td>Site D</td>
<td>101 lbs/acre</td>
</tr>
<tr>
<td>Site E</td>
<td>148 lbs/acre</td>
</tr>
<tr>
<td>Site F</td>
<td>75 lbs/acre</td>
</tr>
<tr>
<td>Site G</td>
<td>117 lbs/acre</td>
</tr>
<tr>
<td>Site H</td>
<td>97 lbs/acre</td>
</tr>
</tbody>
</table>
Overcoming Manure Rate Variability

✓ Calibrate the application equipment

✓ Understand the limitations of the equipment and work toward making improvements

Strive to get uniform application on the land
Variability in the crop available nutrients

✓ Where N availability could be an issue
  • Soil and climate conditions
  • Manure types
  • Timing of manure application
Percent First-Year Crop Available Nitrogen from Manure

<table>
<thead>
<tr>
<th>Livestock</th>
<th>Broadcast / Incorporated</th>
<th>Sweep Inject</th>
<th>Knife Inject</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&gt; 96 hrs</td>
<td>12-96 hrs</td>
<td>&lt; 12 hrs</td>
</tr>
<tr>
<td>Beef</td>
<td>25%</td>
<td>45%</td>
<td>60%</td>
</tr>
<tr>
<td>Dairy</td>
<td>20%</td>
<td>40%</td>
<td>55%</td>
</tr>
<tr>
<td>Swine</td>
<td>35%</td>
<td>55%</td>
<td>75%</td>
</tr>
<tr>
<td>Poultry</td>
<td>45%</td>
<td>55%</td>
<td>70%</td>
</tr>
</tbody>
</table>
Manure Nitrogen Cycle

Most manure nitrogen is:

- Organic N
- Ammonium N (NH$_4^+$)
- Ammonia N (NH$_3$)
- Nitrate N (NO$_3^-$)

If not incorporated:

- Mineralization by soil organisms
- Nitrification by soil organisms

Plants and microbes compete to use ammonium and nitrate to create organic compounds.

Ammonia N (NH$_3$) quickly volatilizes.

Nitrate N (NO$_3^-$) is soluble and easily leaches.

Denitrification:
In warm, low oxygen (saturated) soil, anaerobic soil organisms convert nitrate to volatile compounds.
Mineralization is difficult to quantify

What is needed for the biological process?

- Food supply (manure is an excellent source)
- Favorable temperature
- Supply of oxygen
- Favorable moisture
- Favorable pH
Scheduling manure applications to benefit the crop and environment

*Problem: Application timing is dictated by the manure supply more than the crop nutrient demand*

✔ Applying manure high in inorganic-N during late summer or early fall could lead to higher nutrient losses
  ■ Swine>Poultry>Beef>Dairy
Overcoming the issues with N availability

- Manure sources with higher levels of organic N (dairy and beef) will tend to have more variability in available N due to soil and climate conditions
  - Apply fertilizer N in combination with manure to reduce risk
- Applying manure with high ammonium levels could lead to N losses similar to commercial fertilizers
Summary

✓ Not an exact science
  ■ Manage manure nutrients to reduce risk
✓ Test manure on a regular basis
✓ Be as accurate as possible in application
✓ Become familiar and follow State and Federal Regulations
Questions?