Nitrogen Management

Products

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Ammonia Synthesis

- **Natural Gas**
  - Source of energy
  - Source of $\text{H}_2$
    - $\text{CH}_4 + \text{H}_2\text{O} = \text{CO} + 3 \text{H}_2$
    - $\text{CH}_4 + 2 \text{H}_2\text{O} = \text{CO}_2 + 4 \text{H}_2$
  - Remove CO and $\text{CO}_2$

- **Atmosphere**
  - Source of $\text{N}_2$ (33,000 tons $\text{N}_2$ in air over every acre)

- **Haber-Bosch Process**
  - $3 \text{H}_2 + \text{N}_2 = 2 \text{NH}_3$
Energy - Producing Nitrogen Fertilizer

- For each ton of ammonia production:
  - 26,000 cu ft natural gas
    - 82% for feedstock (hydrogen source)
    - 18% for fuel (heat)
  - Net energy requirement is 30 million BTU per ton N = 15,000 BTU per lb N

- Conversion of ammonia to other N products requires additional energy:
  - Urea = 18,000 BTU per lb N
  - UAN = 16,000 BTU per lb N

## Energy -- Using Nitrogen Fertilizer

<table>
<thead>
<tr>
<th></th>
<th>Transportation BTU/lb N</th>
<th>Application BTU/lb N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia</td>
<td>1,100</td>
<td>1,000</td>
</tr>
<tr>
<td>Urea</td>
<td>2,000</td>
<td>300</td>
</tr>
</tbody>
</table>

- **Total per 100 lb N/acre (diesel fuel equivalent)**
  - Ammonia: 12 gal
  - Urea: 15 gal

Hoeft and Siemens, 1975
Daily Natural Gas Futures Price (NYMEX) - Henry Hub

$/MMBTU

Date

Data Source: Energy Information Administration, DOE

J. E. Sawyer -- Agronomy Extension
Nitrogen Fertilizer Manufacture

- Nitrogen fertilizers originate from anhydrous ammonia
  - Urea
    - Ammonia + Carbon Dioxide
  - Ammonium Nitrate
    - Ammonia + Nitric Acid
  - Urea - Ammonium Nitrate Solutions
    - Urea + Ammonium Nitrate + Water + Ammonia
    - 32% and diluted 28%
Nitrogen Fertilizer Manufacture

- Nitrogen fertilizers originate from anhydrous ammonia
  - Ammonium Sulfate
    - Ammonia + Sulfuric Acid
    - Industrial by-product; coal coke ovens, lysine manufacture, nylon manufacture
  - Aqua Ammonia
    - Ammonia dissolved in water
  - Ammoniated Phosphates - DAP, MAP
    - Ammoniation of phosphoric acid
Nitrogen Fertilizer Manufacture

- **Nitrogen fertilizers originate from anhydrous ammonia**
  - Ammonium Polyphosphate
    - Solutions (10-34-0, 11-37-0)
      - Ammonia + superphosphoric acid + water
    - Dry (12-58-0, 15-61-0)
      - Ammonia + superphosphoric acid
Anhydrous Ammonia

- Advantages
  - Historically least expensive N source
  - High N analysis
  - Dealer system / equipment
  - Slower nitrification
  - Use with nitrification inhibitor
  - Preferred fall N application source
  - Non-leachable in soil immediately after application

\[
\text{NH}_3 + \text{H}_2\text{O} = \text{NH}_4^+ + \text{OH}^-
\]
Anhydrous Ammonia
Field Application

- Requires Injection
  - Depth and soil moisture to retain ammonia
  - For corn -- 20 to 40 inch knife spacing
  - For small grains -- 15 inch or narrower knife spacing
  - Skip row spacing
    - Sidedress
    - Preplant with GPS guidance
Anhydrous Ammonia Band

pH in Highest NH₄-N Zone

120 lb N/acre as Ammonia -- 40 inch rows applied Nov. 19
McIntosh and Frederick, 1958 ISU - Ames, IA -- Nicollet SCL

Initial Soil pH = 6.9
Urea Field Application

- **Urea Hydrolysis**
  - **When urea surface applied**
    - Formation of NH₃ allows volatile loss
    - Up to 20-30% loss under high loss conditions
  - **When urea banded or starter with seed**
    - Plant damage may occur because of ammonia toxicity
    - pH in the 7 to 9 range for 1 to 3 weeks
Urea Band

Soil Solution pH and NH$_4$-N

60 lb N/acre as Banded Urea -- Incubated at 75 F
Isensee and Walsh, 1971; Griswold Loam, pH 7.1

<table>
<thead>
<tr>
<th>pH</th>
<th>Solution NH$_4$ - N, ppm</th>
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<tbody>
<tr>
<td>9.0</td>
<td>0</td>
</tr>
<tr>
<td>8.0</td>
<td>400</td>
</tr>
<tr>
<td>7.0</td>
<td>800</td>
</tr>
<tr>
<td>6.0</td>
<td>1200</td>
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Incubation Days

4 8 16 32
UAN Solutions

Properties

- Mix of urea and ammonium nitrate
- 28% (32%) UAN composition by weight
  - 39.3% (44.3%) Am. Nitrate
  - 30.6% (35.4%) Urea
  - 20.1% (20.3%) water
  - 0.1% Ammonium Hydroxide
  - 10.7 lb/gal (11.0) at 60º F
  - Salt out temperature -1°F (28°F)
  - Biuret 0.4%
Direct Measured Ammonia Loss from Surface Application in No-till

<table>
<thead>
<tr>
<th>Source</th>
<th>Year</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>1992</td>
<td>1993</td>
<td>1994</td>
<td></td>
<td>Average</td>
</tr>
<tr>
<td>Urea</td>
<td>- - - -</td>
<td>lb/acre</td>
<td>- - - -</td>
<td></td>
<td>%</td>
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<tr>
<td></td>
<td></td>
<td>34.6 a</td>
<td>29.4 a</td>
<td>42.3 a</td>
<td>29.5</td>
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<tr>
<td>UAN-Spray</td>
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<td>16.8 a</td>
<td>19.6 b</td>
<td>21.6 b</td>
<td>16.1</td>
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<tr>
<td>UAN-Dribble</td>
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<td>14.6 a</td>
<td>15.3 b</td>
<td>16.9 b</td>
<td>12.9</td>
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</tbody>
</table>

Fox et al., 1996 SSSAJ 60:596-601.
120 lb N/acre rate surface applied to silt loam soils in May.
Impact of N Source and Placement on No-Till Corn Yield

4-yr average C-S rotation (1995-1998) at Belleville, IL
140 lb N/acre; May preplant or weed & feed split (40 lb N bcst - 100 sidedress)
Broadcast Postemergence UAN Application to Corn

- UAN
- Potential for foliage burn
- Limit applications:
  - Up to 90 lb N/acre at V3 to V4 stage corn
  - Up to 60 lb N/acre at V7 stage corn
  - None if larger than V7 stage
    (Randall, Univ. of Minnesota 1984)
  - Herbicides -- consult label, lower UAN rate
Ammonium Sulfate

Properties

- \((\text{NH}_4)_2\text{SO}_4\)
- 21% N; 24% S
- White crystalline solid
- Dry solid granules
- Very soluble in water
- Non-Volatile
- Highest acidifying effect of N fertilizers
  - Adds about $0.02 per pound of N on acid soils
Other N Fertilizers

- Urea forms
  - Coated
    - Sulfur, polyurethane, semi-permeable
  - Urea-formaldehyde
  - Methylene urea
  - Thiourea
  - IBDU - Isobutylidene diurea