Nutrient and Sediment Loss Reduction by Perennial & Cover Crops

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outline

• Variability of nutrient and sediment losses
• Nitrate in tile water discharge
• Sediment and P in surface runoff
• Opportunities for reducing losses
Iowa Nutrient Reduction Strategy Literature Review

<table>
<thead>
<tr>
<th>% reduction in annual Nitrate load</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rye Cover Crop</td>
<td>-10</td>
<td>94</td>
<td>30</td>
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<tr>
<td>Perennial Energy Crops</td>
<td>26</td>
<td>98</td>
<td>73</td>
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<tr>
<td>CRP</td>
<td>67</td>
<td>98</td>
<td>85</td>
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</table>
Surface runoff vs Tile flow

• Surface runoff tends to carry high sediment and phosphorus loads, but moderate or low nitrate loads

• Tile flow from conventional corn and soybean production tends to carry high nitrate loads but moderate phosphorus and low sediment loads.
Estimated Percent of Cropland With Tile Drainage

USDA 1992 National Resources Inventory survey data
(as presented by Wu and Babcock, 1999)
Watersheds where tile drainage is common tend to have high nitrate concentrations and high nitrate loss per unit area.

(Goolsby et al. 1999)
COSHOCTON WEIGHING LYSIMETER
Nitrate in drainage water from monolith Lysimeters near Coshocton, Ohio (Chichester, 1977)

Fig. 1—Change in inorganic N content of lysimeter percolate as related to increase in fertilizer N application rate. [1941–62 data from Harrold and Dreibelbis (1958, 1967); 1963–64 data, F. R. Dreibelbis, unpublished].
Illinois Organic-Conventional Comparison (grain production)


<table>
<thead>
<tr>
<th>Site</th>
<th>Conventional</th>
<th>Organic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20</td>
<td>4</td>
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<tr>
<td>2</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>9</td>
<td>3</td>
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</table>
Nitrate leaching from row crops, *Miscanthus*, switchgrass and restored prairie

~90% reduction in nitrate concentrations draining from perennials in the third year of switchgrass and prairie, and fourth year of *Miscanathus*.

Fig. 2. Nitrate concentrations in tile water during 2008 through 2011 by biofuel crop. Rotation was in corn in 2008 and 2009, soybean in 2010, and corn in 2011.

(Smith et al. 2013)
Nitrate leaching from row crops, *Miscanthus*, switchgrass and restored prairie

~90% reduction in nitrate leaching from perennials in second year of switchgrass and prairie, fourth year of *Miscanathus*.

Fig. 1. Annual nitrate N leaching (April to April) at 50 cm soil depth using resin lysimeters for all biofuel crops (mean ± SE). Means by year across crop types with the same capital letter are not significantly different at the 0.05 level. Means by crop type across years with the same lowercase letter are not significantly different at the 0.05 level.

(Smith et al. 2013)
Tile flow from conventional corn soybean production

• Annual nitrate loss from typical corn-soybean field in central Illinois is about 30 lb N/ac, but there is considerable variability from field to field due to variations in soils, management.

• Much of the nitrate loss occurs in winter and spring, when there is little crop uptake.

• Cover crops grown in late summer, fall and early spring extend the period of nitrate uptake.
Nitrate loss reduction by cover crops

- There is considerable year to year variation in nitrate loss and cover crop performance due to weather.
- The amount of nitrate loss reduction from planting cover crops on a particular field will depend on the background loss, the type of cover crop and the management of the cover crop.
Where are cover crops most likely to provide the most cost effective nitrate loss reduction?

Tile drained fields with high nitrate losses, which are difficult to identify without expensive monitoring

Based on existing studies, fields or portions of fields with relatively high N inputs (especially in fall) and relatively low corn yields are likely to have high tile nitrate losses
Soil Erosion from Cropland

• Varies with slope, rainfall intensity, runoff rate, and soil cover

• Highest rates of erosion are typically from row crops with minimal soil cover, especially in spring when cover is minimal and soils tend to be saturated.

• In many fields there are relatively small areas of high erosion and sediment production (steep slopes or concentrated flow areas with little cover), where the addition of cover crops or conversion to perennial crops could provide large reductions in sediment and P loss.
 Quantifying “disproportional benefits” of grass strips to reduce pollutants in surface runoff

*Slide courtesy of Matt Helmers, Iowa State*
Experimental Watershed Treatments

12 watersheds:
Balanced Incomplete Block Design:
3 reps X 4 treatments X 3 blocks

- 0%
- 10%
- 10%
- 20%

Slide courtesy of Matt Helmers, Iowa State

- yellow = corn - soybean row crops (no-till)
- green = reconstructed prairie
Sediment and P Losses in 2007-2010

10% conversion to Prairie Filter Strip (PFS) led to
96% reduction in sediment loss
89% reduction in P loss     82% reduction in total N loss

avg. sediment loss from 100% rowcrop = 3.7 ton/ac/yr
avg. P loss from 100% rowcrop = 7.4 lb P/ac/yr

*Slide adapted from Matt Helmers, Iowa State*
Soil Erosion from Cropland

• Where erosion is low conversion to perennial crops or adding cover crops will likely provide little sediment reduction benefit.

