Phosphorus Management on High P Soils

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How we got into today’s situation

1. Crops responded to P fertilizers

2. Applied manure to meet crops N needs
   * N to P ratio
   * Soil P build-up
   * P and water quality
Average Soil Test P in Wisconsin

- 1964-67: 29 ppm
- 1968-73: 34 ppm
- 1974-77: 37 ppm
- 1977-81: 40 ppm
- 1982-85: 44 ppm
- 1986-90: 48 ppm
- 1990-94: 50 ppm
- 1995-99: 52 ppm
P and Water Quality: Why the concern?

- No plant toxicity
- Held in soil
- Accumulates slowly
- Does not leach
Features of P-based nutrient management

Using soil test P criteria

- N-based management when soil test is < 50 ppm
- Soil test 50-100 ppm, P additions limited to crop removal or less over 4 year rotation
- Soil test > 100 ppm, limit P to less than crop removal
What options exist?

1. Reduce P inputs
   - feed
   - fertilizer
   - animals

2. Increase land base

3. Identify low-risk sites
### Dairy Dietary P Management

<table>
<thead>
<tr>
<th>Milk Production (lbs/day)</th>
<th>Dietary P Level (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>0.32</td>
</tr>
<tr>
<td>77</td>
<td>0.35</td>
</tr>
<tr>
<td>99</td>
<td>0.36</td>
</tr>
<tr>
<td>120</td>
<td>0.38</td>
</tr>
</tbody>
</table>

Dairy Dietary P Management – Implications of a High-P Diet

<table>
<thead>
<tr>
<th>Dietary-P (%)</th>
<th>Manure-P (lbs/cow/year)</th>
<th>Required Acres* (acres/cow/year)</th>
<th>Req. Land Inc. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.35</td>
<td>42</td>
<td>1.6</td>
<td>--</td>
</tr>
<tr>
<td>0.38</td>
<td>47</td>
<td>1.8</td>
<td>13</td>
</tr>
<tr>
<td>0.48</td>
<td>65</td>
<td>2.4</td>
<td>57</td>
</tr>
<tr>
<td>0.55</td>
<td>78</td>
<td>2.9</td>
<td>87</td>
</tr>
</tbody>
</table>

*Acres required to meet a P-based nutrient management plan; adapted from Powell et al., 2001.
For nonruminants:

- Feed phytase
- Use high available P varieties
Reduce or eliminate P inputs

1. Follow soil test recommendations
2. Credit all nutrient sources
3. Use starter judiciously
# Wisconsin “Sufficiency” Recommendations

<table>
<thead>
<tr>
<th>Level</th>
<th>Interpretation</th>
<th>Response Probability</th>
<th>*Phosphate Recommended</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4 ppm</td>
<td>V. Low</td>
<td>&gt;90</td>
<td>70</td>
</tr>
<tr>
<td>5-10 ppm</td>
<td>Low</td>
<td>60-90</td>
<td>65</td>
</tr>
<tr>
<td>11-15 ppm</td>
<td>Optimum</td>
<td>30-60</td>
<td>55</td>
</tr>
<tr>
<td>16-25 ppm</td>
<td>High</td>
<td>5-30</td>
<td>25</td>
</tr>
<tr>
<td>&gt;25 ppm</td>
<td>E. high</td>
<td>&lt;5</td>
<td>0</td>
</tr>
</tbody>
</table>

*For 150 bu/a yield
Effect of soil K and hybrid RM on corn response to starter fertilizer

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category</th>
<th>No.</th>
<th>Responsive sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil test K</td>
<td>&lt;140 ppm</td>
<td>27</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td>≥140 ppm</td>
<td>73</td>
<td>34</td>
</tr>
<tr>
<td>Hybrid RM</td>
<td>&lt;100 day</td>
<td>64</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>≥100 day</td>
<td>36</td>
<td>53</td>
</tr>
</tbody>
</table>

Adapted from Andraski and Bundy, 1999
Probability of profitable response to starter fertilizer*

<table>
<thead>
<tr>
<th>Relative Maturity</th>
<th>Planting Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4/25</td>
</tr>
<tr>
<td>90</td>
<td>10</td>
</tr>
<tr>
<td>100</td>
<td>20</td>
</tr>
<tr>
<td>105</td>
<td>25</td>
</tr>
<tr>
<td>110</td>
<td>30</td>
</tr>
</tbody>
</table>

* EH Soil P and K
Increase Land Base

1. Buy land

2. Sell cows

3. Use existing land fully
   - cover all land during rotation
   - apply to rented land
   - obtain application rights
Allow P to Build on Low-Risk Sites

- Use P index to identify

- Factors considered
  - erosion
  - crop / cover
  - P level
  - fertilizer / manure practices

- Separates soluble and particulate P risks
Manage P to reduce P losses

1. Identify low risk sites
2. Time application properly
3. Use banded P applications
4. Incorporate manure only when appropriate
5. Use conservation practices / buffers
Other 590 restrictions that affect needed land base:

- Cannot spread in concentrated flow channels or buffers
- No winter spreading near lake (1000 ft), stream (300 ft) or groundwater conduit (200 ft)
- No winter spreading on slopes > 9% or 12% with RRP
- Winter application limited to P for current crop, not exceeding 7000 gal/a liquid manure
Questions to address:

