Soil Sampling, Fertilizer Recommendations, and Economics of Fertilization

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Soil Sampling
Goals of Soil Sampling

- To collect a soil sample that is representative of a field or portion of a field
- Estimate the nutrients needed for economically profitable crop production
- Gain an understanding of nutrient variability within a field
- Monitor changes in nutrient status over time
When to Soil Sample

- pH, P, & K tend to be higher in spring than fall
  - Soil test levels rebound over time – movement between pools within the soil
  - Fall sampling generally provides a more conservative (larger) fertilizer recommendation

- Be consistent with timing

- Sampling frozen ground is generally not a good idea
How to Take a Soil Sample

- **Tools**
  - Buckets
  - Probes/augers
How to Take a Soil Sample

- Sample to plow depth or at least 6"
  - Be consistent with depth every year
  - Push aside residue

- 0 – 8” sample = 21 ppm
- 0 – 6” sample = 25 ppm
- 0 – 4” sample = 30 ppm
How to Take a Soil Sample

- Place 10-20 cores in buckets and mix thoroughly for a composite sample

- Place ~ 2 cups of soil in sample bag
  - Bag should be labeled with your name, field id, and sample number (eg. Laboski – Field A – Sample 3)

- Mark location of sample on an aerial map or drawing

- Fill out soil info. sheet
Where to Soil Sample

Types of sampling schemes
- Whole field
- Grid
- Zone

Scheme used is determined by:
- Expected fertilizer management approach
- Sampling history
- Existing fertility level
Whole Field

- Used where a single fertilizer recommendation will be used in a field
- Conventional sampling
  - Plus – relatively cheap
  - Minus – no info. about nutrient variability
Whole Field – Sampling Intensity

<table>
<thead>
<tr>
<th>Field characteristics</th>
<th>Field size</th>
<th>Suggested number of samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fields tested &gt; 4 years ago; or Fields testing in responsive range</td>
<td>All fields</td>
<td>1 sample/ 5 acres</td>
</tr>
<tr>
<td>Non-responsive fields tested ≤ 4 years ago</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 – 10</td>
<td>2 samples/ field</td>
</tr>
<tr>
<td></td>
<td>11 – 25</td>
<td>3 samples/ field</td>
</tr>
<tr>
<td></td>
<td>26 – 40</td>
<td>4 samples/ field</td>
</tr>
<tr>
<td></td>
<td>41 – 60</td>
<td>5 samples/ field</td>
</tr>
<tr>
<td></td>
<td>61 – 80</td>
<td>6 samples/ field</td>
</tr>
<tr>
<td></td>
<td>81 - 100</td>
<td>7 samples/ field</td>
</tr>
</tbody>
</table>

- Responsive range is where either soil test P or K are in the high (H) category or lower
- Non-responsive range is where both soil test P & K are in the very high (VH) or excessively high (EH) category
Whole Field

- Avoid sampling unusual areas:
  - Dead furrows or back furrows
  - Lime, sludge, or manure piles
  - Near fences or roads
  - Rows where fertilizer has been banded
  - Eroded knolls/ low spots

- If distinctive area is large enough, sample separately
Whole Field

- Sampling pattern for 15 acre field with past soil tests in responsive range

- Each sample should be composed of at least 10 cores
Grid

- Used where nutrients will be applied variably
- Can be useful if purchase/rent new ground and past history not well known
- Plus – good assessment of nutrient variability
- Minus – expensive
Grid

- Unaligned systematic grid point method
  - 300’ (2.1 acre) grid – if both P & K are in non-responsive categories (VH & EH)
  - 200’ (0.92 acre) grid – if either P or K are in responsive categories (below H)
Grid

- Sample locations have GPS coordinates
- Sample consists of at least 10 cores composited within a 10’ radius of grid point
Zone

- Used where management may be different across a field
- Zone borders and/or sampling points can be georeferenced

Plus/Minus
- Provides an assessment of variability better than whole field, not as good as grid
- Cost Effective
Zone

- Zone delineation – based on knowledge of the field
  - Soil and/or yield maps
  - Topography/elevation map
  - Past history
  - Nutrient maps from previous grid sampling

- Follow whole field sampling intensity guidelines, considering the zone a field
Zone Delineation

- Zone 1: Sand
  - 3 zones
  - Loam
  - Muck

- Zone 2: Limed 5 years ago
  - 2 zones
  - Never limed

- Zone 3: Formerly 2 fields now all 1 field
  - 2 zones

- Zone 4: 15 T/a manure last year
  - 2 zones
  - No manure

- Zone 5: Gentle slope
  - 3 zones
  - Well drained
  - Steep slope
  - Well drained
  - Flat
  - Poorly drained
Contour Strip Fields

