The effects of manure application on phosphorus loss

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The Effects of Manure Application on Phosphorus Loss

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Current professional work / research interests:

I am currently not involved directly in Agronomy. I do advise farmers on their animals nutritional needs as well as forage management both in the field and upon harvest time. I hope to move back into an agronomy role in a field level that still allows interaction with farmers.
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• How to determine the phosphorus application rate based upon crop need.

• How to perform an assessment of potential phosphorus loss due to manure application
Introduction

Importance of Nutrient Planning

Nutrient management from manure is important for multiple reasons.

- To avoid water contamination
- Take advantage of available nutrients on farm
- Reduce off farm costs

Each farm needs to tailor their manure plan to their farm. Currently Comprehensive Nutrient Management Plans (CNMPs) are much more complex than many farms need. The time commitment and cost can discourage many farmers from participating in this unless they are required to by the government either due to size or wanting to partake in a program.

This doesn’t mean that there cannot be a plan in place to prevent excessive nutrient loss from incorrect application of manure.
Introduction

Why?

• More recently agriculture has come under public scrutiny for nutrients contaminating public waterways.

  • Gulf of Mexico Dead Zone
  • Des Moines Water Authority Lawsuit
  • Chesapeake Bay
  • Lake Erie Algal Bloom

• While agriculture is by no means the only polluter, farmers and their practices are facing increased scrutiny.

• It is important for farmers to be able to defend themselves and educate the public about why they apply nutrients in a certain manner.

• As phosphorus makes it’s way into the waterway, it is no longer the limiting nutrient; thus it contributes to deterioration of water quality.
Impact on Water Quality

• When phosphorus is no longer a limiting nutrient, eutrophication can occur.

• Eutrophication is the depletion of oxygen within waterways as the result of algae growth (Al-Kaisi and Licht, 2005).

• A depletion of oxygen within the algal blooms also known as a hypoxic or “dead” zone can lead to a loss in wildlife such as fish, shellfish, and birds that need that water to survive.

• Poor water quality caused by an excess of phosphorus not only impacts the ability of wildlife and humans to use the water, it also causes an economic loss in other industries such as fishing and recreation (EPA, 2015).
Introduction

Current Resources

Currently, there are various resources that can help farmers determine when to apply manure such as:

- Michigan State University (https://enviroimpact.iwr.msu.edu/)
- Iowa State University (http://www.agronext.iastate.edu/immag/pubsnm.html)

These tools are developed by different universities and their partners are modified as new research becomes available.

Many of these tools have been specialized based on the region the university is located in. There are also many bulletins that can be found webpages of agricultural universities.
Phosphorus Transport

Phosphorus Loss Factors and Equation

Loss Factors

- Erosion Rate
- Runoff class
- Frequency of flooding
- Distance to surface waters
- Subsurface Drainage
- Phosphorus levels in soil
- Application rate
- Application method

P-Index

- There is a formula that calculates the potential phosphorus loss, also known as P-Index, using RUSLE2, tillage, and drainage which is available online from the USDA – NRCS.
Application and Incorporation Methods

Application Methods

There are various application methods that can be utilized depending on set up and type of manure.

- Broadcast:
  - Liquid Tank Spreaders
  - Drag Hose for liquids
  - Dry Spreaders
- Knife Injection:
  - Manure is placed directly underneath the soil surface (LaBarge, 2016)
- Irrigation:
  - Only used for liquids
  - System must be appropriate for manure (Jarrett and Graves, 2014)

Broadcast application by liquid tank spreaders
Photo courtesy of B. Osantoski (personal communication, text message, 2018)
Application and Incorporation Methods

Incorporation Methods

- There are various options when it comes to incorporation of manure following application.
  - No incorporation following broadcast
    - Leads to the highest loss via runoff (Minnesota Pollution Control Agency, 2018)
  - Chisel Plow
  - Moldboard Plow

- In trials by Daverede et al. (2004) all plots that had any type of incorporation showed decreased levels of phosphorus in runoff versus plots without incorporation.