- Does manure affect runoff volume?
- Does manure affect runoff quality?
- What situations are most risky?
Manure is a soil conditioner:

- Aggregation increased
- Bulk density decreased
- Water holding capacity increased
- Hydraulic conductivity increased
- Crop production increased
- Runoff/soil loss decreased
Effect of annual manure rate on runoff and soil loss ratios

adapted from Gilley and Risse (2000); slope length 20-40 m; gradient 4-13%
Factors influencing manure impacts on runoff volume:

- Worm population 3.5x for all times of application (Converse et al., 1976)
- Manure slows snowmelt (Kongoli, 2000)
- Mulch effect from manure (Young and Holt, 1977)
Site/soil interactions with manure on runoff and soil loss:

- Slope length
- Tillage system/surface residue
- Vegetative cover
- Frost type
- Fate of first melt water
- Position in the snow pack
Snow depth and melting rate as affected by 70 Mg/ha dairy manure

Adapted from Kongoli, 2000.
Runoff P as %P applied from winter-spread manure:

- Five studies (Vermont, Wisconsin, New York, Minnesota, & Wisconsin)
- Averages 7.58%
- Range = \(<0.1\) to 27.4%

(Adapted from Moore and Madison, 1985)
Effect of time of manure application to alfalfa on runoff volume and total P loss:

<table>
<thead>
<tr>
<th>Manure app time</th>
<th>Runoff 72</th>
<th>Runoff 73</th>
<th>Runoff 74</th>
<th>P loss 72</th>
<th>P loss 73</th>
<th>P loss 74</th>
</tr>
</thead>
<tbody>
<tr>
<td>Check</td>
<td>82</td>
<td>142</td>
<td>185</td>
<td>0.75</td>
<td>0.76</td>
<td>2.40</td>
</tr>
<tr>
<td>Fall</td>
<td>52</td>
<td>78</td>
<td>90</td>
<td>1.24</td>
<td>1.20</td>
<td>8.09</td>
</tr>
<tr>
<td>Winter</td>
<td>82</td>
<td>103</td>
<td>128</td>
<td>0.64</td>
<td>0.58</td>
<td>6.09</td>
</tr>
<tr>
<td>Spring</td>
<td>67</td>
<td>128</td>
<td>150</td>
<td>2.39</td>
<td>0.55</td>
<td>1.81</td>
</tr>
</tbody>
</table>

Annual manure rate 22.5 Mg/ha; gradient 10% (adapted from Converse et al., 1976).
Effect of tillage and manure applications on snowmelt and rainfall runoff and sediment and P losses:

+ Average of 2 years; manure rate 56 Mg/ha; gradient 12%
(Adapted from Ginting et al., 1998a,b).

<table>
<thead>
<tr>
<th>Tillage</th>
<th>Manure</th>
<th>Snowmelt</th>
<th>Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>RO</td>
<td>Sediment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>mm</td>
<td>kg/ha</td>
</tr>
<tr>
<td>RT</td>
<td>-</td>
<td>23.3</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>+</td>
<td>21.4</td>
<td>36</td>
</tr>
<tr>
<td>Mb</td>
<td>-</td>
<td>17.7</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>+</td>
<td>22.7</td>
<td>17</td>
</tr>
</tbody>
</table>

+Average of 2 years; manure rate 56 Mg/ha; gradient 12%
(Adapted from Ginting et al., 1998a,b).
Runoff and P loss in snowmelt from manure

<table>
<thead>
<tr>
<th>Crop / Manure Applic.</th>
<th>Runoff</th>
<th>Total P loss</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>in</td>
<td>lb/a</td>
</tr>
<tr>
<td>Corn</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>2.64</td>
<td>0.1</td>
</tr>
<tr>
<td>Fall manure plowed</td>
<td>0.60</td>
<td>0.2</td>
</tr>
<tr>
<td>Fall on frozen</td>
<td>0.47</td>
<td>0.5</td>
</tr>
<tr>
<td>Spring on snow</td>
<td>0.50</td>
<td>0.2</td>
</tr>
<tr>
<td>Alfalfa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>3.43</td>
<td>0.1</td>
</tr>
<tr>
<td>Fall on frozen</td>
<td>2.74</td>
<td>5.4</td>
</tr>
<tr>
<td>Spring on snow</td>
<td>1.43</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Average of 3 years; adapted from Young and Mutchler, 1976; 9% slope
Worst-case situations:

- “Concrete” frost in place
- High residue
- Smooth soil surface
- Manure at soil/snow interface
- Application during melt or immediately before rain
P Best Management Practices

- Balance P inputs and removals
- Check and limit P in animal diets
  - 0.40%P adequate for dairy
- Minimum P in starter
  - 15-20 lb P\textsubscript{2}O\textsubscript{5}/a
- Incorporate manure & fertilizer?
- Time applications to minimize runoff
  - Fall or winter apply to tilled fields
  - Spring apply to NT fields
BMP’s continued

- Apply manure P on lowest fields first
- Allow soil P to build on low risk areas
- Avoid applications if soil test P >100-150 ppm
- Use conservation practices
- Cover/buffers