TILLAGE & MANURE TIMING TO MINIMIZE PHOSPHORUS LOSSES

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Introduction

- Timing of manure applications and tillage can influence risk of P loss.
- These effects are important for:
  - Minimizing water quality effects
  - Phosphorus-based nutrient management planning
Tillage and manure timing effects on P losses studied in recent experiments

Results used to develop Wis. P index

Summarize:
- Results from runoff experiments
- P loss estimates from P index
- Seasonal guidelines for applying manure
How do tillage and manure affect runoff P losses?

- Manure applications reduce runoff volumes and soil loss.
- Incorporating manure increases sediment loss (erosion) but lowers soluble P losses in runoff.
- Surface manure provides residue cover and decreases sediment P losses.
- Unincorporated manure increases soluble P losses.
How do tillage and manure affect runoff P losses?

- High soil P and manure applications usually increase soluble P losses.
- Tillage often increases sediment/particulate P in runoff.
- Spreading manure on no-till or alfalfa fields in fall and winter increases soluble P losses.
- Rain soon after manure application or winter spreading can lead to large P losses.
Wisconsin Datasets used for P Index Development

Simulated rainfall runoff:

- Alfalfa – 20 events
- Corn – 267 events, 4 sites
  Varying:
    - Tillage
    - Manure applications
    - Timing
    - Soil test P
Natural rainfall runoff:

- Alfalfa – 24 plots
- Corn – 36 plots

Research ongoing. Datasets growing.
SPRING MANURE TREATMENTS

• Tillage
  ▪ No-till
  ▪ Chisel plow

• Manure (spring applied)
  ▪ None
  ▪ 32 tons/acre (dairy manure)
Tillage and spring-applied manure effects on residue cover and runoff volume. Arlington, 1999

<table>
<thead>
<tr>
<th>Tillage/manure</th>
<th>Residue cover</th>
<th>Runoff volume</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Spring</td>
<td>Fall</td>
</tr>
<tr>
<td>No-till -</td>
<td>79</td>
<td>47</td>
</tr>
<tr>
<td>No-till +</td>
<td>99</td>
<td>74</td>
</tr>
<tr>
<td>C. Plow -</td>
<td>26</td>
<td>16</td>
</tr>
<tr>
<td>C. Plow +</td>
<td>50</td>
<td>23</td>
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</table>

<table>
<thead>
<tr>
<th>Tillage/manure</th>
<th>Runoff volume</th>
<th>Sediment load</th>
<th>Runoff Phosphorus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm</td>
<td>kg/ha</td>
<td>Soluble</td>
</tr>
<tr>
<td>No-till -</td>
<td>17</td>
<td>855</td>
<td>4</td>
</tr>
<tr>
<td>No-till +</td>
<td>5</td>
<td>125</td>
<td>8</td>
</tr>
<tr>
<td>C. Plow -</td>
<td>29</td>
<td>2223</td>
<td>11</td>
</tr>
<tr>
<td>C. Plow +</td>
<td>14</td>
<td>1065</td>
<td>8</td>
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</table>

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<tr>
<td></td>
<td>mm</td>
<td>kg/ha</td>
<td>Soluble</td>
</tr>
<tr>
<td>No-till -</td>
<td>16</td>
<td>153</td>
<td>32</td>
</tr>
<tr>
<td>No-till +</td>
<td>14</td>
<td>60</td>
<td>207</td>
</tr>
<tr>
<td>C. Plow -</td>
<td>39</td>
<td>3019</td>
<td>44</td>
</tr>
<tr>
<td>C. Plow +</td>
<td>24</td>
<td>1461</td>
<td>68</td>
</tr>
</tbody>
</table>
Fall Manure Treatments

• Manure:
  - None (control)
  - Semi-solid (32 tons/a), broadcast
  - Liquid/Slurry (19,000 gal/a)
    • Broadcast
    • Injected (6-inch depth)
• Tillage: Fall chisel plowing or no-till
Tillage and fall-applied manure effects on sediment and phosphorus in runoff. Arlington, October, 2002.

