
5th Annual NITROGEN: MINNESOTA’S GRAND CHALLENGE & COMPPELLING OPPORTUNITY CONFERENCE

Sessions 9:05 a.m.-3:40 p.m.

- **General Session**
  - 8:15 a.m. Registration
  - 9:00 a.m. Welcome
    - Tom Rothman
    - University of Minnesota
  - 9:05 a.m. Lessons Learned in 2018, Opportunities for 2019
    - Brad Carlson
    - University of Minnesota Extension
    - Dave Nicolai
    - University of Minnesota Extension
    - Brandon Fast
    - Minnesota Corn Research & Promotion Council
  - 9:55 a.m. An Industry Perspective on Nitrogen: Beginning with 4R Nutrient Stewardship
    - Dr. Tai Maaz
    - International Plant Nutrition Institute
  - 10:50 a.m. Break
  - 11:05 a.m. NUE and Potential Environmental Outcomes Associated with N Application Timing
    - Dr. Carrie Laboski
    - University of Wisconsin-Madison
  - 12:00 Lunch

- **Breakout Session #1**
  - 1:00 p.m. Managing Corn for High Yield and Environmental Stewardship While Controlling Costs
    - Dr. Jeff Coulter
    - University of Minnesota
  - 1:55 p.m. N loss from Midwest cropping systems: What can we do about it?
    - Dr. Dan Jaynes
    - USDA ARS, Ames, IA
  - 2:50 p.m. Urea Fertilizer Do’s and Don’ts
    - Dr. Fabian Fernandez
    - University of Minnesota

- **Breakout Session #2**
  - 1:00 p.m. Improving Nitrogen Mineralization Predictions
    - Dr. Jason Clark
    - South Dakota State University
  - 1:55 p.m. Soil Health and Implications for Nitrogen Management
    - Dr. Anna Cates
    - University of Minnesota
  - 2:50 p.m. Nitrogen Management with Manure
    - Dr. Melissa Wilson
    - University of Minnesota
  - 3:40 p.m. Adjourn
Nitrogen Management with Manure

MELISSA WILSON, Ph.D.
Assistant Professor and Extension Soil Scientist
Department of Soil, Water, and Climate
University of Minnesota

Photo credit: MPCA
AGENDA

- What impacts nitrogen availability?
  - Housing/Storage
  - Species
  - Application equipment
  - Timing/Seasonal application
Figure 1. Percent NH$_3$ emissions from total manure-NH$_3$ in each component of livestock operation (EPA National Emissions Estimates, 2005)
MANURE STORAGE AND HANDLING

- How is the manure collected and stored?
  - Liquids: Deep pits? Flushed system? Anaerobic lagoons or storage ponds?
  - Solids: Indoors or outdoors? Is it mixed often? How is it stacked?

<table>
<thead>
<tr>
<th>Storage, handling method</th>
<th>Manure type</th>
<th>% N loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily scrape, haul</td>
<td>Solid (tons)</td>
<td>25</td>
</tr>
<tr>
<td>Manure pack</td>
<td>Solid (tons)</td>
<td>30</td>
</tr>
<tr>
<td>Open lot</td>
<td>Solid (tons)</td>
<td>50</td>
</tr>
<tr>
<td>Litter</td>
<td>Solid (tons)</td>
<td>35</td>
</tr>
<tr>
<td>Above ground tank</td>
<td>Liquid (gals)</td>
<td>20</td>
</tr>
<tr>
<td>Below ground covered pit</td>
<td>Liquid (gals)</td>
<td>20</td>
</tr>
<tr>
<td>Below ground open pit</td>
<td>Liquid (gals)</td>
<td>25</td>
</tr>
<tr>
<td>Under-floor dry</td>
<td>Solid (tons)</td>
<td>25</td>
</tr>
<tr>
<td>Under-floor liquid</td>
<td>Liquid (gals)</td>
<td>20</td>
</tr>
<tr>
<td>Earthen storage</td>
<td>Liquid (gals)</td>
<td>30</td>
</tr>
<tr>
<td>Lagoon</td>
<td>Liquid (gals)</td>
<td>75</td>
</tr>
</tbody>
</table>
Figure 1. Percent NH₃ emissions from total manure-NH₃ in each component of livestock operation (EPA National Emissions Estimates, 2005)
NUTRIENT CONTENT VARIES BY ANIMAL TYPE

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Swine Liquid</th>
<th>Poultry Litter</th>
<th>Beef Solid</th>
<th>Dairy Liquid</th>
</tr>
</thead>
<tbody>
<tr>
<td>N (total)</td>
<td>60</td>
<td>20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ammonium-N</td>
<td>40</td>
<td>20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Phosphate</td>
<td>20</td>
<td>20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Potash</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
NUTRIENT CONTENT VARIES BY ANIMAL TYPE

Nutrient Content
(lbs per ton or lbs per 1000 gal)