Tillage shanks attached behind broadcast spreader
Photo courtesy of Falor, 2018
Application and Incorporation Methods

Incorporation Methods

- A study done by Rotz et al. (2011) that evaluated different applications of both swine and dairy manure showed a reduction in phosphorus loss in most cases when incorporation was used.

<table>
<thead>
<tr>
<th>Phosphorus Loss by Incorporation Method as a Percentage of Phosphorus Loss by Broadcast Application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Dissolved Phosphorus</td>
</tr>
<tr>
<td>Dairy</td>
</tr>
<tr>
<td>35.7%</td>
</tr>
<tr>
<td>45.7%</td>
</tr>
<tr>
<td>Swine</td>
</tr>
<tr>
<td>14.9%</td>
</tr>
<tr>
<td>54.5%</td>
</tr>
<tr>
<td>Total Phosphorus</td>
</tr>
<tr>
<td>Dairy</td>
</tr>
<tr>
<td>59.5%</td>
</tr>
<tr>
<td>54.4%</td>
</tr>
<tr>
<td>Swine</td>
</tr>
<tr>
<td>77.2%</td>
</tr>
<tr>
<td>104.5%</td>
</tr>
</tbody>
</table>

Adapted from Rotz et al., 2011
Application and Incorporation Methods

Incorporation Methods (cont.)

- While increased incorporation led to decreased phosphorus concentration in surface runoff, forms of incorporation that reduced surface residue increased overall soil erosion of the fields (Al-Kaisi and Licht, 2005).
- If a crop, such as alfalfa, is present in a field when manure is applied, this helps reduce erosion as well as facilitate nutrient uptake.
Effect of Soil Type and Tiling

Soil Type

- More coarsely textured soil provide a more uniform flow of nutrients throughout the soil profile (Glaesner et al., 2011). Since there is a more structure to the soil this means that the nutrients can flow more freely through the soil.

- Phosphorus loss on the other hand is higher in clay loams than loamy sands (van Es et al., 2004).

Tiling

- If a field has tile drainage, it has an higher potential for phosphorus leaching (van Es et al., 2004). A study by Hergert et al. (1981) concluded that manure applications increased the probability of phosphorus parts above 30 parts per billion in tile discharge.
  - With a 35 metric ton application the increase in occurrence at 1 year was 0.05 and at 3 years .08
  - With a 200 metric ton application the increase in occurrence at 1 year was 0.06 and at 3 years 0.47
Effects of Slope

Slope

- The slope of a field or section of field plays a role in nutrient loss, largely from erosion and surface run-off of unincorporated manure.

- The direct correlation of soil loss and slope gradient has been debated over the years and continues to be a current agricultural research topic. In a study by Shen et al. (2016) soil erosion greatly increased when a slope gradient went from 10 degrees to 15 degrees; however, the difference was much less from 15 degrees to 20 degrees. This indicates that slope plays a part in soil erosion, but once it hits a certain gradient the changes are less dramatic.

- An increase in soil slope leads to an increase in surface runoff when rain events occur (Davis, 2013).
Application Timing

Weather

- If a rain event takes place too soon after application and before incorporation, an increase in manure loss from surface run-off occurs.

Example of run-off through pasture after rain event
Photo courtesy of A. Tyrrell (personal communication, text message, 2018)
Application Timing

Seasonality

- Fall applications of manure result in the highest loss of nitrates due to a number of factors including timing until crop uptake (van Es et al., 2006).
- Applying manure on frozen ground can lead to an increase in nutrient loss due to a decrease in infiltration and the inability to incorporate, thus leading to an increase in manure present in surface run-off (Sawyer and Mallarino, 2009).
- Levels of increased phosphorus in runoff occur during late winter and early spring as the ground is thawing (Minnesota Pollution Control Agency, 2018).

