Soil pH and Fertility

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What is soil pH?

The concentration of H⁺ in the soil solution
Strength of binding of ions to soil

\[
\text{Al}^{+3} > \text{H}^+ > \text{Ca}^{+2} > \text{Mg}^{+2} > \text{K}^+ = \text{NH}_4^+ > \text{Na}^+ 
\]

The Lyotropic Series
What is an acid soil?

- **basic** = high base saturation
- **acid** = low base saturation

80% base saturation  50% base saturation
The production of acidity during nitrification

Nitrification

\[ \text{NH}_4^+ \rightarrow \text{NO}_3^- + 2\text{H}^+ \]

Nitrification of ammonium or ammonium forming fertilizers is the primary source of acidity in agricultural soils.
Assumption:
For each NH₄ or NO₃ take up by the plant 1 H⁺ or OH⁻ will be exchanged. This is not the case.
Soil Acidity and Environment

- Oklahoma soils have a predominate characteristic of a neutral subsoil.
- Observed trends in Sorghum and Sunflower pH trials
  - In 2009 where soil conditions were relatively dry during the 30 day window after planting emergence and yield was significantly impacted.
  - In 2010 we had perfect moisture at and after planting emergence was near perfect at any pH greater than 4.5 and final yield was not greatly impacted.
Soil Acidity and Environment

- 2010 continued
  - We did see crop differences mid season when we experienced periods of dry hot weather.
  - Plant height, NDVI, and final stand count significantly impacted when pH < 6.0.
Herbicides and pH

- Where/how is most of the N applied in a No-till field.
- Where do we apply our herbicide in No-Till
Atrazine is more persistent at **higher** soil pH

- **10% control after 2 months**
- **90% control after 2 months**

Hiltbold and Buchanan, Weed Sci. 25:515-520
SUs are more persistent at higher soil pH

Glean (chlorsulfuron)

Soil pH 7.5
Half-life ≈ 10 weeks

Soil pH 5.6
Half-life ≈ 2 weeks
How much soil will lime react with in no-till?

<table>
<thead>
<tr>
<th>Depth</th>
<th>CLA</th>
<th>CLA</th>
<th>CLB</th>
<th>CLB</th>
<th>OS</th>
<th>OS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>5.8</td>
<td>6.7*</td>
<td>5.5</td>
<td>6.5*</td>
<td>5.6</td>
<td>6.2*</td>
</tr>
<tr>
<td>1-2</td>
<td>5.5</td>
<td>6.1*</td>
<td>5.1</td>
<td>5.7*</td>
<td>5.3</td>
<td>5.7*</td>
</tr>
<tr>
<td>2-3</td>
<td>5.7</td>
<td>6.0*</td>
<td>5.1</td>
<td>5.2*</td>
<td>5.4</td>
<td>5.6*</td>
</tr>
<tr>
<td>3-4</td>
<td>5.8</td>
<td>6.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.4</td>
<td>5.5</td>
</tr>
<tr>
<td>4-5</td>
<td>5.9</td>
<td>5.9</td>
<td>5.0</td>
<td>5.0</td>
<td>5.5</td>
<td>5.6</td>
</tr>
<tr>
<td>5-6</td>
<td>5.9</td>
<td>6.0</td>
<td>5.1</td>
<td>5.1</td>
<td>5.6</td>
<td>5.9</td>
</tr>
<tr>
<td>6-9</td>
<td>6.1</td>
<td>6.1</td>
<td>5.4</td>
<td>5.4</td>
<td>6.0</td>
<td>6.1</td>
</tr>
</tbody>
</table>
The “How To” Part

- Soil sampling no-till fields
  - Generally, I recommend a 0–3 inch sample for pH
  - a 0–6 inch sample for P, K and Zn
  - a profile sample for N, S and Cl where appropriate

- Selecting target pH
  - Most people still believe we need to lime to higher pH than necessary.
  - For most grains, and forage grasses maintaining pH in the 5.5 to 6.0 range is fine
  - For most forage legumes, 6.4 and above
  - Soybeans are probably somewhere in between
Lime rates and frequency
- Generally my rule of thumb is half normal rate recommended for conventional tillage, but twice as often.
- 100 lbs of N per year for 3 years produces enough acidity to require about 1 ton of common ag lime to neutralize it (50–60% ecc)