- N (total)
- Ammonium-N
- Phosphate
- Potash

Swine Liquid
Poultry Litter
Beef Solid
Dairy Liquid

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NITROGEN CYCLING

Organic N → Ammonium N → Nitrate N

Plant Uptake

NITROGEN CYCLING

Organic N → Ammonium N → Nitrate N

Plant Uptake

MANURE N DISTRIBUTION

- Swine
- Dairy
- Beef
- Poultry

Inorganic N
Organic N

Percent of Total N
Nitrogen Cycling

Organic N > Ammonium N > Nitrate N

- Volatilization
- Plant Uptake
- Denitrification
- Runoff/erosion
- Leaching
- Immobilization
- Mineralization

Nitrogen Cycling
## IMPACTS ON NUTRIENT AVAILABILITY

- **Animal species**
- **Application method**

### Percent of total nitrogen available per year

<table>
<thead>
<tr>
<th>Year</th>
<th>Available</th>
<th>Broadcast + Timing of Incorporation</th>
<th>Injection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>&gt; 96 hours 12-96 hours &lt; 12 hours</td>
<td>Sweep Knife</td>
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<tr>
<td>Beef</td>
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<td>1</td>
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<td>25 45 60</td>
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<td>2</td>
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<td>25 25 25</td>
<td>25 25</td>
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<tr>
<td>Lost</td>
<td></td>
<td>40 20 5</td>
<td>5 10</td>
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<tr>
<td>Dairy</td>
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<td>20 40 55</td>
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<td>25 25 25</td>
<td>25 25</td>
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<tr>
<td>Lost</td>
<td></td>
<td>40 20 10</td>
<td>5 10</td>
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<tr>
<td>Swine</td>
<td></td>
<td>35 55 75</td>
<td>80 70</td>
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<tr>
<td>1</td>
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<td>15 15 15</td>
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<td>2</td>
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<td>15 15 15</td>
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<tr>
<td>Lost</td>
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<td>50 30 10</td>
<td>5 15</td>
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<td>Poultry</td>
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<td>45 55 70</td>
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<tr>
<td>Lost</td>
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<td>30 20 5</td>
<td>n/a n/a</td>
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</tbody>
</table>
APPLICATION METHOD

Three basic methods for application:
1. Surface (no incorporation)
2. Incorporation or injection
3. Irrigation

*Depends on type and form*
*Most influential factor for controlling N losses*
APPLICATION METHOD

1: Surface application
   – Substantial NH$_3$ volatilization (most in first 24 hours)
   – P and K losses through runoff and erosion
   – Odors can be an issue

APPLICATION METHOD

2: Incorporation and injection

– Substantially reduces total N loss
  ▪ 5-10% lost if incorporated within 12 hours
  ▪ 20-30% if within 4 days
  ▪ 30-50% if left on surface

– Also reduces odors and P & K loss
INJECTION

- Uniform application
  - Pockets of high ammonium & salts can reduce seed germination, injure seedlings
  - Spacing is important, can see striping

- Sweep vs. knife injection
  - Disperses liquid, reduces denitrification loss
  - Shallower, so slows down leaching in sandy soils
WHAT ABOUT THESE?

Double disk applicators

Aerway (soil aerators)
DOUBLE DISK APPLICATORS

- Essentially, it bands manure and immediately incorporates it
  - Shallow incorporation

<table>
<thead>
<tr>
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<th>% of total N available per year</th>
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<tbody>
<tr>
<td></td>
<td>&gt; 96 hours</td>
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<tr>
<td>Beef</td>
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<tr>
<td>1</td>
<td>25</td>
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<td>20</td>
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</tbody>
</table>
AERWAY (SOIL AERATORS)

- Study found dairy manure applied at 20,000 gal per acre to cropland:

## AERWAY (SOIL AERATORS)

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<tr>
<td>Lost</td>
<td>30</td>
<td>20</td>
</tr>
</tbody>
</table>
APPLICATION METHOD

3: Irrigation

- Lagoon effluent alkaline - > NH$_3$ concentration high
- Large volatilization losses
- Need to monitor salt levels in effluent to avoid burning plants
## APPLICATION METHOD

<table>
<thead>
<tr>
<th>Application method</th>
<th>Manure type</th>
<th>NH$_4$-N loss* (% of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface</td>
<td>Solid</td>
<td>15-30</td>
</tr>
<tr>
<td>Surface</td>
<td>Liquid</td>
<td>10-25</td>
</tr>
<tr>
<td>Incorporate†</td>
<td>Solid</td>
<td>1-5</td>
</tr>
<tr>
<td>Incorporate†</td>
<td>Liquid</td>
<td>1-5</td>
</tr>
<tr>
<td>Injection</td>
<td>Liquid</td>
<td>0-3</td>
</tr>
<tr>
<td>Irrigation</td>
<td>Liquid</td>
<td>30-40</td>
</tr>
</tbody>
</table>

*N loss 3 days after application; †Incorporated within a few hours.

WHAT ELSE IMPACTS NUTRIENT AVAILABILITY?

