Objectives Today

• Discuss factors that affect volatilization and high risk conditions for volatilization
• Present timing, placement and source options to reduce volatilization
• Present results of different sources and timing on grain yield and protein
The N cycle

- NH$_3$ (g)
- Organic Nitrogen
- Immobilization
- Mineralization
- NH$_4^+$
- Plant Uptake
- N$_2$ and N$_2$O
- Volatilization
- Leaching
- Denitrification
- Nitrification
- Urea
- UAN
High risk conditions for urea volatilization

- Moist soil, heavy dew, or high humidity
- Wind
- High soil pH (>7.0)
- High soil temperature (>50 °F) or frozen soil
- Crop residue, perennial thatch or sod WHY?
- Low cation exchange capacity soil (sandy) WHY?
- Poorly buffered soils (low soil organic matter, low bicarbonate content)

- Large number of factors make volatilization amounts variable and difficult to predict.
- The risk of volatilization increases as the number of high risk conditions increase, with soil moisture likely being the most important.
Practices to decrease volatilization from N fertilizers, especially urea

• Incorporate with tillage if possible, seed place (max 10 lb N/acre), mid-row, or subsurface band (in buffered or calcareous soils) at least 2” deep. Applying urea immediately in front of air-drills did not decrease volatilization b/c of insufficient incorporation.

• On thatch, UAN band better than foliar spray

• Apply to dry, cool, but thawed ground

• Apply prior to a large (> 0.5”) moisture event

• Use a protected product (e.g. Agrotain® = NBPT or slow or controlled release) if can’t apply during low risk periods, allows greater amount seed placed
Incorporation depth on volatilization

Urea Rate = 100 lb N/ac
Texture = silt loam
Soil pH = 6.5
Temp. = 75° F

Ernst & Massey 1960
Effect of urea placement on Hays annual forage yield

![Bar chart showing the effect of urea placement on forage yield in 2009 and 2010. The chart includes data from Angvick et al. unpub data.](image-url)
Timing

Generally better to apply near peak uptake to avoid losses, however, weather conditions near application and soil texture may be more important.

- Shallow, coarse soil. Fall or spring?  Spring
- Cool fall temps with ability to irrigate or warmer spring temps before irrigation water delivered. Fall or spring?  Fall
Effect of irrigation amount on urea volatilization

R² = 0.92

Echo, Oregon
Soil Temp = 46°F
Holcomb et al. 2011

Surface soils was pre-moistened
Different N sources have different volatilization loss potential

<table>
<thead>
<tr>
<th>POTENTIAL volatilization loss compared to urea</th>
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<tbody>
<tr>
<td><strong>Conventional Fertilizers</strong></td>
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<tr>
<td>Ammonium nitrate, CAN, ammonium sulfate</td>
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<tr>
<td>UAN (solution 28 or 32)</td>
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<tr>
<td><strong>Enhanced Efficiency Fertilizers</strong></td>
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<tr>
<td>Urease inhibitors (NBPT=Agrotain)</td>
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<tr>
<td>Nitrification inhibitors (DCD, N-Source, N-Serve, Instinct)</td>
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<td>Combinations (SuperU)</td>
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<tr>
<td>Controlled release polymer coated (ESN)</td>
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<tr>
<td>Slow release (Nitamin, N-Sure, N-Demand)</td>
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Stabilized fertilizers: Urease inhibitors

- Volatilization
- Leaching
- Denitrification

- Organic Nitrogen
  - Immobilization
  - Mineralization

- Plant Uptake

- NH₃ (g)
- NH₃

- NH₄⁺
  - Slow urea hydrolysis
    - here, most common is NBPT

- NO₃⁻
  - Nitrification
    - Urea
    - UAN

- N₂ and N₂O

- NO₂⁻
Slow and controlled release fertilizers

- NH$_3$ (g)
- NH$_3$
- Organic Nitrogen
- Plant Uptake
- NO$_3^-$
- N$_2$ and N$_2$O
- Volatilization
- Immobilization
- Mineralization
- Nitrification
- Leaching
- Denitrification
- control release here
- Urea
- UAN
- slow release here
Effect of N source on volatilization

150 lb N/acre on turf in late Sept.

