Objective of UWEX Soil Fertility Management Guidelines

Maintain an adequate supply of soil nutrients to support economically optimal yield and quality of the crops grown while minimizing losses to the environment.
# 17 Essential plant nutrients

<table>
<thead>
<tr>
<th>Structural nutrients</th>
<th>Secondary nutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td>C Carbon</td>
<td>Ca Calcium</td>
</tr>
<tr>
<td>O Oxygen</td>
<td>Mg Magnesium</td>
</tr>
<tr>
<td>H Hydrogen</td>
<td>S Sulfur</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Primary nutrients</th>
<th>Micronutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td>N Nitrogen</td>
<td>B Boron</td>
</tr>
<tr>
<td>P Phosphorous</td>
<td>Zn Zinc</td>
</tr>
<tr>
<td>K Potassium</td>
<td>Fe Iron</td>
</tr>
<tr>
<td></td>
<td>Cl Chlorine</td>
</tr>
<tr>
<td></td>
<td>Mo Molybdenum</td>
</tr>
<tr>
<td></td>
<td>Ni Nickel</td>
</tr>
</tbody>
</table>
UWEX Soil Fertility Guidelines

Outlined in UWEX A2809

Nutrient application guidelines for field, vegetable and fruit crops in Wisconsin

Carrie Laboski and John Peters

Newly revised - 2012
Soil nutrient application guidelines based on:

- Soil sampling and analysis (every 3-4 years)
  - Routine soil analysis
    - P Phosphorously, K Potassium, pH acidity,
      %OM Percent organic matter content
    - Secondary and micro nutrient tests are optional
- Soil type/series
- Crops in rotation/pasture species
  - Yield goal (tons DM/acre)
- Nutrient contributions from manure/urine deposition
A Summary of Dairy Grazing Practices in WI
L. Paine and R. Gildersleeve

• 2010 survey of 1568 WI dairy farms using grazing practices
  – 771 farms responded
    • 49% use soil testing
    • 42% use commercial fertilizers on pastures
    • 44% use nutrient management planning
Soil sampling
Methods are important

• Samples need to accurately represent the fertility of the pasture;
• Use a soil probe - insert to a 6 inch depth;
• Take one “composite sample” per 5 acres of field/pasture. At least one composite sample should be taken in each field/paddock;
• Each composite sample should be made up of at least 10 cores. Use “W” shaped sampling pattern;
• See UWEX A2100 Sampling Soils for Testing for info
Avoid areas of concentration. Or, sample those areas separately, keeping with the one composite sample per 5-acre guideline.
Pasture crop categories in Wisconsin soil test program

### Pasture crop categories
- Pasture, grass
- Pasture, < 30% legume–grass seeding
- Pasture, < 30% legume–grass established
- Pasture, > 30% legume–grass seeding
- Pasture, > 30% legume–grass established
- Pasture, unimproved

### Pasture-related crop categories
- Red Clover
- Alfalfa
- Birdsfoot Trefoil
- Reed Canarygrass
pH and Liming

- Soil pH regulates nutrient availability and influences microbial reactions in soil
- Lime need determined by species present
- Grasses and clovers do fine at pH=6.0
- Alfalfa requires pH=6.5-6.8
- Repeated N fertilizer applications (manure and urine also) have potential for acidifying soil surface
Soil Acidity

- Managed with application of lime
  - Calcitic lime $\text{CaCO}_3$
  - Dolomitic lime $\text{CaCO}_3\cdot\text{MgCO}_3$
  - Neutralization – it’s the carbonate ion, not $\text{Ca}^{2+}$
    \[
    \text{CaCO}_3 + 2\text{H}^+ \rightarrow \text{Ca}^{2+} + \text{CO}_2\uparrow + \text{H}_2\text{O}
    \]
  - Gypsum is not a liming material
    $(\text{Ca(SO}_4\cdot\text{2H}_2\text{O})$
  - Dolomitic lime is an important source of Ca and Mg
UWEX Soil Fertility Recommendations for P, K, other nutrients