Adapted from Vadas et al., 2017
The most accurate way for a farm to develop a plan is to use specific data. This includes:

- Taking manure samples correctly and using those analysis when planning
- Having soil sample results for fields they are planning to spread on

If manure sample results are not available for a farm, there are “book values” available from various universities that can be used. However, accuracy of these values is not guaranteed as there is much variation in these “book values”.

Species Specific Information

Farm Planning and Management Practices

Photo courtesy of B. Osantoski (personal communication, text message, 2018)
Manure Samples

How to sample liquid manure

Lagoon or Liquid Storage Surface:

- Use plastic cup on end of 10 to 12 foot handle
- Take multiple samples from around the pit at approximately 1 foot below surface and 6 ft off bank (Chastain, 2018)
- Mix samples in bucket
- Take a 16 ounce sample of this mixture and place in a 20 ounce plastic bottle with cap.
- If possible freeze before sending
- Mail to an accredited lab for testing

Agitated Liquids:

- Throw bucket toward center of lagoon
- Stay within 75 to 100 feet of the agitator (Chastain, 2018)
- Make sure that the bucket has time to sink as dragging back in with rope.
- Make sure that the bucket is above the water before it hits the bank
- Mix individual samples in large bucket
- Take 16 ounce sample of this mixture and place in a 20 ounce plastic bottle with cap.
- If possible freeze before sending
- Mail to an accredited lab for testing
Manure Samples

How to sample solid manure

Stockpile

• Take multiple samples from around the pile
• Samples must be at least 18 inches deep in the pile (Zhang and Hamilton, 2017)
• Mix all samples thoroughly in bucket, quickly as to avoid letting it dry
• Take sample from bucket place in plastic bag
• If possible freeze before shipping
• Ship to accredited lab for manure analysis

Photo Courtesy of C. Tyrrell (personal communication, text message, 2018)
Manure Samples

How to read manure sample results

• Once samples have been sent to the lab the results will be received in a manner similar to soil samples.
• When samples are sent in, the selection of test to run can provide a variety of information. The very basic tests should provide at least total nitrogen, phosphorus, potassium and dry matter. While more intensive testing can include micronutrients (Rieck-Hinz et al., 2011).
• When reading manure results be sure to monitor the following variations that can be included:
  • Nitrogen – Is it reported as total nitrogen or do they also include ammonium-N (inorganic) which allows calculation of organic nitrogen (Rieck-Hinz et al., 2011)?
  • Phosphorus – Is it reported as P or P$_2$O$_5$ (Rieck-Hinz et al., 2011)?
  • Potassium – Is it reported as K or K$_2$O (Rieck-Hinz et al., 2011)?
Manure Samples

Manure Applications based on Nutrient Needs

- Recommendations for manure application can be made based upon either phosphorus requirements or nitrogen requirements.
- If recommendations are based on Nitrogen requirements for the plant, the phosphorus level in the soil can build (Sharpley and Beegle, 2001).
- Even if recommendations are based on nitrogen needs, it is advised that it should not exceed 4 years worth of phosphorus.
- To keep phosphorus levels in check there are two methods:
  - Full application for needed nitrogen in one year and then no subsequent applications until phosphorus has been utilized (Lory et al., 2005).
  - Limited application to one year worth of phosphorus removal and then manure can be reapplied yearly (Lory et al., 2005).
Manure Samples

**Nutrient Availability**

When planning manure applications to manage nutrients, it is important to remember that all nutrients applied are not available the first year.

The table to the right provides data on nutrient availability for the first 3 years following manure application for 3 of major species grown in confinement.

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cattle</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td>30-50**</td>
<td>25*</td>
<td>10-15*</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>80-100**</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Potassium</td>
<td>90-100**</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Swine</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td>35-80*</td>
<td>15*</td>
<td>0*</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>90-100**</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Potassium</td>
<td>90-100**</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Poultry</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td>45-70**</td>
<td>25*</td>
<td>0*</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>90-100**</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Potassium</td>
<td>90-100**</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Wilson, 2018

**Sawyer and Mallarino, 2016**
Species Specific Information

• The previous section explains one method of how to sample each type of manure. There are other methods that can be utilized as well.