- If strips are $\geq 5$ acres, sample each strip separately
  - Use whole field sampling intensity guidelines

- If strips are $< 5$ acres and cropping & management histories are identical:
  - Combine cores from 2 – 3 strips

- If grid sampling a contour striped field, make sure sampling locations are in each strip
Fields requiring special sampling procedures

- Chisel plowing and offset disking
  - ¾ of tillage depth

- Till-plant and ridge till
  - Sample ridges to 6” and between rows (furrows) to 4”

- No-till
  - 0-2” for pH
  - 0-6” for nutrients
Soil Sampling

- See UWEX Factsheet A2100 for additional details
Soil Testing
Sample Analysis

- Samples must be analyzed by a Wisconsin DATCP certified lab
- Analyses must follow specified procedures
- UW recommendations
DATCP Certified labs

- UW Soil and Plant Analysis Lab - Madison
- UW Soil and Forage Analysis Lab - Marshfield
- A & L Great Lakes, Inc. – Fort Wayne
- Ag Source Cooperative Services
- Dairyland Laboratories
- Mowers Soil Testing Plus, Inc.
- Rock River Laboratory

List current as of October 2004
Specified Procedures

- Details of procedures can be found at:
  http://uwlab.soils.wisc.edu/procedures.htm
Recommendations

- Recommendations for nutrients must be consistent with UW recommendations
  - UWEX Bulletin A2809

- UW recommendations
  - Best estimate to optimize economic return
  - Not developed as an environmental standard
  - Based on research on Wisconsin soils
Soil Test Interpretation Categories

- **Soil Test Level**
  - Very High
  - High
  - Optimum
  - Low
  - Very Low

- **Relative Supply of Nutrients From Soil and Fertilizer**
  - Soil
  - Fertilizer

- **Probability of Yield Increase**
  - <5%
  - 5-30%
  - 30-60%
  - 60-90%
  - >90%

Nutrients available from soil
Nutrients required

Adapted from Havlin et al., 1999 using WI interpretations

* Fertilizers used at high soil test levels are for starter or maintenance purposes
Relationship Between P & K Soil Test and Fertilizer Recommendation

Soil Test Level

Nutrient Rate

**VL & L category**

**H & VH category**

**Opt. category**

- **Buildup Range**
- **Critical Level**
- **Maintenance Range**
- **Maintenance Limit**
- **Drawdown Range**
- At VH or EH

**Opt. category**

**H & VH category**

**VL & L category**
## Relationship Between P & K Soil Test and Fertilizer Recommendation

<table>
<thead>
<tr>
<th>Soil Test Category</th>
<th>Fertilizer Recommendation Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low, Low</td>
<td>Crop removal +</td>
</tr>
<tr>
<td>Optimum</td>
<td>Crop removal</td>
</tr>
<tr>
<td>High, Very High</td>
<td>½ or ¼ Crop removal</td>
</tr>
<tr>
<td>Excessively High</td>
<td>None</td>
</tr>
</tbody>
</table>
UW Recommendations – P & K

- Recommendations in A2809 consider:
  - Crop demand (Table 4, p 17)
  - Soil type (Table 10, p 25-32)
    • Get subsoil group code
  - Soil test level (Tables 5 & 6, p 19-20)
    • Determines interpretation range, probability of response
  - Yield goal
    • Determine relative nutrient need
# N Recommendations

<table>
<thead>
<tr>
<th>OM %</th>
<th>--- Sands/loamy sands ---</th>
<th>----- Other soils yield potential -----</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Irrigated</td>
<td>Non-irrigated</td>
</tr>
<tr>
<td>&lt; 2</td>
<td>200</td>
<td>120</td>
</tr>
<tr>
<td>2-9.9</td>
<td>160</td>
<td>110</td>
</tr>
<tr>
<td>10-20</td>
<td>120</td>
<td>100</td>
</tr>
<tr>
<td>&gt; 20</td>
<td>80</td>
<td>80</td>
</tr>
</tbody>
</table>

- Subtract legume & manure N credits
- Does not include ≤ 20 lb N/a in starter
  - Any starter N > 20 lb N/a should be subtracted from rate in the table
- If > 50% residue cover after planting, increase rate by 30 lb N/a
- Optimum N rate similar for good or bad year – not a function of yield goal
## Legume N Credits