Washington
Soil Temp = 50°F
Koenig unpub. data
UAN volatilization with and without Agrotain®

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<tr>
<th></th>
<th>Check</th>
<th>UAN</th>
<th>UAN+Agrotain</th>
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<tbody>
<tr>
<td>May (74°F)</td>
<td>0</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>July (86°F)</td>
<td>0.6</td>
<td>50</td>
<td>16</td>
</tr>
</tbody>
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Grant et al. 1996, Manitoba
Sources to reduce volatilization on newly seeded grass field

Oregon, 150 lb N/acre fall applied, Horneck et al. 2011
Straw residue and NBPT effect on volatilization

Cumulative Volatilization Loss (% of Applied N)

- Urea on residue
- Urea on bare soil
- NBPT-urea on bare soil
- NBPT-urea on residue

Day

Carmona et al. 1990 lab conditions
Does NBPT decrease volatilization losses in Montana (Engel et al.)?

- Significant ammonia losses (30-40% of applied N) from surface-applied urea can occur even though soil temperatures are near freezing!
- Worst case-conditions for loss:
  - moist surface with only sprinkles for weeks, prolonged damp commonly found in MT during late fall or early spring (Fertilizer Fact #59)
- Based on 17 studies:
  - Average N lost from urea: 18.1%
  - Average N lost from NBPT-urea: 6.5%
NBPT (Agrotain®) reduces N loss in central MT

NH₃ losses observed for late-fall and winter app > than spring, even though temperatures were colder; mitigation by NBPT ≈ 65%

Coffee Creek MT
Engel unpub. data
NBPT with broadcast urea can increase WW grain protein in central MT

90 lb N/acre

Coffee Creek, MT
Engel unpub data

NBPT sig increased protein by about 0.4 to 0.8 % points for both years. NBPT only increased yield in Fall 2012.
Economics

- Agrotain is about $75/ton-urea. So if applied 200 lb urea this would be an additional $7.50/acre cost.
- Would need to grow at least 1 bu/acre more, which only happened fall applied (not winter or spring) in 1 of 2 years.
- However, this does not take into account increased protein and N recovery (9-10% increase with NBPT), with reduced risk to air and water quality.
- The best economic solution might be to use NBPT only when you need to apply during high risk conditions.
Conclusions

• Many factors contribute to volatilization loss; some can, others cannot be controlled
• Soil moisture is likely the most important factor
• Mechanical incorporation or >0.5” water in one event are best to reduce volatilization
• Products are available with lower volatilization potential (ex: UAN, CAN, NBPT, ESN)
• Management practices to reduce volatilization loss can increase yield and grain protein, and reduce risk to air and water quality
Soil fertility publications:
Go to “Extension Publications”
• *Factors Affecting Nitrogen Fertilizer Volatilization*
• *Management to Minimize Nitrogen Fertilizer Volatilization*

MT research data on volatilization: Fertilizer Facts 59 & 60, and
http://landresources.montana.edu/ureavolatilization

This presentation: Go to “Presentations”

To help us assess the impact of Rick Engel’s and my work on urea volatilization, please take a survey at
https://www.surveymonkey.com/s/7FNTZKL
Judith Basin Nitrogen Project (Ewing, Jones, Sigler, and Jackson-Smith)

- Start of 3rd year of studying alternative management practices that reduce nitrate leaching.
- 3 farms (Stanford, Moccasin, and Moore) and 3 alternative practices (replacing fallow with annual legume, slow release N, and split application)
- Practices to test were largely selected by our Producer Research Advisory Group (6 local producers) and Advisory Committee (14 members)
- We’ve learned a lot about what drives nitrate leaching process (like high mineralization)
- More info at: [http://waterquality.montana.edu/docs/judith.shtml](http://waterquality.montana.edu/docs/judith.shtml)
Questions?

Watrous, SK, 1920s