Nitrogen placement
- The acidity is produced where the N is nitrified.
- Surface applied N produces surface acidity
- Knifed ammonia produces acidity below where surface applied N will effect it.
# Crop Use and Deposition

<table>
<thead>
<tr>
<th>Element</th>
<th>67 wheat</th>
<th>200 Corn</th>
<th>60 Bean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfur</td>
<td>6</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>Chloride</td>
<td>4</td>
<td>4.8</td>
<td>1</td>
</tr>
<tr>
<td>Calcium</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boron</td>
<td>0.08</td>
<td>0.2</td>
<td>0.18</td>
</tr>
<tr>
<td>Lbs/ac</td>
<td>67 wheat</td>
<td>200 Corn</td>
<td>60 Bean</td>
</tr>
</tbody>
</table>
Crop Use and Deposition

- $\text{SO}_4\ 08/09$
- Cl 08/09
- Ca 08/09
Secondary and Micro Def.

- High Yielding, Highly productive areas.
  - Commonly have better soil and more OM.
- Low OM, Deep Sands, Irrigated.
  - Pay attention to nutrient levels in irrigation water.
- pH extremes, low and high.
  - Nutrients can be tied up in the extremes.
  - Lime will help in acidic soils.
  - Will have to fertilize for metals in high pH.
Soil Samples

- What are you Growing?
  - Wheat, Corn, Sorghum, Canola, Sunflower, Cotton, Sesame.
- What is do their roots look like?
- Why only test 0–6 if the crop has a deep tap root.
- Does your soil have more clay at depth?
- Many will find large amounts of N, S, B in the 6–18.
Tissue Testing

- Snap Shot in Time
- Sensitive to the Environment
- Evaluation of Management Strategy
- Diagnosis In–Season Problems
Sample Collection

- Is somewhat dependent on goal.
  - Diagnosis
    - Whole plant early, top fully developed Trifoliate later
  - Monitoring
    - Top fully developed trifoliate at flowering

- Allow leaves to wilt over night to remove excess moisture, placed in a paper bag or mailing envelope, and shipped to a lab for analysis. **Do not place the leaves in a plastic bag or other tightly sealed container**, as they will begin to rot and decompose during transport, and the sample won’t be usable.

- **Do not sample during periods of stress**, drought, pest ect.
Evaluation of Nutrition

- Taken Later in Season
- Uses a list of Sufficiency's
  - Based on Range
- If sample is on the edge of being low, either edge, response will be variety/environmentaly dependent.
- If results shows extreme lows, deficiency and response more likely
Table 4.12. Sufficiency levels of plant nutrients for several crops at recommended stages of growth shown in Table 4.13.