- Based on Sufficiency Level of Available Nutrients (SLAN) approach:
- There are definable levels of individual nutrients in the soil, below which crops will respond to additions of that nutrient; above which, probability of response is lower, = “optimum” level for the soil/crop rotation
Soil test P and K interpretation ranges for pasture forages

<table>
<thead>
<tr>
<th>Soil Test P</th>
<th>Very low (VL)</th>
<th>Low (L)</th>
<th>Optimum (O)</th>
<th>High (H)</th>
<th>Very high (VH)</th>
<th>Excessively high (EH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandy, Organic</td>
<td>&lt; 12</td>
<td>12–22</td>
<td>23–32</td>
<td>33–42</td>
<td>—</td>
<td>&gt; 42</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil Test K</th>
<th>Very low (VL)</th>
<th>Low (L)</th>
<th>Optimum (O)</th>
<th>High (H)</th>
<th>Very high (VH)</th>
<th>Excessively high (EH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loamy</td>
<td>&lt; 70</td>
<td>70–100</td>
<td>101–130</td>
<td>131–160</td>
<td>161–190</td>
<td>&gt; 190</td>
</tr>
<tr>
<td>Sandy, Organic</td>
<td>&lt; 45</td>
<td>45–65</td>
<td>66–90</td>
<td>91–130</td>
<td>—</td>
<td>&gt; 130</td>
</tr>
</tbody>
</table>
Pasture, Legume (<30%) Grass

$P_2O_5$ Recommendations

<table>
<thead>
<tr>
<th>Yield Goal (ton/ac)</th>
<th>Soil Test Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>---------------------</td>
<td>------</td>
</tr>
<tr>
<td>2-3</td>
<td>60</td>
</tr>
<tr>
<td>3.1 - 4</td>
<td>75</td>
</tr>
<tr>
<td>4.1 - 5</td>
<td>90</td>
</tr>
</tbody>
</table>
# Pasture, Legume (<30%) Grass

## K$_2$O Recommendations

<table>
<thead>
<tr>
<th>Yield Goal (ton/ac)</th>
<th>Low</th>
<th>Optimum</th>
<th>High</th>
<th>V. High</th>
<th>Ex. High</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-3</td>
<td>160</td>
<td>130</td>
<td>65</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td>3.1 - 4</td>
<td>210</td>
<td>180</td>
<td>90</td>
<td>45</td>
<td>0</td>
</tr>
<tr>
<td>4.1 - 5</td>
<td>260</td>
<td>230</td>
<td>115</td>
<td>60</td>
<td>0</td>
</tr>
</tbody>
</table>
Nitrogen fertilization guidelines for pastures

<table>
<thead>
<tr>
<th>Crop</th>
<th>Yield range per acre</th>
<th>Soil organic matter content (%)</th>
<th>lb N/a to apply^c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasture, grass ab</td>
<td>0.5–5 ton</td>
<td>160</td>
<td>130</td>
</tr>
<tr>
<td>Pasture, ≤ 30% legume-grass, seeding</td>
<td>0.5–1.9 ton</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>Pasture, ≤ 30% legume-grass, established</td>
<td>2–5 ton</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pasture, &gt; 30% legume-grass, seeding</td>
<td>0.5–1.9 ton</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Pasture, &gt; 30% legume-grass, established</td>
<td>2–5 ton</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pasture, unimproved a</td>
<td>1–4 ton</td>
<td>120</td>
<td>100</td>
</tr>
</tbody>
</table>

^a Split N applications into two to three applications per year. ^b Grass = includes bromegrass, orchardgrass, fescue, ryegrass, timothy (any combination). ^c This is the total amount of N to apply including starter fertilizer.
Nitrogen fertilization guidelines for pastures

• When significant legumes present, 30-50 lb N/ac/yr transferred to grasses, no N recommended

• However, if goal = max production, apply 80-100 lbs N/acre
  – May give grass competitive advantage over legumes, which will be lost over time.
Nitrogen fertilization guidelines for pastures

- For tall grass pastures, up to 160 lbs N/acre will maximize production
  - Split applications: 40-80 lbs N early June
  - 40-80 lbs N early August
- Nitrate poisoning caution
- Risk of some volatization loss (up to 20%) from urea applications
- Forage yield response dependent on rain, cooler temperatures
Nitrogen fertilization guidelines for pastures