• This section also includes how to interpret the results that are obtained from manure samples.

• It also included the nutrient availability by year for specific species to be used when determining manure application rates.

• The next section provides information that can be utilized if pulling manure samples is not a feasible option.

• These numbers are generalized and are not tailored to the individual farm. Diet being fed to livestock or the amount of time manure is being stored before being spread among other factors can effect the nutrient values of manure.
Species Specific Information

Using Book Values

- The following 2 slides have book values that can be utilized if a manure sample is not available.
- These numbers can vary widely depending on which source you use for a book value.
- As indicated by the table to the right, there can be a lot of variation depending on which source is used.

<table>
<thead>
<tr>
<th></th>
<th>Iowa State University</th>
<th>University of Nebraska</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Swine Slurry (Wet Dry)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td>58</td>
<td>59</td>
<td>-1</td>
</tr>
<tr>
<td>P$_2$O$_5$</td>
<td>44</td>
<td>40</td>
<td>4</td>
</tr>
<tr>
<td>K$_2$O</td>
<td>40</td>
<td>24</td>
<td>16</td>
</tr>
<tr>
<td><strong>Dairy Slurry</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td>31</td>
<td>25</td>
<td>6</td>
</tr>
<tr>
<td>P$_2$O$_5$</td>
<td>15</td>
<td>25</td>
<td>-10</td>
</tr>
<tr>
<td>K$_2$O</td>
<td>22</td>
<td>40</td>
<td>-18</td>
</tr>
<tr>
<td><strong>Turkey Litter</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nitrogen</td>
<td>40</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>P$_2$O$_5$</td>
<td>50</td>
<td>15</td>
<td>35</td>
</tr>
<tr>
<td>K$_2$O</td>
<td>30</td>
<td>30</td>
<td>0</td>
</tr>
</tbody>
</table>

Examples of Variations in Manure Nutrient Value "Book Values"

Adapted from Sawyer, 2009 and Koelsch and Shapiro, 2006
## Species Specific Information: Average Values

<table>
<thead>
<tr>
<th></th>
<th>Nitrogen</th>
<th>P$_2$O$_5$</th>
<th>K$_2$O</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average Manure Nutrient Content (pounds per ton (solids), pounds per 1000 gallons (semi-solids))</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dairy</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solid</td>
<td>9</td>
<td>4.5</td>
<td>7</td>
</tr>
<tr>
<td>Slurry</td>
<td>25</td>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td>Liquid Effluent (pounds per acre inch)</td>
<td>679</td>
<td>674</td>
<td>1082</td>
</tr>
<tr>
<td><strong>Beef</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solid*</td>
<td>9</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Slurry***</td>
<td>25</td>
<td>17.3</td>
<td>24.7</td>
</tr>
<tr>
<td>Liquid Effluent (pounds per acre inch)</td>
<td>79</td>
<td>47</td>
<td>92</td>
</tr>
<tr>
<td><strong>Swine</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid Effluent (pounds per acre inch)</td>
<td>136</td>
<td>104</td>
<td>189</td>
</tr>
<tr>
<td><strong>Solids</strong>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grow-Finish (wet/dry feeder)</td>
<td>59</td>
<td>40</td>
<td>24</td>
</tr>
<tr>
<td>Grow-Finish (dry feeder)</td>
<td>39</td>
<td>34</td>
<td>24</td>
</tr>
<tr>
<td>Grow-Finish (Earthen Storage)*</td>
<td>32</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>Nursery*</td>
<td>25</td>
<td>19</td>
<td>22</td>
</tr>
<tr>
<td>Breeding Gestation*</td>
<td>25</td>
<td>25</td>
<td>24</td>
</tr>
<tr>
<td>Solids***</td>
<td>13</td>
<td>7.5</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Koelsch and Shapiro, 2006
*Sawyer, 2009.
**Hashemi et al., 2013
*** Adapted from Sawyer, 2009 data
Species Specific Information: Average Values (cont.)

