Water and Fertility Management for Small Pastures

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Utah State University
Irrigation Management

- Soil properties and water relations
- Plant-Soil-Water interactions
- Irrigation scheduling
- Geared toward sprinklers
Primary Soil Components

- Minerals (45%)  
  - (primary soil particles and nutrients for plants)

- Water (25%)  
  - (water for transpiration and nutrient transport)

- Air (25%)  
  - (oxygen to roots)

- Organic Matter (5%)  
  - (soil structure and nutrients for plants)
Soil texture

- The relative proportion (percent) of sand, silt and clay in soil
- Refers to individual or primary soil particles left after structure is removed

The mineral particles: sand, silt, and clay

- **Sand**
  - .05 to 2mm
  - feels gritty

- **Silt**
  - .002 to .05mm
  - feels smooth

- **Clay**
  - less than .002mm
  - feels sticky
The effect of particle size

Sand particles

Air flow

Water flow

Clay particles
# Texture effects on soil physical properties

<table>
<thead>
<tr>
<th>Texture</th>
<th>Available water</th>
<th>Aeration</th>
<th>Drainage</th>
<th>Compaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silt loam</td>
<td></td>
<td></td>
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<tr>
<td>Clay loam</td>
<td></td>
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<tr>
<td>Clay</td>
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</tbody>
</table>

- **Texture** effects on soil properties:
  - **Available water**
  - **Aeration**
  - **Drainage**
  - **Compaction**
### Available Water-holding Capacity of Soils

Inches of available water per foot of moist soil

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>0.5 - 0.75</th>
<th>.8 - 1.0</th>
<th>1.2 - 1.5</th>
<th>1.9 - 2.0</th>
<th>1.9 - 2.0</th>
<th>1.7 - 2.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sands and fine sands</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Very fine sands, loamy sand</td>
<td></td>
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<tr>
<td>Sandy Loam</td>
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<td></td>
<td></td>
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<tr>
<td>Loam</td>
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<td></td>
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</tr>
<tr>
<td>Silt loam, silt</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Silty clay loam</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Sandy clay loam, Clay loam</td>
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</tbody>
</table>

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### Irrigation How Much and How Often?

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Water*</th>
<th>Irrigation Interval**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loamy Sand</td>
<td>1.25&quot;</td>
<td>4-6 days</td>
</tr>
<tr>
<td>Loam</td>
<td>2.5&quot;</td>
<td>9-11 days</td>
</tr>
<tr>
<td>Clay</td>
<td>2.5&quot;</td>
<td>9-11 days</td>
</tr>
</tbody>
</table>

* Water to be replaced in the 2.5’ foot rooting zone when the soil is at 50% of its water holding capacity

** Average July Irrigation Interval (Valid 4,000-5,000 feet elevation in Utah)

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**Loam example:**

Grass root depth:

\[
2 \text{ in/ft} \times 2.5 \text{ ft} = 5 \text{ inches}
\]

50% of 5 inches = 2.5 inches

Daily water use = 0.23 to 0.28 in/day

Irrigation interval = 9 to 11 days
A number of county-specific irrigation guides are available at:

extension.usu.edu
Examples of information

**DESIGN**

A well designed sprinkler system applied

**OPERATION AND MAINTENANCE**

To realize the full benefit of the sprinkler system, it must be properly maintained throughout the irrigation season. This may involve

**CALCULATING AN IRRIGATION INTERVAL**

The available soil water in the root zone, crop water use (Et) rate (cm/d), and allowable soil water depletion at irrigation are needed information for the interval between irrigations. Conversely, the irrigation system applied for all irrigations) could be used in place of the allowable depletion.

**Example A:** Simple Irrigation Calendar. Determine the irrigation interval for alfalfa on sandy loam soil at Roosevelt. Use July Et and a root depth of 1.5 ft when one half of the available soil water has been depleted, i.e., when the depletion (MAD) is 50%.
Goes hand-in-hand with water management

- Nutrients soluble and move with water—some more soluble and mobile;
- Efficiency of nutrient use depends on ample moisture—movement to and into roots;
- Cycling and transformation of nutrients depends on moisture—particularly Nitrogen;
- Water critical to incorporation of nutrients into pasture soils.
Good results begins with good information.