Economic return to N applications will depend on:

– Cost of N vs. value of additional forage produced

– Need for additional forage and timing of those needs

– Ability to use/manage additional forage
Nitrogen Management in Rotationally Grazed Pastures
Dr. Dennis Cosgrove, UW River Falls, 2006

Table 1. Yield increases from nitrogen application

<table>
<thead>
<tr>
<th>Species</th>
<th>Control Yield (lbs DM/acre)</th>
<th>May 1</th>
<th>June 15</th>
<th>August 1</th>
<th>May 1 + June 15</th>
<th>May 1 + June 15 + August 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>KB</td>
<td>4365</td>
<td>246</td>
<td>14</td>
<td>232</td>
<td>710</td>
<td>885</td>
</tr>
<tr>
<td>SB</td>
<td>5293</td>
<td>1326</td>
<td>456</td>
<td>1002</td>
<td>1054</td>
<td>2019</td>
</tr>
<tr>
<td>OG</td>
<td>4654</td>
<td>1052</td>
<td>516</td>
<td>729</td>
<td>1062</td>
<td>1284</td>
</tr>
</tbody>
</table>

Yield Increase (lbs DM/acre)

2 year trial @ UW River Falls, 2004-05
KB = Kentucky bluegrass + white clover
SB = Smooth bromegrass + alfalfa
OG = Orchardgrass + red clover
Nitrogen application economics

Example:

• 50 lbs N applied @ $.55/lb N = $28
• 1,000 lbs additional forage @ $130 per-ton = $65 gross return

• Net return to N ($65 - $28) = $37 per-acre
Nutrient crediting of pasture-deposited manures

- Determined by:
  - Quantity of manure (urine and feces) deposited in tons per-acre
    - Estimated according to time spent grazing
  - Nutrient content of manure
  - Reliable crediting depends on good distribution of manure
Total and available nutrient content of pasture-deposited manures

Source: Midwest Plan Service and American Society of Ag. Engineers

<table>
<thead>
<tr>
<th>Dry Matter %</th>
<th>Total Nutrients</th>
<th>Available Nutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P₂O₅</td>
</tr>
<tr>
<td>Beef</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>Dairy</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>Sheep</td>
<td>25</td>
<td>19</td>
</tr>
<tr>
<td>Goat</td>
<td>32</td>
<td>22</td>
</tr>
<tr>
<td>Horse</td>
<td>14</td>
<td>7</td>
</tr>
</tbody>
</table>

Values differ slightly from manure Table 9.1, UWEX A2809
How much manure is being deposited in the pasture?  
MWPS Manure quantity estimation form

---

**Wisconsin Manure Quantity Estimation**

<table>
<thead>
<tr>
<th>Animal</th>
<th>Size</th>
<th>Daily Manure Production To Apply</th>
<th>Annual Manure Production To Apply</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lbs/day</td>
<td>Cds/day</td>
</tr>
<tr>
<td>Dairy</td>
<td>Calf</td>
<td>.13</td>
<td>.020</td>
</tr>
<tr>
<td></td>
<td>Calf</td>
<td>.20</td>
<td>.032</td>
</tr>
<tr>
<td></td>
<td>Heifer</td>
<td>.65</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>Lact. Cows</td>
<td>100 00</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>Dry Cows</td>
<td>100 00</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>1400 00</td>
<td>1.620</td>
<td>1.82</td>
</tr>
<tr>
<td>Beef</td>
<td>Calf</td>
<td>.40</td>
<td>.080</td>
</tr>
<tr>
<td></td>
<td>High Forage</td>
<td>.60</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>High Energy</td>
<td>.60</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>High Energy</td>
<td>.60</td>
<td>1.000</td>
</tr>
<tr>
<td></td>
<td>Beef Cows</td>
<td>100 00</td>
<td>1.000</td>
</tr>
<tr>
<td>Swine</td>
<td>Nursery Pig</td>
<td>.25</td>
<td>.040</td>
</tr>
<tr>
<td></td>
<td>Grow-Finish Pig</td>
<td>.50</td>
<td>.010</td>
</tr>
<tr>
<td></td>
<td>Gestating Sow</td>
<td>.75</td>
<td>.010</td>
</tr>
<tr>
<td></td>
<td>Sow &amp; Litter</td>
<td>.75</td>
<td>.010</td>
</tr>
<tr>
<td></td>
<td>Boar</td>
<td>.75</td>
<td>.010</td>
</tr>
<tr>
<td>Poultry/Other</td>
<td>Layers</td>
<td>9.02</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>Broilers</td>
<td>2.10</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>Turkeys</td>
<td>2.00</td>
<td>0.014</td>
</tr>
<tr>
<td></td>
<td>Duck</td>
<td>6.00</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Sheep</td>
<td>100 00</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Horse</td>
<td>1000 00</td>
<td>.000</td>
</tr>
</tbody>
</table>