Average Manure Nutrient Content (pounds per ton (solids), pounds per 1000 gallons (semi-solids))

<table>
<thead>
<tr>
<th></th>
<th>Nitrogen</th>
<th>P$_2$O$_5$</th>
<th>K$_2$O</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Poultry</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Layer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slurry</td>
<td>57</td>
<td>51</td>
<td>33</td>
</tr>
<tr>
<td>Solid</td>
<td>37</td>
<td>55</td>
<td>31</td>
</tr>
<tr>
<td><strong>Broiler</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slurry*</td>
<td>63</td>
<td>40</td>
<td>29</td>
</tr>
<tr>
<td>Solid*</td>
<td>46</td>
<td>53</td>
<td>36</td>
</tr>
<tr>
<td><strong>Turkey</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solid*</td>
<td>40</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td><strong>Sheep</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solids**</td>
<td>23</td>
<td>8</td>
<td>20</td>
</tr>
<tr>
<td><strong>Horse</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solids**</td>
<td>9</td>
<td>6</td>
<td>11</td>
</tr>
</tbody>
</table>

Koelsch and Shapiro, 2006
*Sawyer, 2009.
**Hashemi et al., 2013
Soil Samples

How to interpret soil tests for application

- Normal soil tests are important when deciding a fertilization plan, whether using manure or synthetic.
  - Frequency of testing varies depending on rotation and fertilizer being applied
  - When establishing a base, 1-2 years is needed (Warncke, 2013)
  - Once established an average number would be to sample once every 3 years (Warncke, 2013)

- In the case of manure the decision for application can be either based upon crop nitrogen needs or phosphorus needs.

- Making manure applications based upon nitrogen can lead to a build up in soil phosphorus levels.

- This means it is important to consider the amount of phosphorus a crop will use.
It is typically suggested that no more than 4 years of crop removal be applied in a single application of manure.

- This helps avoid an excessive soil build up
- Optimal agronomic level is 30-50ppm (Beegle, 2002)

In general, phosphorus can be considered 100% available in the first year. However, some research indicates that it can be as low as 80% plant available phosphorus in the first year (Wilson, 2018).

- If application is being based upon phosphorus to be on the safe side it could be beneficial to use that 80% availability instead.
Many factors effect the nutrient loss that can occur from manure management. Before applying manure, keep in mind the following:

- **Weather** – Application timing in comparison to rain timing.
- **Seasonality** – The timing of nutrient uptake by crops versus application timing as well as soil temperature.
- **Soil sample results** – Current nutrient levels let us know what is already available.
- **Manure sample results** – Allow tailored suggestions based upon what will actually get applied, as long as accurate samples are taken.
- **Slope of the field** – The greater the slope the higher the rate of run-off.
- **Soil type** – Sandier soils tend to have faster infiltration rates of water, however finer soils tend to have a higher phosphorus loss.
- **Application and Incorporation** – The method of application and incorporation have different effects on the loss of nutrients.
- **Application Rate** – Using all the above information can help determine the accurate application rate to reduce the amount of nutrient loss.
The following is an example of making a manure application based upon either nitrogen removal or phosphorus removal.

**Manure Application Example**

**Example Using Dairy Slurry**

Important Numbers for Manure Calculations:

- Manure Analysis
- Soil Analysis – this gives you a base on phosphorus and potassium levels and therefore the phosphorus availability you want to use in the first year.
- 4 year crop plan and target yield
- Nutrient removal by crop
- Nutrient Availability by year for nitrogen and phosphorus
- Nitrogen based manure application plan
- Phosphorus based manure application plan
Manure Application Example

Manure and Soil Analysis

<table>
<thead>
<tr>
<th>Manure Analysis (lbs/1000 gal)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total N</td>
<td>26</td>
</tr>
<tr>
<td>P₂O₅</td>
<td>11</td>
</tr>
<tr>
<td>K₂O</td>
<td>19</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil Analysis (ppm)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphorus</td>
<td>59</td>
</tr>
<tr>
<td>Potassium</td>
<td>223</td>
</tr>
</tbody>
</table>

There are a lot of important details for making the best recommendation when manure application is concerned. Sample results for both manure and soil help to not only make calculations (manure) but overall picture (soil sample).
Manure Application Example (cont.)

