The Reactions of Fertilizers

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Reactions

- Commercial fertilizers are chemicals
- They are going through physical reaction
- They are involved in chemical reactions
- Some reactions are biologically mediated
- We can manage the nutrients better by knowing their behavior
## Nitrogen Fertilizers

<table>
<thead>
<tr>
<th>Name</th>
<th>Formula</th>
<th>N%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anhydrous ammonia</td>
<td>NH₃</td>
<td>82%</td>
</tr>
<tr>
<td>Ammonium Nitrate</td>
<td>NH₄NO₃</td>
<td>34%</td>
</tr>
<tr>
<td>Urea</td>
<td>(NH₂)₂CO</td>
<td>46%</td>
</tr>
<tr>
<td>UAN solution</td>
<td></td>
<td>28-32%</td>
</tr>
<tr>
<td>Ammonium Sulfate</td>
<td>(NH₄)₂SO₄</td>
<td>21%</td>
</tr>
</tbody>
</table>
The Nitrogen Cycle

- Atmospheric fixation and deposition
- Animal manures and biosolids
- Biological fixation by legume plants
- Organic nitrogen
- Immobilization
- Mineralization
- Atmospheric nitrogen
- Crop harvest
- Volatilization
- Industrial fixation (commercial fertilizers)
- Plant residues
- Plant uptake
- Ammonium (NH₄)
- Nitrification
- Nitrate (NO₃)
- Denitrification
- Runoff and erosion
- Leaching

Input to soil:
Component:
Loss from soil:
Behavior and uptake of mobile nutrients in soil
• Urease inhibitors interfere with the process of urea hydrolysis
• The slowing of conversion of urea to ammoniacal N can significantly reduce the potential for NH3 volatilization
• Nitrification inhibitors interfere with activity of *Nitrosomonas* bacteria, slowing the nitrification process
• This leaves more N in ammoniacal form, thus reducing the chance of leaching and denitrification

Nitrification
a natural process in soils
Sulfur Coated Urea

- **Mechanisms of N Release**
  - pin holes, cracks
  - Microbial degradation

- **Factors affecting N release**
  - Coating thickness and uniformity
  - Temperature
  - Moisture
Polymer Coated Urea

- N release controlled by diffusion
- Major factors affecting release
  - coating thickness
  - temperature
  - moisture
Stabilized Fertilizers

- With nitrification inhibitors
  - DCD (dicyandiamide)
  - Nitrapyrin
- With urease inhibitors
  - BTPT
  - Hydrochinone (HC)
## Major Phosphorus Fertilizers

<table>
<thead>
<tr>
<th>Name</th>
<th>Formula</th>
<th>N-P$_2$O$_5$-K$_2$O</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAP</td>
<td>(NH$_4$)$_2$HPO$_4$</td>
<td>18-46-0</td>
</tr>
<tr>
<td>MAP</td>
<td>NH$_4$H$_2$PO$_4$</td>
<td>11-54-0</td>
</tr>
<tr>
<td>Ammonium polyphosphate</td>
<td></td>
<td>10-34-0</td>
</tr>
</tbody>
</table>
Ionic forms of P taken up by plants (H$_2$PO$_4^-$ and HPO$_4^{2-}$) exist in equal amounts at about pH 7.2. Plants do not appear to have a preference for one form over the other, thus there is little justification for trying to lime a soil to a pH where ‘P is most available’.
Characteristics of P

- Phosphate ions form Al and/or Fe phosphate at low soil pH
- Phosphate ions form Ca phosphate at high soil pH
- Make P less available to plants
AVAIL P Fertilizer Enhancer

Calcium, iron, magnesium, and aluminum ions fix the phosphorus in the soil, keeping it tied-up and less available to crops.