- Application timing

```
Spring
Summer
Fall
Winter
```

Photo credits: MPCA
### APPLICATION TIMING: SPRING

**Advantage**
- Short window between application and uptake
  - Best time on sandy soils

**Disadvantages**
- Logistics
- Greater risk of salt and NH$_3$ toxicity for germinating seeds and young seedlings
- Less time for mineralization for manures with high C:N ratio
  - Immobilization $=>$ early season N deficiency
FIELD EXPERIMENTS

- 2 locations with two sites each
- 6 types of manure
  - Applied all at N-based rate of 140 pounds of plant available N per acre
- Fertilizers (to develop response curve)
- Total treatments: 16
MANURE NUTRIENT AVAILABILITY

Funded by AFREC
MANURE NUTRIENT AVAILABILITY
MANURE NUTRIENT AVAILABILITY

Picture taken June 18, 2018 at SROC

Turkey Litter
Bedded beef pack
June 28, 2018 at SWROC
July 26, 2018 at SWROC
SPRING APPLIED MANURE IN 2018 AT WASECA

Manure Source

- Swine
- Beef
- Dairy
- Separated Dairy
- Composted chicken layer
- Turkey

Nitrogen Rate (lb/A)

- 0
- 42
- 84
- 126
- 168

Corn yield (bu/acre)
### APPLICATION TIMING: SUMMER

<table>
<thead>
<tr>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Sidedressing: Apply nutrients to a growing crop</td>
</tr>
<tr>
<td>▪ Post-harvest: Easy to apply following early-harvested crops</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Can damage standing crops, especially in end rows</td>
</tr>
<tr>
<td>▪ High potential for salt damage when topdressing perennial crops</td>
</tr>
<tr>
<td>▪ NH$_3$ volatilization losses from surface applications are high</td>
</tr>
<tr>
<td>- Warm, dry conditions</td>
</tr>
</tbody>
</table>
SUMMER APPLICATIONS - SIDEDRESSING

- On-farm experiment to test N sources

**Corn-corn-soybean**

- 40 lbs N in starter
- Sidedressed 140 lbs N at V4/V5 stage
- Compared:
  - Swine manure with dragline (3,500 gal per acre)
  - Anhydrous ammonia
  - Liquid UAN (32%)
  - No N sidedressed
SIDEDRESSING MANURE INTO CORN
SIDEDRESSING MANURE INTO CORN
SIDEDRESSING MANURE

Late July, 2018

Anhydrous

Swine

Control

UAN

Anhydrous

Swine

Control

UAN

Partially funded by MN Pork Board and MN Soybean Research and Promotion Council
SIDEDRESSING MANURE

![Bar chart showing corn yield (Bu/acre) for different treatments.](chart)

- **Treatment A**: 208.4 Bu/acre
- **Treatment B**: 204.8 Bu/acre
- **Control**: 140.8 Bu/acre
- **Dragline**: 204.6 Bu/acre

Partially funded by MN Pork Board and MN Soybean Research and Promotion Council
# APPLICATION TIMING: FALL

## Advantages

- Logistics
- Soil generally less subject to compaction
- More time for organic matter mineralization

## Disadvantages

- More time for nutrient losses:
  - Do not fall apply on sandy soils
  - Other soils, apply when soil temperatures <50°F (to reduce nitrification)
- Surface fall application subject to same snowmelt losses as winter application
## APPLICATION TIMING: WINTER

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Avoid compaction if on frozen ground?</td>
<td>- Cannot incorporate</td>
</tr>
</tbody>
</table>

### Disadvantages
- High nutrient loss potential
  - Snowmelt runoff, frozen ground
- Potential to burn perennial crops
- If winter application necessary:
  - Apply only on level ground
  - Fields with more residue are best
  - Most inorganic N will still be lost
WINTER MANURE APPLICATIONS

Applied January 24, 2018
First runoff event

Collected samples: Jan. 28, 2018

14% Solids  3% Solids  No Manure
Third runoff event

Collected samples mid-event after a rainfall: Mar. 4, 2018
WINTER RUNOFF NUTRIENT LOSSES

- Nutrient loss timing through the end of March

Inorganic N: Ammonium + Nitrate

Sampling dates

Nitrogen (mg/L)
WINTER RUNOFF NUTRIENT LOSSES

- Cumulative nutrient losses through the end of March
TAKE HOME MESSAGES

- Large proportion of nitrogen is lost during housing and storage

- Distribution of manure nitrogen between organic and inorganic pools impacts availability
  - Liquid manures tend to be closer to 50% inorganic N, except swine which is 60% inorganic N
  - Solid manures tend to have only 10-20% inorganic N
TAKE HOME MESSAGES

- Application equipment also impacts N availability
  - The faster manure is mixed with soil, the more N is conserved

- Timing of manure application during the year determines N availability, too
  - More research is being conducted to open up the window of opportunity for application
Thank you!

Questions?

Contact Info:
- Email: mlw@umn.edu
- Follow me on twitter: @ManureProf

Research Sponsors:
- Ag. Fertilizer Research and Education Council (AFREC)
- MN Pork Board
- MN Soybean Research and Education Council

Photo by Nastia Vvodenska