<table>
<thead>
<tr>
<th>Crop</th>
<th>Sandy Soils Regrowth</th>
<th>Other Soils Regrowth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; 8”</td>
<td>&gt; 8”</td>
</tr>
<tr>
<td>Alfalfa, &gt; 70% stand</td>
<td>100</td>
<td>140</td>
</tr>
<tr>
<td>Alfalfa, 30-70% stand</td>
<td>70</td>
<td>110</td>
</tr>
<tr>
<td>Alfalfa, &lt; 30% stand</td>
<td>40</td>
<td>80</td>
</tr>
<tr>
<td>Alfalfa, seeding</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>Red Clover/Birdsfoot Trefoil, &gt; 70%</td>
<td>80</td>
<td>110</td>
</tr>
<tr>
<td>Red Clover/Birdsfoot Trefoil, 30-70%</td>
<td>50</td>
<td>90</td>
</tr>
<tr>
<td>Red Clover/Birdsfoot Trefoil, &lt; 30%</td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>Vetsch</td>
<td>40</td>
<td>110</td>
</tr>
<tr>
<td>Soybean</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>Beans (snap/dry), peas</td>
<td>0</td>
<td>20</td>
</tr>
</tbody>
</table>
Notes: Forage Legume N Credits

- Credits not affected by:
  - Time of killing
  - Method of killing
  - Tillage

- 2nd year credits
  - 50 lb N/a for good or fair stands
  - No credit on sands and loamy sands

Stand Assessment

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Stand</th>
<th>Alfalfa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>Plants/ft²</td>
</tr>
<tr>
<td>Good</td>
<td>&gt; 70</td>
<td>&gt; 4</td>
</tr>
<tr>
<td>Fair</td>
<td>30 – 70</td>
<td>1.5 – 4</td>
</tr>
<tr>
<td>Poor</td>
<td>&lt; 30</td>
<td>&lt; 1.5</td>
</tr>
</tbody>
</table>
Lime Recommendations

- Based on:
  - Soil pH, OM, buffer pH, target pH

- Recommendation based on crop with greatest target pH

- Lime recommended when:
  - soil pH < target pH – 0.2

- Report indicates T/a of 60-69 and 80-89 lime needed to reach target pH
# Lime Recommendations

## Rotation 1

<table>
<thead>
<tr>
<th>Crop</th>
<th>Target pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>6.0</td>
</tr>
<tr>
<td>Oats</td>
<td>5.8</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>6.8</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>6.8</td>
</tr>
</tbody>
</table>

Lime to 6.8 if pH is ≤ 6.6

## Rotation 2

<table>
<thead>
<tr>
<th>Crop</th>
<th>Target pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>6.0</td>
</tr>
<tr>
<td>Oats</td>
<td>5.8</td>
</tr>
<tr>
<td>Red Clover</td>
<td>6.3</td>
</tr>
<tr>
<td>Red Clover</td>
<td>6.3</td>
</tr>
</tbody>
</table>

Lime to 6.3 if pH is ≤ 6.1
Reading a Soil Test Report
# Soil Test Report

**Samples Analyzed By:**
UW Soil & Plant Analysis Lab  
5711 Mineral Point Road  
Madison, WI 53705

**LAB #: 12345**

- **County:** Dane  
- **Account No:** 556996  
- **Date Received:** 7/30/2003  
- **Date Processed:** 8/27/2003

**Nutrient Recommendations**

<table>
<thead>
<tr>
<th>Cropping Sequence</th>
<th>Yield Goal per acre</th>
<th>Crop Nutrient Need</th>
<th>Fertilizer Credit</th>
<th>Nutrients to Apply</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N</td>
<td>P2O5</td>
<td>K2O</td>
</tr>
<tr>
<td>Corn, grain</td>
<td>131-150 bu</td>
<td>150</td>
<td>25</td>
<td>70</td>
</tr>
<tr>
<td>Oat</td>
<td>61-90 bu</td>
<td>60</td>
<td>15</td>
<td>90</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>4.6-5.5 tons</td>
<td>0</td>
<td>65</td>
<td>290</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>4.6-5.5 tons</td>
<td>0</td>
<td>65</td>
<td>290</td>
</tr>
</tbody>
</table>

The lime required for this rotation to reach pH 6.8 is 4 T/a of 60-69 lime or 3 T/a of 80-89 lime.

### Additional Information

If lime has been applied in the last two years, more lime may not be needed due to incomplete reaction.

**Year 1:** If corn harvested for silage instead of grain add extra 30 lbs P2O5 per acre and 90 lbs K2O per acre to next crop.

If barley or oats are undersown with a legume forage, reduce nitrogen by 50%.

Starter fertilizer (e.g. 10+20+20 lbs N+P2O5+K2O/a) is advisable for row crops on soils slow to warm in the spring.

A soil nitrate test may better estimate actual corn needs.

If conservation tillage leaves more than 50% residue cover when corn follows after corn, add an additional 30 N lbs/a.

If alfalfa will be maintained for more than three years, increase recommended K2O by 20% each year.