AVAIL creates a shield around P fertilizer.
Soil Phosphorus Cycle

Figure 6.9  The soil P cycle. An overview of the physical, chemical, and microbiological processes controlling the availability of P to plants and P transport in runoff or leaching waters. (Adapted from Gachon, 1969.)
## Potassium Fertilizers

<table>
<thead>
<tr>
<th>Name</th>
<th>Formula</th>
<th>K$_2$O%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium Chloride</td>
<td>KCl</td>
<td>60</td>
</tr>
</tbody>
</table>
Negatively Charged Colloids Attract Cations

Negatively Charged Colloids

Soil Colloid

K⁺  Na⁺  NH₄⁺  Mg⁺⁺  Ca⁺⁺  H⁺  Ca⁺⁺
Crop uptake of immobile nutrients (P and K)

Absorption is from just a thin cylinder of soil around each root.

Immobile nutrients can buildup to adequate levels (crankcase full)
Fertilizers

- Virtually all fertilizer materials are salts.
- Salt concentration increases when they dissolve in soil.
Salt Effects

- Osmotic pressure of the soil solution increases with salt concentration.
- It makes plant water uptake difficult.
- Some ions may harm the roots when concentrations are high enough.
Poor Stand due to High Amount of Starter fertilizer
Salt Index

“Salt index of a fertilizer is the measurement of the salt concentration that fertilizer induces in the soil solution.”
## Salt Index of Common Fertilizers

<table>
<thead>
<tr>
<th>Fertilizer</th>
<th>Salt Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium Chloride, 0-0-60</td>
<td>116</td>
</tr>
<tr>
<td>Ammonium Nitrate, 34-0-0</td>
<td>105</td>
</tr>
<tr>
<td>Sodium Nitrate, 17-0-0</td>
<td>100</td>
</tr>
<tr>
<td>Urea, 46-0-0</td>
<td>75</td>
</tr>
<tr>
<td>Potassium Thiosulfate, 0-0-25-17(S)</td>
<td>68</td>
</tr>
<tr>
<td>UAN, 28-0-0</td>
<td>63</td>
</tr>
<tr>
<td>Diammonium Phosphate (DAP), 18-46-0</td>
<td>29</td>
</tr>
<tr>
<td>Monoammonium Phosphate (MAP), 11-52-0</td>
<td>27</td>
</tr>
<tr>
<td>Ammonium Polyphosphate, 10-34-0</td>
<td>20</td>
</tr>
</tbody>
</table>
How to Calculate the Amount of Salts?

- Total salt = N + K\(_2\)O
- 5 gallons 10-34-0
- 11.6 lbs x 5 = 58 lbs of liquid
- 58 x 10% = 5.8 lbs of N
Salt Tolerance of Common Crops

- Barley
- Wheat---30 lbs/acre
- Grain Sorghum
- Corn---7 lbs/acre
- Soybean
Fertilizer placed 2x2” from seeds (Starter)

Fertilizer in furrow
(Seed -row or Pop-up application

Alley et al.
# Safe Levels of Fertilizer Salt
(N + K₂O + S in lbs/acre)

<table>
<thead>
<tr>
<th>Fertilizer Placement (distance from seed)</th>
<th>Sandy Soils</th>
<th>Loamy Soils</th>
<th>Clayey Soils</th>
</tr>
</thead>
<tbody>
<tr>
<td>In direct contact</td>
<td>6</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>¼ - ½ inch</td>
<td>10</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>1 - 2 inches</td>
<td>20</td>
<td>30</td>
<td>40</td>
</tr>
<tr>
<td>&gt;2 inches</td>
<td>25+</td>
<td>38+</td>
<td>50+</td>
</tr>
</tbody>
</table>
Considerations for Salt Index

1. Type of fertilizer
2. Amount of salts
3. Distance of fertilizer from the seed
4. Crops
5. Soil texture
6. Soil moisture conditions
Fertilizers best suited for seed-row application

- Low salt index
- High water solubility
- Minimize content of compounds that liberate NH3
Under drought Condition

- Soil nitrate concentration tend to be higher (less leaching and less uptake)
- Lower soil pH (higher salt concentration in soil solution)