Crop Plan and Target Yield

A crop plan and target yields are needed to calculate crop nutrient removal rate for the next four years.

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Crop (Grain)</th>
<th>190 bushels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 2</td>
<td>Soybeans</td>
<td>60 bushels</td>
</tr>
<tr>
<td>Year 3</td>
<td>Corn (Silage)</td>
<td>25 tons</td>
</tr>
<tr>
<td>Year 4</td>
<td>Wheat</td>
<td>80 bushels</td>
</tr>
</tbody>
</table>
Manure Application Example (cont.)

Nutrient Removal by Crops each year

Another piece of necessary information is crop nutrient removal rates. The table below indicates removal rate per bushel or ton of production.

<table>
<thead>
<tr>
<th>Crop Nutrient Removal Rate (lb/bushel or lb/ton)</th>
<th>Nitrogen</th>
<th>P$_2$O$_5$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn (Grain)*</td>
<td>0.9</td>
<td>0.37</td>
</tr>
<tr>
<td>Corn (Silage)**</td>
<td>9</td>
<td>3.6</td>
</tr>
<tr>
<td>Soybeans*</td>
<td>3.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Wheat**</td>
<td>1.2</td>
<td>0.6</td>
</tr>
</tbody>
</table>

The above table takes the values from the table on the left and multiplies them by the target yield for total pounds of removal of these nutrients.
Manure Application Example (cont.)

Nutrient Availability from the Manure by year

<table>
<thead>
<tr>
<th>Nutrient Availability By Year (lbs per 1000gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1</td>
</tr>
<tr>
<td>Nitrogen</td>
</tr>
<tr>
<td>Phosphorus</td>
</tr>
</tbody>
</table>

The table above is based upon the nutrient availability discussed earlier in the presentation. This did use the following values:

- Nitrogen: Year 1 – 50%, Year 2 – 25%, Year 3 – 15%
- Phosphorus: Year 1 – 100% available, based upon sources as well as this soil being sufficient in phosphorus per the soil results.
Manure Application Example (cont.)

Nitrogen Based Manure Plan

<table>
<thead>
<tr>
<th>Nitrogen Based Manure Application (lbs/year or gal/acre)</th>
<th>Grain Corn</th>
<th>Soybean</th>
<th>Corn Silage</th>
<th>Wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>N Required</td>
<td>171</td>
<td>228</td>
<td>225</td>
<td>96</td>
</tr>
<tr>
<td>Manure N Residual</td>
<td>0</td>
<td>85.5</td>
<td>122.5</td>
<td>84</td>
</tr>
<tr>
<td>N Still Needed</td>
<td>171</td>
<td>142.5</td>
<td>102.5</td>
<td>12</td>
</tr>
<tr>
<td>Manure Rate Required</td>
<td>13153</td>
<td>10961</td>
<td>7884</td>
<td>923</td>
</tr>
<tr>
<td>Manure P$_2$O$_5$ Applied</td>
<td>144.68</td>
<td>120.57</td>
<td>69.81</td>
<td>10.15</td>
</tr>
</tbody>
</table>

The above table is based from information in the previous slides.
- “N Required” is directly from nutrient removal by year.
- “Manure N Residual” = (Manure Still Required from previous year/1000) x N available second year, repeat similarly for third year availability
### Nitrogen Based Manure Plan (cont.)

