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• Runoff losses of P, N, and sediment from crop fields, especially where manure has been applied, can contribute to degradation of surface waters.

• In a dairy cropping system, the silage corn phase typically poses the most serious threat to water quality.

Objective

• To evaluate runoff losses of nutrients and pathogens from different manure/crop/tillage management systems for silage corn production.
Field Site

- UW/USDA-ARS Research Station, Marshfield, WI.
- Somewhat poorly drained Withee silt loam (Aquic Glossudalfs), 1-3% slope
- Surface drainage using drive-through diversion pathways and berms

Paired-Watershed Design

- Field-scale “watersheds”
- Four fields – 3.4-4.4 acre each

6.4 ha, or 16 acres total
Gauge Station: Runoff Monitoring

24-inch H flumes with approach channels
Gauge Station: Runoff sampling

Runoff, Nutrients, and Sediment

• Runoff quantity
• Suspended sediment (SS)
• Total P (TP)
• Dissolved P (DP)
• TKN, Nitrate-N, Ammonium-N

Individual samples combined into a flow-weighted composite

Protozoan, bacterial, and viral pathogens (See M. Borchardt presentation)
Paired Watershed Design

Calibration Period

Control Watershed

Treatment Watershed

Credit: D. Meals
logTPX2 = 0.80(logTPX3) + 0.22  \( r^2 = 0.54 \)

Credit: D. Meals
Paired Watershed Design

Treatment Period

Control Watershed  Treatment Watershed

Credit: D. Meals
Fall Manure and Chisel Plow (Control, M1)

Manure Rate (avg): 5100 gal/ac, 14% DM, 145 N, 75 NH$_4$-N, 53 P$_2$O$_5$ lb/ac

Fall after chisel plowing

Spring after field cultivate/plant emergence
Vegetative buffer/waterway with fall manure and chisel plow (M4)

Legume-grass mix (alsike clover, timothy, brome)
Rye Cover Crop with Spring Manure and Chisel Plow (M2)

Fall

Spring
Fall Surface-applied Manure with Spring Chisel Plow (M3)
(surface manure over-winter)
# Treatment Period Results

## Annual Runoff and N and P Loads

<table>
<thead>
<tr>
<th>Mean</th>
<th>Runoff</th>
<th>Suspend Sediment</th>
<th>Total P</th>
<th>Dissolved P</th>
<th>Total N</th>
<th>NO$_3$-N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>inches</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Load</td>
<td>8.5</td>
<td>1680</td>
<td>3.2</td>
<td>0.33</td>
<td>16.9</td>
<td>4.7</td>
</tr>
<tr>
<td>Snowmelt /Total</td>
<td>0.39</td>
<td>0.05</td>
<td>0.11</td>
<td>0.45</td>
<td>0.24</td>
<td>0.35</td>
</tr>
</tbody>
</table>
Did management treatment significantly affect runoff nutrients?

Compare Treatment vs Control regression during Calibration and Treatment Period

Example: Total P Conc. - Veg. Buffer-Fall Manure/Till

\[ y = 0.870x + 0.155 \]

\[ R^2 = 0.74 \]
Did management treatment significantly affect runoff nutrients?

Compare Treatment vs Control regression during Calibration and Treatment Period

Example: Total P Conc. - Veg. Buffer-Fall Manure/Till

![Graph showing regression lines with R² values]

Statistical Signif. (permutation test)
- Slope **
- Mean **
What was magnitude of treatment effect?

Compare values observed during treatment period to values predicted from calibration period (Observed-Predicted)

Example: Total P Concentration

Veg. Buffer-Fall Manure/Till/ (M4)

Fall Manure/Spring Till (M3)

Negative = Decrease from treatment
Positive = Increase from treatment
**Observed-Predicted: % Change**

<table>
<thead>
<tr>
<th></th>
<th>Rye cover – Spring Man/Till</th>
<th>Veg Buffer – Fall Man/Till</th>
<th>Fall manure – Spring Till</th>
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<tbody>
<tr>
<td>Susp Sed.</td>
<td>-47</td>
<td>-45</td>
<td>-36</td>
</tr>
<tr>
<td>Total P</td>
<td>-28</td>
<td>-39</td>
<td>43</td>
</tr>
<tr>
<td>Dissolved P</td>
<td>-16</td>
<td>81</td>
<td>127</td>
</tr>
</tbody>
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*NS indicates mean and slope difference of Calibr-Trt regressions nonsignificant at P-value of 0.10.*
### Observed-Predicted: % Change

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<tr>
<td><strong>Concentration</strong></td>
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</tr>
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<td>-47</td>
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<td>-16</td>
<td>81</td>
<td>127</td>
</tr>
<tr>
<td><strong>Export (Load)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Susp Sed.</td>
<td>-9</td>
<td>-62</td>
<td>NS</td>
</tr>
<tr>
<td>Total P</td>
<td>NS</td>
<td>-42</td>
<td>NS</td>
</tr>
<tr>
<td>Dissolved P</td>
<td>57</td>
<td>25</td>
<td>237</td>
</tr>
</tbody>
</table>

*NS indicates mean and slope difference of Calibr-Trt regressions nonsignificant at P-value of 0.10.*
Summary

• Snowmelt runoff is important: 11 to 45% of P and N export (avg. across treatments).

• Surface over-winter manure (fall manure/spring till) increased TP and, especially, DP concentration and DP load, but decreased SS concentration.

• Rye cover crop-spring manure/till decreased SS, TP, and DP concentrations and SS load, not TP or DP load.
  - Limited growth of rye in fall
  - Increased runoff
Summary

• Vegetative buffer/waterway-fall manure/till decreased runoff (slightly) and concentration and load of SS and TP (but not DP); the most effective management system in this study.

• None of the manure-crop management systems were effective in controlling dissolved P in runoff.