Secondary Nutrients

- Sulfur (S)
- Calcium (Ca)
- Magnesium (Mg)
Typical Crop Removal Rates of Sulfur, Calcium and Magnesium

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield/Acre</th>
<th>Ca</th>
<th>Mg</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn Grain</td>
<td>150 bu</td>
<td>3</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Corn Silage</td>
<td>20 Tons</td>
<td>30</td>
<td>30</td>
<td>18</td>
</tr>
<tr>
<td>Sorghum Grain</td>
<td>100 bu</td>
<td>4</td>
<td>5</td>
<td>14</td>
</tr>
<tr>
<td>Wheat Grain</td>
<td>50 bu</td>
<td>2</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Soybean Grain</td>
<td>40 bu</td>
<td>7</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>5 Tons</td>
<td>140</td>
<td>25</td>
<td>25</td>
</tr>
</tbody>
</table>
Sulfur

• Absorbed from soil as sulfate (SO$_4^{--}$)
• Constituent in 3 of the 21 amino acids
• Deficiency symptoms
  – Yellowing and stunting
  – Begins on young leaves
  – Alfalfa - the leaves become long and slender
Sulfur Cycle

[Diagram of the sulfur cycle with labeled steps including:
- Soil Organic Matter
- Atmospheric Sulphur
- Elemental Sulphur (S) Fertilizer
- Sulphate Sulphur Fertilizer
- Sulphate Sulphur
- Plant and Animal Residues
- Bacterial Assimilation (Immobilization)
- Plant Uptake
- Crop Removal
- Leaching Loss]
SULPHUR RATES
LB/A
90 0
JUNE, 1978  WARTMAN, GRAY CO
Sulfur Fertilization Need Increasing?

- Higher crop yields – greater S demand
- Low sulfur fertilizers - ???????
- Less manure used in certain areas
- Less atmospheric S deposition
- Soil organic matter is lower than past
Sulfur Sources

• 95%+ of soil sulfur is in organic matter
  – Decomposition of organic matter releases sulfate ions to plants
  – More is released under warm, moist conditions than when soils are excessively dry or cold

• Manure
  – Varies with animal, age and feeding program

• Atmospheric Sulfur
  – Sulfur dioxide and other sulfur gases are dissolved in rain or snow
  – 5-20 pound per acre annually

• Irrigation water
  – Sulfur only applied when water applied, however
Determining Sulfur Need

• Low Organic Matter Soils
• Sands
• High demand crops such as alfalfa remove more sulfur and respond to sulfur fertilization
• Responsive crops/situations such as wheat and corn
• Low sulfate irrigation water

• Soil tests are more reliable on sandy soils
• Plant tissue tests more useful in diagnosing a deficiency
# Common Sulfur Fertilizers

<table>
<thead>
<tr>
<th>Name of Fertilizer</th>
<th>Chemical Formula</th>
<th>Average % of Sulfur</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Soluble</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonium Sulfate</td>
<td>((\text{NH}_4)_2\text{SO}_4)</td>
<td>24</td>
</tr>
<tr>
<td>Potassium-Magnesium Sulfate</td>
<td>(\text{K}_2\text{SO}_4 \cdot 2\text{MgSO}_4)</td>
<td>22-23</td>
</tr>
<tr>
<td>Ammonium Thiosulfate Solution</td>
<td>((\text{NH}_4)_2\text{S}_2\text{O}_3 + \text{H}_2\text{O})</td>
<td>26</td>
</tr>
<tr>
<td><strong>Less Soluble</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium Sulfate (Gypsum)</td>
<td>(\text{CaSO}_4 \cdot 2\text{H}_2\text{O})</td>
<td>15-18</td>
</tr>
<tr>
<td><strong>Insoluble</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elemental Sulfur</td>
<td>(\text{S})</td>
<td>88-95</td>
</tr>
</tbody>
</table>

- **Soluble** fertilizers are fully soluble in water.
- **Less Soluble** fertilizers partially dissolve in water.
- **Insoluble** fertilizers do not dissolve in water. 
Calcium (Ca)

• Functions in plants
  – Absorbed as Ca$^{++}$
  – Cell wall strength

• Calcium Deficiency
  – Rarely observed in field
  – Only on very acid soils
  – Apply lime to correct

• Calcium in soil
  – Most common cation on exchange complex
  – Soil pH is indicator of availability
Magnesium (Mg)

• Functions in plants
  – Absorbed as Mg\(^{++}\)
  – Constituent of chlorophyll
  – Phosphorus metabolism and plant enzyme systems

• Deficiency
  – Mg is transferred from older to new tissue
  – Most common on acid, sandy, low CEC soils

• Mg in soil
  – ‘Low’ tissue Mg in soil can induce grass tetany
Secondary Nutrients

- Sulfur (S)
- Calcium (Ca)
- Magnesium (Mg)