**Manure Application Example (cont.)**

- **“N Still Needed”** = N Required – Manure N Residual
- **“Manure Rate Required”** is calculated as follows:
  \[(N \text{ Still Needed} / N \text{ Available year 1}) \times 1000 = \text{Manure Rate Required, for subsequent years add the N availability for previous applications.}\]

<table>
<thead>
<tr>
<th>Grain Corn</th>
<th>Soybean</th>
<th>Corn Silage</th>
<th>Wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>N Required</td>
<td>171</td>
<td>228</td>
<td>225</td>
</tr>
<tr>
<td>Manure N Residual</td>
<td>0</td>
<td>85.5</td>
<td>122.5</td>
</tr>
<tr>
<td>N Still Needed</td>
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<tr>
<td>Manure Rate Required</td>
<td>13153</td>
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<tr>
<td>Manure P$_2$O$_5$ Applied</td>
<td>144.68</td>
<td>120.57</td>
<td>69.81</td>
</tr>
</tbody>
</table>

Nitrogen Based Manure Application (lbs/year or gal/acre)
Manure Application Example (cont.)

Phosphorus Based Manure Plan

<table>
<thead>
<tr>
<th>Phosphorus Based Manure Application Rates (lbs/year or gal/acre)</th>
<th>Grain Corn</th>
<th>Soybean</th>
<th>Corn Silage</th>
<th>Wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manure Rate P Removal</td>
<td>6390</td>
<td>4363.64</td>
<td>8181.82</td>
<td>6390</td>
</tr>
<tr>
<td>Manure Rate applied 4 year P Removal</td>
<td>23300</td>
<td>23300</td>
<td>23300</td>
<td>23300</td>
</tr>
<tr>
<td>Manure N applied P Removal</td>
<td>83.07</td>
<td>56.73</td>
<td>106.36</td>
<td>56.73</td>
</tr>
<tr>
<td>Manure N applied 4 year P Removal</td>
<td>209.38</td>
<td>209.38</td>
<td>209.38</td>
<td>209.38</td>
</tr>
</tbody>
</table>

- “Manure Rate Removal” = (P from Nutrient Removal by Year/ P available year 1) x 1000
- “Manure Rate applied 4 year P Removal” = Total P removed over 4 year crop plan/ P available year 1) x 1000
- “Manure N applied P Removal” = (Manure Rate P Removal/1000) x 1st year available N
- “Manure N applied 4 year P Removal” = (Manure Rate applied 4 year P Removal/1000) x 1st year available N
Manure Application Example (cont.)

Comparison of Recommended Rates

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manure Rate P Removal</td>
<td>6390</td>
<td>4363.64</td>
<td>8181.82</td>
<td>6390</td>
</tr>
<tr>
<td>Manure Rate applied 4 year P Removal</td>
<td>23300</td>
<td>23300</td>
<td>23300</td>
<td>23300</td>
</tr>
<tr>
<td>Manure Rate Required (Using N)</td>
<td>13153</td>
<td>10961</td>
<td>7884</td>
<td>923</td>
</tr>
</tbody>
</table>
Manure Application Example (cont.)

Conclusions

- As indicated by the previous two slides, the application rates could have much variation depending on if the decision is based upon nitrogen or phosphorus needs.
- There also is variation depending if manure applications are based upon a single year or multiple year phosphorus use rate.
- If soil levels are low, it can be advantageous to plan for some extra phosphorus and assume there will not be 100% availability from manure in the first year.
- However, if manure is always applied based upon nitrogen need it could cause a rise in the soil phosphorus levels.
Summary

- A little planning can go a long way when trying to reduce nutrient loss from manure application and thus taking the maximum economic benefit from them.
- With farming under increasing scrutiny for issues with nutrient contamination in public waterways, now is the time for farmers and agronomists to put extra focus on proper nutrient management from manure.
- In order to properly plan it is important to use the best information available.
- By keeping up to date soil tests, crop plans and manure tests allows for the calculation of manure applications in a way that best utilizes the nutrients available from the manure.
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