Source: Wisconsin Manure Quantity Estimation (MWPS) 2020. The liquid and solid manure quantities are computed from the MWPS daily production and have approximately equal nutrient values annually as solid manure. MWPS liquid and solid manure quantities are multiplied by 1.5 and 2.5, respectively. Additional seasonal dilution may be necessary as material storage volume to determine manure production volume to land.
SnapPlus Nutrient Management Planning software

Crop Year: 2013

Grazing herds:
- Beef cows, calves
- Beef

Animal Type | Number of Animals | Daily Manure Production (lbs/animal) | Total Daily Manure Production
--- | --- | --- | ---
Beef Cow 1000 lbs | 18 | 63 | 1,134
Beef Calf 450 lbs | 16 | 26 | 416
Beef High Forage 750 lbs | 17 | 62 | 1,054
Beef Bulls 1400 lbs | 1 | 115 | 115

Total daily production (all animals) = 1.4 tons/day
SnapPlus Nutrient Management Planning software

Grazing application rate estimator

Grazing Season: Grazing

- Use herd information to fill daily manure production (optional)

Crop year: 2013

Herd name: Beef cows, calves

Total daily herd manure production: 1.4 tons/day

Field/Pasture size: 50 acres

Days on pasture: 190 days

Percent of each day spent grazing: 85%

Estimated application rate: 4.5 tons/acre

Grazing Est
<table>
<thead>
<tr>
<th>Year</th>
<th>Soil Test Date</th>
<th>pH</th>
<th>OM</th>
<th>P</th>
<th>K</th>
<th>County</th>
<th>Acres</th>
<th>Pred. Soil</th>
<th>Symbol</th>
<th>Rest</th>
<th>Group</th>
<th>Texture</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>2012-10-30</td>
<td>6.8</td>
<td>3.8</td>
<td>18</td>
<td>125</td>
<td>Chippewa</td>
<td>5.0</td>
<td>Seaton</td>
<td>SFA</td>
<td>L</td>
<td></td>
<td>Silt Loam</td>
</tr>
</tbody>
</table>

**Crop Year (Fall to Fall):**

- **Crop:** Pasture, rotational stock
- **Yield Goal:** 3.1-4
- **Tillage:** None
- **Soil Test Date:** 2012-10-30
- **Lime Rec:** NA
- **Irrigation / MRTN info:** Not irrigated

<table>
<thead>
<tr>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>P205</td>
<td>K2O</td>
<td>N</td>
</tr>
<tr>
<td>130</td>
<td>55</td>
<td>195</td>
<td>130</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>130</td>
<td>55</td>
<td>195</td>
<td>130</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Adjusted UW recommendation:**

- 1st & 2nd year legume credit:
- 2nd year manure credit:
- This year's manure:
- This year's fertilizer:
- Total credits & applications:
- Over(+)/Under(-) adj UW rec:

**Annual Total PII:**

- Particulate PII: 0.0
- Soluble PII: 0.1
Optimizing nutrient cycling in pastures

- Supplying required nutrients with pasture-deposited manures requires even distribution of manure across and throughout the pasture.
- Improved by good intensive rotational grazing practices:
  - Heavy grazing pressure in small areas for short periods of time
  - Provide water sources throughout the pasture
  - Limit access to typical “loafing” areas
Thank you!

Kevin Shelley
Nutrient and Pest Management Program
UW Extension / UW CALS