### Test Interpretation

<table>
<thead>
<tr>
<th>Cropping Sequence</th>
<th>Very Low</th>
<th>Low</th>
<th>Optimum</th>
<th>High</th>
<th>Very High</th>
<th>Excessive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn, grain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alfalfa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alfalfa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotation pH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Example

- Plano soil
- Crop to be grown is corn (180 bu/a)
- Previous crop = soybean, next crop = soybean
- No manure applied within past 5 years
- Tillage = chisel/disk
- Soil test info.
  - P = 25 ppm
  - K = 85 ppm
  - pH = 6.0
  - Buffer pH = 6.1
  - OM = 3.0%
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Subsoil group</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Yield potential</strong></td>
<td></td>
</tr>
<tr>
<td><strong>P &amp; K demand level (Table 4)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Target pH (Table 4)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Soil test P category (Table 5)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Soil test K category (Table 6)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>P recommendation (Tables 14 &amp; 19)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>K recommendation (Tables 14 &amp; 19)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>N recommendation (Tables 20 &amp; 25)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Lime recommendation (Table 9 &amp; p. 6)</strong></td>
<td></td>
</tr>
</tbody>
</table>
### Example

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsoil group</td>
<td>B</td>
</tr>
<tr>
<td>Yield potential</td>
<td>1</td>
</tr>
<tr>
<td>P &amp; K demand level (Table 4)</td>
<td>1</td>
</tr>
<tr>
<td>Target pH (Table 4)</td>
<td>6.3</td>
</tr>
<tr>
<td>Soil test P category (Table 5)</td>
<td>H</td>
</tr>
<tr>
<td>Soil test K category (Table 6)</td>
<td>L</td>
</tr>
<tr>
<td>P recommendation (Tables 14 &amp; 19)</td>
<td>0 lb/a</td>
</tr>
<tr>
<td>K recommendation (Tables 14 &amp; 19)</td>
<td>80 lb/a</td>
</tr>
<tr>
<td>N recommendation (Tables 20 &amp; 25)</td>
<td>120 lb/a</td>
</tr>
<tr>
<td>Lime recommendation (Table 9 &amp; p. 6)</td>
<td>2.4 T/a of 60-69 lime</td>
</tr>
</tbody>
</table>
Economics of Fertilization
Law of Diminishing Returns

- Grain Yield (bu/a)
- N applied (lb N/a)

Price Ratios
- 10:1 = $2.00/bu : $0.20/lb N
- 6:1 = $2.00/bu : $0.33/lb N

corn after corn

Medium Yield Potential Soils
- 6:1
  - 82 lb/a
  - 123 bu/a
- 10:1
  - 107 lb/a
  - 126 bu/a

High Yield Potential Soils
- Max. Yield
  - 160 lb/a
  - 164 bu/a

Max. Yield
- 193 lb/a
- 166 bu/a

N applied (lb N/a)
### Soil Test Interpretation Categories

<table>
<thead>
<tr>
<th>Soil Test Level</th>
<th>Relative Supply of Nutrients From Soil and Fertilizer</th>
<th>Probability of Yield Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High</td>
<td>Soil</td>
<td>&lt;5%</td>
</tr>
<tr>
<td>High</td>
<td>Soil, Fert.*</td>
<td>5-30%</td>
</tr>
<tr>
<td>Optimum</td>
<td>Soil, Fertilizer</td>
<td>30-60%</td>
</tr>
<tr>
<td>Low</td>
<td>Soil, Fertilizer</td>
<td>60-90%</td>
</tr>
<tr>
<td>Very Low</td>
<td>Soil, Fertilizer</td>
<td>&gt;90%</td>
</tr>
</tbody>
</table>

- Nutrients available from soil
- Nutrients required

Adapted from Havlin et al., 1999 using WI interpretations

* Fertilizers used at high soil test levels are for starter or maintenance purposes.
Prioritizing Fertilizer Applications for Immobile Nutrients

- Soil test to determine nutrient need
- Fully credit nutrients in manure
- Apply nutrients to lowest testing fields first
- Apply some nutrients to all fields likely to respond to nutrient application
- Depending on fertilizer supply and cost, defer nutrient applications on soils testing high or above
- Consider overall nutrient needs and the budget available for purchases
7 “Fail-Safe” Steps for Maximizing Fertilizer Returns with Limited Resources

1. Soil test to determine need
2. Lime adequately
3. Grow best crop possible
4. Use “right” rate
5. Take nutrient credits
6. Maximize efficiency /avoid losses
7. Avoid unnecessary additions
Top-Seven “Fail-Safe” Steps for Maximizing Fertilizer Returns with Limited Resources

7. Avoid unnecessary additions
6. Maximize efficiency /avoid losses
5. Take nutrient credits
4. Use “right” rate
3. Grow best crop possible
2. Lime adequately
1. Soil test to determine need