<table>
<thead>
<tr>
<th>Manure/tillage</th>
<th>Runoff volume</th>
<th>Sediment load</th>
<th>Runoff Phosphorus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mm</td>
<td>kg/ha</td>
<td>Soluble</td>
</tr>
<tr>
<td>None NT</td>
<td>17</td>
<td>105</td>
<td>9</td>
</tr>
<tr>
<td>None CP</td>
<td>4</td>
<td>279</td>
<td>3</td>
</tr>
<tr>
<td>Solid NT</td>
<td>30</td>
<td>317</td>
<td>1396</td>
</tr>
<tr>
<td>Solid CP</td>
<td>5</td>
<td>245</td>
<td>15</td>
</tr>
<tr>
<td>Liquid NT</td>
<td>39</td>
<td>568</td>
<td>2543</td>
</tr>
<tr>
<td>Liquid CP</td>
<td>7</td>
<td>326</td>
<td>141</td>
</tr>
<tr>
<td>Liquid Inject</td>
<td>23</td>
<td>267</td>
<td>89</td>
</tr>
</tbody>
</table>
Runoff dissolved P can be predicted by soil test P and soil type.

Simulated rainfall runoff corn plots without manure applications.
Results

- Spring-applied manure often reduced P losses by reducing runoff volume and sediment loss.
- Runoff volumes usually much higher in fall than spring.
- Runoff lower in CP than NT in fall.
Results - Fall Manure

- Surface manure increased runoff in NT but not with injected or CP
- No effects on sediment load
- Dissolved and total P losses were correlated with runoff volume
Summary

- Potential for P loss from fall-applied manure can be reduced by injection or chisel plowing.
- The risk of P losses in runoff appears to be lower with spring applications.
The Wisconsin P Index

• Based on research results from runoff experiments
• Indicates potential of a field to deliver P to surface water
• Provides one option for P-based nutrient management planning
Components of the Phosphorus Index (PI):

\[ \text{PI} = \text{PP} + \text{SP} \]

- **PI** = Total P index
- **PP** = Particulate P
- **SP** = Soluble P
Single-event worst-case losses from surface manure applications are added to estimated annual P delivery.
Risks of manure P loss change by season of application:

- Fall
- Spring
- Winter (frozen soil)
Runoff dissolved P and particulate P from simulated rainfall event one week after a 32 ton per acre dairy manure surface application to silt loam soil in the Spring (Lancaster) and Fall (Arlington)

<table>
<thead>
<tr>
<th></th>
<th>DP</th>
<th>DP Load</th>
<th>PP</th>
<th>PP Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No manure</td>
<td>0.20</td>
<td>32</td>
<td>539</td>
<td>75</td>
</tr>
<tr>
<td>Manure</td>
<td>1.41</td>
<td>207</td>
<td>1009</td>
<td>70</td>
</tr>
<tr>
<td>Fall</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Manure</td>
<td>0.05</td>
<td>9</td>
<td>336</td>
<td>36</td>
</tr>
<tr>
<td>Manure</td>
<td>4.69</td>
<td>1396</td>
<td>5069</td>
<td>1660</td>
</tr>
</tbody>
</table>
The additional SP load from
• Spring manure = 0.5 %
• Fall manure = 3.7 %
of the manure water soluble P.

The additional PP load from
• Spring manure = 0
• Fall manure = 2.9 %
of the manure total P.
Putting it all together:

The P Index shows the relative effects of different field management practices on P loads.
P Index Values for Grant County Corn Field

Rozetta silt loam soil, 6% slope, Bray P 50 ppm

Chisel Plow

- No Manure
- Fall Manure
- Winter Manure
- Spring Manure

No - till

- No Manure
- Fall Manure
- Winter Manure
- Spring Manure

Legend:
- Particulate P
- Soluble P
P Index Values for Winnebago County Corn Field
Kewaunee silty clay loam soil, 4% slope, Bray P 50 ppm

![Bar chart showing P Index values for Winnebago County Corn Field]
Summary - Spring Manure

- **Areas to apply**
  - Prior to tillage
  - No-till corn
  - Inject manure

- **Areas to avoid**
  - Estab. Alfalfa
  - On snow/frozen ground
  - Wet soils
### Summary - Fall Manure

<table>
<thead>
<tr>
<th>Areas to apply</th>
<th>Areas to avoid</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Post-tillage to fall-plowed fields</td>
<td>- Estab. Alfalfa</td>
</tr>
<tr>
<td>- Before/after tillage on fall chiseled fields</td>
<td>- No-till corn</td>
</tr>
<tr>
<td>- After silage</td>
<td>- Smooth surfaces with little residue cover</td>
</tr>
<tr>
<td>- Before tillage on old hay fields</td>
<td></td>
</tr>
<tr>
<td>- Inject manure</td>
<td></td>
</tr>
</tbody>
</table>
Summary - Winter Manure

• Areas to apply
  - Level chisel plowed fields
  - Slopes less than 6%
  - Little upslope runoff

• Areas to avoid
  - Estab. Alfalfa
  - No-till corn
  - Slopes over 6%