Management of Nitrogen in Tile Drained Systems

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http://transformingdrainage.org/tools
Nitrogen losses are usually high from tile-drained systems

- At sites across the Midwest, nitrate-N loads typically 20 to 40 kg/ha/yr.
- The Transforming Drainage project has brought together data from sites across the region where innovative practices are compared.

Transforming Drainage database
Opportunities for reducing nitrogen losses

Ten Ways to Reduce Nitrogen Loads from Drained Cropland in the Midwest

Processes that can reduce nitrogen losses

Reducing nitrogen sources
Reducing drain flow
Increasing plant uptake
Increasing denitrification

Simplified nitrogen cycle in drained agricultural systems

- Orange arrows: Inputs
- Green arrows: Outputs to plants and air
- Blue arrows: Outputs to water
### Practices that modify the cropping system

#### 1. Improved nitrogen management

<table>
<thead>
<tr>
<th>What it is</th>
<th>How it works to reduce nitrogen loss</th>
<th>Adoption issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen recommendations often given as 4Rs:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Right source</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Right place</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Right time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- When crop needs it (after planting)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Right rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Economically Optimum Nitrogen Rate (EONR).</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Reducing nitrogen sources**
- **Increasing plant uptake**

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- **Nitrogen in the atmosphere**
- **Ammonium**
- **Nitrification**
- **Nitrate**
- **Seepage**
- **Drainage**
- **Nitrogen Fixation**
- **Fertilizer or Manure Application**
- **Plant Uptake**
- **Denitrification**
Practices that modify the cropping system

2. Winter cover crops

What it is
Cover crops are grown after the cash crop is harvested. Goals are soil health, erosion reduction, carbon sequestration, and nitrogen loss reduction.

Adoption issues
- Added cost, effort
  - Costs of seed and planting
  - Difficulty of establishment in many years
  - Difficulty in terminating in the spring
- Strongly supported by multiple conservation programs

How it works to reduce nitrogen loss
- Increasing plant uptake
- Reducing drain flow

Image: NRCS
Practices that modify the cropping system
3. Add perennials to cropping systems

What it is
Perennials are plants that can grow for two or more years without re-planting.
- Grass and legumes planted for pasture
- Bioenergy crops
- Perennial grains and oil seed crops.

How it works to reduce nitrogen loss
- Increasing plant uptake
- Reducing drain flow

Adoption issues
- Adoption is very limited, due to lack of markets, infrastructure, and on-farm utilization opportunities.
Practices that modify the drainage system
4. Controlled drainage (Drainage water management)

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<tr>
<td>Managing drainage water using adjustable water control structures placed in the drainage system.</td>
<td>Reducing drain flow</td>
<td>Cost of installation</td>
</tr>
<tr>
<td>After harvest</td>
<td>Raising the outlet level when drainage is less critical reduces drainage and nitrogen that move downstream.</td>
<td>– Most cost-effective on slopes &lt; 0.5%.</td>
</tr>
<tr>
<td>Before planting or harvest</td>
<td></td>
<td>Manually-operated gates require time</td>
</tr>
<tr>
<td>After planting</td>
<td></td>
<td>– Adjustments spring and fall required for water quality benefits</td>
</tr>
<tr>
<td></td>
<td></td>
<td>– Adjustments following wetness will benefit yield</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Automation is being developed but adds cost.</td>
</tr>
</tbody>
</table>
Practices that modify the drainage system

5. Reduced drainage intensity (drains with wider spacing)

**What it is**
Installing drainage pipes either with wider spacing or closer to the soil surface can reduce the total water drained.

**How it works to reduce nitrogen loss**
- **Reducing drain flow**

**Adoption issues**
- Newer drainage systems are moving in the opposite direction: Narrower spacing
- Increases in precipitation in the Midwest make narrower spacing more likely in the future.
## Practices that modify the drainage system

### 6. Drainage water recycling

**What it is**

Storing drained water in a reservoir and using it as irrigation later in the season.

**How it works to reduce nitrogen loss**

- Reducing drain flow
- Increasing plant uptake

**Adoption issues**

- **Expensive**
  - Land taken out of production for water storage reservoir
  - Cost of construction
- Irrigation on poorly-drained soils in the Midwest is new and not well researched.
- New NRCS Conservation Practice Standard (CPS 447) may support this once adopted in Midwest states.
Practices that work at the edge of the field

7. Denitrifying woodchip bioreactors

What it is
Bioreactors are trenches filled with woodchips that treat the water by enhancing the natural, biological process of denitrification.

Adoption issues
- No yield benefit
- Require space at the edge of the field.
- Questions still being researched, including longevity.

How it works to reduce nitrogen loss

WCS/IDALS Photo by Lynn Betts. Conservation Media Library
Practices that work at the edge of the field

8. Constructed wetlands

What it is
Wetlands are dynamic ecosystems containing plants, soil, bacteria, and water.

How it works to reduce nitrogen loss

- Increasing plant uptake
- Increasing denitrification
- Reducing drain flow

Adoption issues
- Cost of taking land out of production
- CREP and other programs provide funding
Practices that work at the edge of the field

9. Two-stage Ditches

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<tr>
<td>Adding a floodplain for high flows within the ditch. This creates a zone of plants and soil for plant uptake and denitrification, and may also reduce flow.</td>
<td>![Diagram](Two-stage Ditch Design)</td>
<td>Cost of land needed for wider ditch</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ditches may be more stable, reducing maintenance longterm</td>
</tr>
</tbody>
</table>

- Increasing plant uptake
- Increasing denitrification
- Reducing drain flow

![Typical trapezoidal ditch](Typical trapezoidal ditch) ![Two-stage ditch](Two-stage ditch)
## Practices that work at the edge of the field

### 10. Saturated buffers

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<td>Drain water is distributed through a riparian buffer via a shallow perforated drain pipe that extends laterally along the buffer.</td>
<td><img src="https://via.placeholder.com/150" alt="Diagram" /></td>
<td><strong>No yield benefit</strong>&lt;br&gt;<strong>Not all areas are suitable:</strong>&lt;br&gt;– Buffer should be at a lower elevation than the field&lt;br&gt;– Soil must contain high organic matter content and not have layers of high permeability (sand or gravel layers)</td>
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**What it is**

- Drain water is distributed through a riparian buffer via a shallow perforated drain pipe that extends laterally along the buffer.

**How it works to reduce nitrogen loss**

- Increasing plant uptake
- Increasing denitrification
- Reducing drain flow

**Adoption issues**

- No yield benefit
- Not all areas are suitable:
  - Buffer should be at a lower elevation than the field
  - Soil must contain high organic matter content and not have layers of high permeability (sand or gravel layers)
Conclusions

- **Ten Ways** exist to reduce nitrogen loads from drained cropland.
- All can work, but all have costs for individual farmers with today’s incentives.

Researchers are working on new ways to combine processes, but all options have costs.

- Reducing nitrogen sources
- Reducing drain flow
- Increasing plant uptake
- Increasing denitrification

Adoption Issues

- Today’s incentives have resulted in today’s nitrogen losses.
- Education and research may help, but reducing the nitrogen problem and its health impacts likely requires shifting the incentives.

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