• Reduction in cropland erosion across a large watershed may or may not lead to sediment reduction at the watershed outlet, due to in-field deposition, mobilization of previously deposited sediment, and stream bank erosion.
Estimated sediment budgets for Coon Creek watershed, Wisconsin USA

(From Trimble, 1999)
Opportunities for Precision Conservation
Typical buffer and tile-drained field:

Tile discharge carries flow under the buffer. Buffer reduces sediment and pollutants in surface flow. But nitrates & pollutants in tile flow are not removed.

Adapted from Dan Jaynes, USDA, 2009.
Saturated buffer concept:
Tile flow is diverted to soil column under buffer. Nitrates removed via plant uptake and denitrification. “Lost” nutrients could fertilize a perennial biomass crop.

Adapted from Dan Jaynes, USDA, 2009.
Saturated Buffer – Piatt Co. Demo Site

Sec. 3 of Willow Branch Twp. in Piatt Co.
T. 18 N. – R. 4 E.
Innovations in agricultural drainage technology can facilitate saturated hillsides and related concepts.

Agri Drain’s Water Gate float-activated head pressure valves can be used to manage the water table on a sloping field from a single control structure.
Cropland subject to ponding could potentially be converted to harvestable seasonal wetlands producing perennial crops that tolerate periods of saturation.
‘Savoy’ prairie cordgrass standing on wet marginal land
Cultivar ‘Savoy’ was developed by D.K. Lee for bioenergy feedstock production
Provisional patent application was filed in the U.S. PTO.

*Slide courtesy of D.K. Lee*
Eastern gamagrass (*Tripsacum dactyloides*):
- Native warm season bunch grass
- Highly palatable forage (called “ice cream grass”)
- Thrives in wet conditions
- Promising candidate for nitrate removal and hay production in harvested saturated buffers
Correlating Profit and Sustainability

140 ac field in north central Iowa

50 Year Profit Average
($/acre)
(933) - (784)
(784) - (576)
(576) - (404)
(404) - (195)
(195) - (76)
(76) - 11
11 - 101
101 - 168
168 - 223
223 - 611

Summary

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
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<tbody>
<tr>
<td>50 Year Yld Ave:</td>
<td>170 bu/acre</td>
</tr>
<tr>
<td>50 Year Yld STD:</td>
<td>38 bu/acre</td>
</tr>
<tr>
<td>Profit Average:</td>
<td>$47 $/acre</td>
</tr>
<tr>
<td>Profit STD:</td>
<td>$235 $/acre</td>
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<tr>
<td>Years Profitable Ave:</td>
<td>31</td>
</tr>
<tr>
<td>Years Profitable STD:</td>
<td>14</td>
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<tr>
<td>Percentage of Field Profitable:</td>
<td>74%</td>
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Correlating Profit and Sustainability

50 Year Profit Average
Adjusted Ins Prem-Int Rates
Release Acres Below (250)
($/acre)
- No Row Crop
- (239) - (58)
- (58) - 0
- 0 - 16
- 16 - 42
- 42 - 101
- 101 - 107
- 107 - 134
- 134 - 158
- 158 - 224
- 224 - 577

Summary
- Discontinue ops on areas with ave loss > $250/acre with risk adjusted ins prem’s and int rates
- Profit Average: $76 $/acre
- Profit STD: $124 $/acre
- Percentage of Field Profitable: 72%
- Percentage of Field Used Profitable: 81%

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David Muth, 2014
summary

• The amount of nutrient and sediment loss from cropland is highly variable depending on characteristics of the land, management practices and dominant water flow pathways

• The amount of nutrient and sediment loss reduction by cover crops and perennial crops is also variable depending on the existing losses and the management of the cover and perennial crops
Summary

• Understanding factors that influence nutrient and sediment losses and row crop profitability will help identify the acres that provide the greatest opportunities for cost effective reductions in nutrient and sediment losses when planted to cover crops or converted to perennial crops
Illinois Organic-Conventional Comparison Site 3
Nitrate N Concentrations

Nitrate N Concentrations

- Corn
- Soybean
- Popcorn
- Legume Mix
- Rye/Legume Mix/vol rye
- Blue Corn

Comparison

Site 3

ppm NO3-N

Conventional

Organic
Organic-Conventional Comparison Site 6
Nitrate N Concentrations

ppm NO3-N

<table>
<thead>
<tr>
<th>Site</th>
<th>Nitrate N Concentrations</th>
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<tbody>
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- Conventional
- Organic