Most important information is current soil condition

SOIL TEST!

www.usual.usu.edu

Sampling tools and submission materials available at county agents office
FERTILIZER MANAGEMENT FOR GRASS AND GRASS-LEGUME MIXTURES

Rich Koenig, Extension Soil Specialist
Mark Nelson, Beaver County Extension Agent
James Barnhill, Weber County Extension Agent
Dean Miner, Utah County Extension Agent

August 2002

AG-FG-03

Excellent On-line Publication!
Sampling Tips

- Multiple soil cores taken throughout uniform areas (top foot most important in grass or grass-legume mixes)
- Sample dissimilar areas separately
- Combine and thoroughly mix cores together (compositing)
- No more than 20-30 acres covered by one composite sample.
Example of field variation

- 100 square foot grid of a field in Cache county
- Small dot – 0-3 ppm P
- Large circle – 20 ppm P
- 14% severely deficient
- 36% mod. deficient
- 50% needed P
- 27% does NOT need P
- More typical in grazed pastures
What Nutrients Do I Need, and How Much?

- **Primary nutrients:**
  - Nitrogen, Potassium and Phosphorous
  - Sulfur (generally only on sandy, low organic matter soils, and/or high elevation soils irrigated with very “clean” water).

- **Micronutrients:**
  - Zinc, Iron, Copper, Manganese and Boron
    - Not generally deficient in grass and grass-legume pastures
What Nutrients Do I Need, and How Much?

- Amount needed depends on soil properties, pasture management and soil test results.
- Hayed fields remove large quantities of nutrients (especially N and P).
- In grazed pastures, 85 to 90% of nutrients returned in manure and urine, but not uniformly distributed.
- Legumes reduce N need (due to fixation).
- Test hayed fields annually, pastures every 3 yrs.
Table 1. Average nutrient concentrations and removal by grass hay.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Dry matter concentration</th>
<th>Removal per ton of hay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>2.0 % N</td>
<td>40 lb N</td>
</tr>
<tr>
<td>Potassium</td>
<td>3.0 % K₂O</td>
<td>60 lb K₂O</td>
</tr>
<tr>
<td>Phosphate</td>
<td>0.65 % P₂O₅</td>
<td>13 lb P₂O₅</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.25 % S</td>
<td>5 lb S</td>
</tr>
</tbody>
</table>
Nitrogen

- Most limiting nutrient—need annual application—primarily based on yield potential
- Soil applied N is effective for about 8 weeks
- Split N applications
  - Take advantage of spring moisture and cooler conditions—add largest amount in early spring (example: 100 lbs/ac in April, 60 lbs in late June, and 60 lbs in late August)
- Legumes reduce N needs, reduce application amount by the percentage of legume in mix
Table 2. Nitrogen recommendations for irrigated grass and grass-legume mixtures.

<table>
<thead>
<tr>
<th>Stand composition</th>
<th>Yield potential of the site</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-2 tons/acre</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>100% grass</td>
<td>50</td>
</tr>
<tr>
<td>75% grass, 25% legume</td>
<td>25</td>
</tr>
<tr>
<td>50% grass, 50% legume</td>
<td>0</td>
</tr>
<tr>
<td>25% grass, 75% legume</td>
<td>0</td>
</tr>
</tbody>
</table>

\(^1\)For pasture, split the total nitrogen rate into two or three separate applications. Apply 1/3 to 1/2 of the nitrogen in early spring, 1/3 to 1/2 in June, and the remainder in late August. Schedule mid- and late-season nitrogen applications to coincide with irrigation or rainfall events. For hay-pasture systems, apply 2/3 of the nitrogen in early spring and 1/3 after the hay crop is removed to stimulate regrowth for grazing.
Nitrogen (cont)

- **Apply N** to coincide with irrigation or rainfall.
  - N needs to be incorporated to prevent ammonia loss from soil—especially Urea sources.
  - Soluble N forms with low volatility are Ammonium Nitrate (becoming expensive and scarce) and Ammonium Sulfate.