<table>
<thead>
<tr>
<th>Element</th>
<th>Grain sorghum</th>
<th>Soybeans</th>
<th>Small grains</th>
<th>Peanuts</th>
<th>Alfalfa</th>
<th>Bermuda-grass</th>
</tr>
</thead>
<tbody>
<tr>
<td>N, %</td>
<td>2.7-3.5</td>
<td>3.3-4.0</td>
<td>4.2-5.5</td>
<td>1.7-3.0</td>
<td>3.5-4.5</td>
<td>4.5-5.0</td>
</tr>
<tr>
<td>P, %</td>
<td>0.25-.40</td>
<td>0.20-.35</td>
<td>0.26-.50</td>
<td>0.20-.50</td>
<td>0.20-.35</td>
<td>0.26-.70</td>
</tr>
<tr>
<td>K, %</td>
<td>1.7-2.5</td>
<td>1.4-2.5</td>
<td>1.7-2.5</td>
<td>1.5-3.0</td>
<td>1.7-3.0</td>
<td>2.0-3.5</td>
</tr>
<tr>
<td>Ca, %</td>
<td>0.21-.1</td>
<td>0.30-.60</td>
<td>0.36-2.0</td>
<td>0.20-.50</td>
<td>1.25-1.75</td>
<td>0.50-3.0</td>
</tr>
<tr>
<td>Mg, %</td>
<td>0.21-.60</td>
<td>0.20-.50</td>
<td>0.26-1.0</td>
<td>0.15-.50</td>
<td>0.30-.80</td>
<td>0.30-1.0</td>
</tr>
<tr>
<td>S, %</td>
<td>0.20-.30</td>
<td>0.26-.50</td>
<td>0.15-.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B, ppm</td>
<td>4-25</td>
<td>1-10</td>
<td>21-55</td>
<td>5-10</td>
<td>20-50</td>
<td>30-80</td>
</tr>
<tr>
<td>Cu, ppm</td>
<td>2-6</td>
<td>2-7</td>
<td>10-30</td>
<td>5-25</td>
<td>10-50</td>
<td>7-30</td>
</tr>
<tr>
<td>Fe, ppm</td>
<td>21-25</td>
<td>65-100</td>
<td>51-350</td>
<td>50-150</td>
<td>100-350</td>
<td></td>
</tr>
<tr>
<td>Mg, ppm</td>
<td>20-150</td>
<td>8-190</td>
<td>21-100</td>
<td>25-100</td>
<td>100-350</td>
<td>31-100</td>
</tr>
<tr>
<td>Zn, ppm</td>
<td>20-70</td>
<td>15-30</td>
<td>21-50</td>
<td>15-70</td>
<td>20-50</td>
<td>21-70</td>
</tr>
</tbody>
</table>
### Table 4.13. Guide to plant sampling for tissue analysis.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Plant part to sample</th>
<th>Stage of growth</th>
<th>Number of plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn or Grain sorghum</td>
<td>All above-ground</td>
<td>Seedling stage (less than 12&quot;)</td>
<td>20-30</td>
</tr>
<tr>
<td>Corn or Grain sorghum</td>
<td>Top fully developed leaf</td>
<td>Prior to tasseling</td>
<td>15-25</td>
</tr>
<tr>
<td>Corn</td>
<td>Leaf at ear node</td>
<td>Tasseling to early silk*</td>
<td>15-25</td>
</tr>
<tr>
<td>Grain sorghum</td>
<td>Second leaf from top</td>
<td>At heading</td>
<td>15-25</td>
</tr>
<tr>
<td>Soybeans</td>
<td>All above-ground</td>
<td>Seedling stage (less than 12&quot;)</td>
<td>20-30</td>
</tr>
<tr>
<td>Soybeans</td>
<td>Top fully developed trifoliate leaves</td>
<td>Prior to or during initial flowering*</td>
<td>20-30</td>
</tr>
<tr>
<td>Small grain</td>
<td>All above-ground</td>
<td>Seedling stage (prior to tillering)</td>
<td>50-100</td>
</tr>
<tr>
<td>Small grain</td>
<td>All above-ground</td>
<td>As head emerges from boot*</td>
<td>15-25</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>All above-ground</td>
<td>Prior to bloom</td>
<td>30-40</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>Top 1/3 of plant</td>
<td>At bloom*</td>
<td>15-25</td>
</tr>
<tr>
<td>Cotton</td>
<td>Whole plants</td>
<td>Early growth</td>
<td>20-30</td>
</tr>
<tr>
<td>Cotton</td>
<td>Petioles of youngest fully expanded leaves</td>
<td>During bloom*</td>
<td>20-30</td>
</tr>
</tbody>
</table>

*Recommended sampling period for fertilizer evaluation.

Oklahoma Soil Fertility Handbook 2006
The top, fully developed leaves are generally the dark green leaves visible at the top of the canopy, which are attached at the second or third node down from the top of the stem, ear leaf, or 2nd leaf from head.

Sampling later, once seed development begins, will give lower nutrient contents as soybean plants begin to translocate nutrients from leaves to the developing seed very quickly.
Diagnostic

- Take comparison samples from both good/normal areas of the field, and problem spots.
- Collect soil samples from the same good and bad areas, and don’t wait for flowering to sample soybeans.
Diagnostic

- Will identify what is different in the plant.
- You must identify why.
  - K deficiency: due to planter compaction.
  - P deficiency: due to Acidic soil condition.
Summary on Tissue Testing

- Similar to GreenSeeker
  - Without a known reference there are a lot of variables.
- A quality tool for the tool belt
- “Plant analysis cannot be used to make fertilizer recommendations because the soil pH and soil nutrient level must be known. It can be used to adjust the fertilizer recommendation once the soil level is known. The same factors that interfere with identifying nutrient deficiency symptoms must be considered when interpreting plant analysis.“

- Oklahoma Soil Fertility Handbook 2006
Thank you!!!

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Thank you!!!