- **N fertility favors grasses**, high levels can cause shift in stand mix.
Effect of N application on pasture yield

Plot on the left received no N, Plot on right received 50 lbs N per acre in April
Phosphorus and Potassium

- Amounts best determined by soil test levels
- P important in seedling development—very important in new pasture seedings—till in before planting.
- P favors legume growth, watch shifts in mix
- K generally not deficient except in sandier soils, intensively hayed.
- K addition on high test soils can cause undesirable K levels in forage
- P and K generally remain sufficient in grazed pastures once properly adjusted (re-deposited in urine & manure).
Low levels of P and K can severely limit production.

Test soil each year until level is sufficient. Level will remain sufficient for several years under grazed conditions.

**Table 3.** Phosphorus recommendations for grass and grass-legume mixtures. Soil test phosphorus is based on a 12 inch sample depth and sodium bicarbonate soil extract.

<table>
<thead>
<tr>
<th>Soil test phosphorus (mg/kg soil or ppm)</th>
<th>Recommendations (lbs P₂O₅/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 3*</td>
<td>100-125</td>
</tr>
<tr>
<td>4 to 7</td>
<td>75-100</td>
</tr>
<tr>
<td>8 to 10</td>
<td>50-75</td>
</tr>
<tr>
<td>11 to 15</td>
<td>0-50</td>
</tr>
<tr>
<td>&gt; 15</td>
<td>0</td>
</tr>
</tbody>
</table>

*Low soil test levels are severely limiting yield. Test soil annually until levels are adequate.

**Table 4.** Potassium recommendations for grass and grass-legume mixtures. Soil test potassium is based on a 12 inch sample depth and sodium bicarbonate soil extract.

<table>
<thead>
<tr>
<th>Soil test potassium (mg/kg soil or ppm)</th>
<th>Recommendation (lbs K₂O/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 40*</td>
<td>180-220</td>
</tr>
<tr>
<td>40 to 70</td>
<td>140-180</td>
</tr>
<tr>
<td>70 to 100</td>
<td>80-120</td>
</tr>
<tr>
<td>100 to 150</td>
<td>40-60</td>
</tr>
<tr>
<td>&gt; 150</td>
<td>0</td>
</tr>
</tbody>
</table>

*Low soil test levels are severely limiting.
Sulfur

- S deficiencies are uncommon in Utah
- Additions should be added if soil test level below 8 mg/kg (or ppm).
- Under low soil test, add 25 to 50 lbs S/ac.
- Sources are Ammonium sulfate (also an excellent pasture N source), Potassium sulfate, and elemental S (slow release lasts 3 to 4 years).
Micronutrients

- Pasture soils rarely deficient in the micronutrients.
- Sources are generally sulfate salts of Zn, Fe, Mn and Cu.
- Sodium borate or boric acid are sources of B.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Low</th>
<th>Marginal</th>
<th>Adequate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc</td>
<td>&lt;0.8</td>
<td>0.8-1.0</td>
<td>&gt;1.0</td>
</tr>
<tr>
<td>Iron</td>
<td>&lt;3.0</td>
<td>3.0-5.0</td>
<td>&gt;5.0</td>
</tr>
<tr>
<td>Copper</td>
<td>&lt;0.2</td>
<td>–</td>
<td>&gt;0.2</td>
</tr>
<tr>
<td>Manganese</td>
<td>&lt;1.0</td>
<td>–</td>
<td>&gt;1.0</td>
</tr>
<tr>
<td>Boron</td>
<td>&lt;0.25</td>
<td>0.25-0.5</td>
<td>&gt;0.5</td>
</tr>
</tbody>
</table>

*DTPA extractable zinc, iron, copper, and manganese; hot water extractable boron.
**Additional Considerations**

- Due to non-uniform grazing habits, pastures should be dragged each year to re-distribute manure.

- Pasture mixes vary in production, each site imposes specific limitations, target yield potential for your site through careful nutrient management (important for N management).

- **SOIL TEST!**
  - Every 3 yrs After sufficiency established on grazed pasture.
  - Annual sampling on hayed, or hayed/grazed ground.
Questions?