Fertility and Nitrogen Management in Pasture Systems
MODNR-SWCP
Mark Kennedy and John Turner

 Mostly stolen from
John A. Lory, University of Missouri
and Rick Schwieter, NRCS
Obtaining a Quality Soil Sample

- Individual soil samples should not represent more than 20 acres.
  - 20 cores at random points along a zig-zag pattern in the field
- Avoid sampling near road
- Avoid sampling near feeding areas, water tanks, and shade trees in pasture
Soil Test Levels in the Field Are Highly Variable

Mean: 44  STD: 48
Obtaining a Quality Soil Sample (cont.)

- Sample 4 inches deep in the soil
  - Take a uniform quantity of soil from each depth
  - If using a shovel dig a hole and slice off one side

- After collecting all 15-20 cores in a bucket - crumble the soil into small pieces and mix well.

- Place about 1.5 cups in a soil sample box. Discard excess soil.

- Label the box with the farm and field name.
Soil Sampling Devices

Probe

Screw auger (manual or cordless drill)

Tile spade
Interpreting Soil Test Results

- Low
  - Yield loss likely
  - Forage quality reduced

- Medium
  - Yield loss possible
  - Improved persistence

- High
  - Benefits from fertilization unlikely
Low pH$_s$ (below 5)

- **Increased aluminum solubility**
  - Stunted root growth
  - Reduced nutrient uptake

- **Reduced nutrient availability**
  - Phosphorous

- **Poor legume growth**
  - Survival and activity of N fixing bacteria reduced
  - Reduced success of the symbiosis
Low Phosphorus

- **Poor crop growth**
  - Critical for energy conversions in plant
  - Affects all aspects of growth

- **Poor legume growth**
  - Reduced survival and activity of N fixing bacteria
Low Potassium

- Poor crop growth
  - Inhibition through reduced enzyme activity
  - Impaired water uptake
- Reduced disease resistance
- Reduced winter hardiness
Soil Test Level for Persistence

<table>
<thead>
<tr>
<th></th>
<th>Very low</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td></td>
<td></td>
<td></td>
<td>55</td>
</tr>
<tr>
<td>Annual lespedeza</td>
<td></td>
<td></td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>Birdsfoot trefoil</td>
<td></td>
<td></td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>Red clover</td>
<td></td>
<td></td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>White clover</td>
<td></td>
<td></td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Cool-season grass</td>
<td></td>
<td></td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>Warm-season grass</td>
<td></td>
<td></td>
<td></td>
<td>40</td>
</tr>
</tbody>
</table>
Now about managing fertility:
Maintenance Applications: Hay System

Inputs
- Fertilizer
- Manure
- Legumes (N)

Nutrient Cycle

Exports
- Remove 80% of nutrients in hay

Tons of Hay Removes:
- 150 lb. Nitrogen
- 18 lb. P (40 lb. P₂O₅)
- 120 lb. K (145 lb. K₂O)
Maintenance Applications: Pasture System

Inputs
- Fertilizer
- Manure
- Legumes (N)
- Feed

Nutrient Cycle

Exports
- Calves
- Beef

Cow/calf pair, stocker removal rates
- 10 lb. Nitrogen
- 3 lb. P (7 lb. P$_2$O$_5$)
- 0.7 lb. K (1 lb. K$_2$O)
Phosphorus Cycle: Pasture System

**Efficiency:** 90% returned

<table>
<thead>
<tr>
<th>Component</th>
<th>Phosphorus (lb)</th>
</tr>
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<tbody>
<tr>
<td>Forage</td>
<td>29</td>
</tr>
<tr>
<td>Retained-animal</td>
<td>-3</td>
</tr>
<tr>
<td>Excreted</td>
<td>26</td>
</tr>
</tbody>
</table>
Nitrogen Cycle: Pasture System

Efficiency: Only an average of 25% of N excreted survives volatilization, solution, and other losses to be available to plants

<p>| | |</p>
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Forage</td>
<td>280 lb N</td>
</tr>
<tr>
<td>- Retained</td>
<td>-10</td>
</tr>
<tr>
<td>Excreted</td>
<td>270</td>
</tr>
<tr>
<td>- Volatilization &amp; other</td>
<td>-202</td>
</tr>
<tr>
<td>Returned for plants</td>
<td>68 lb N</td>
</tr>
</tbody>
</table>
Recovery of excreted nitrogen by pasture plants is generally low:

- 30% from urine
- 10% from dung
Nitrogen Cycle: Grasses

Available N in Soil

Fertilizers
Animal manure
Atmospheric deposition
Soil Organic matter
Nitrogen for Tall Fescue

Forage yield

Herd feed requirement

April     June     August    October

Unfertilized
Traditional spring fertilization for Hay:
- apply nitrogen in mid March
- maximizes natural growth curve
Fertilization of Tall Fescue

Hoveland and Richardson, 1992

Nitrogen Applied (lb/acre)

Yield (lb/acre)

Georgia

Hoveland and Richardson, 1992
N Fertilizer for Tall Fescue Hay

- Spring application early near time plant starts growing.
  - High probability of response.
  - Harvest quality hay to make fertilizer pay.
- Fall application in mid August to promote fall growth.
  - Response depends on sufficient fall moisture
- Typical split: 60% – 40% with highest rate in the season that you most likely to utilize the forage.
Nitrogen for Tall Fescue Pasture

Spring fertilization for Pasture:
- apply nitrogen in early May
- extends spring forage into July
- less response, higher potential value

Herd feed requirement

Forage yield

April    June    August    October
Nitrogen for Tall Fescue Pasture

Fall fertilization for Pasture:
- apply nitrogen in mid August
- increases and extends fall forage
- less response, higher potential value

Forage yield

Herd feed requirement

April June August October
N Fertilizer for Tall Fescue Pasture

- Spring application after early grazing (late April to early May) *if forage is needed.*
  - High probability of response.
  - Fertilization later than hay promotes more late spring growth

- Fall application in mid August to promote fall growth.
  - Response depends on sufficient fall moisture
  - Fall forage valuable in pasture systems
Ergovaline Concentration: Tall Fescue

Rottinghaus et al., 1991
Nitrogen Cycle: Grasses and Legumes

Symbiotic $N_2$ fixation

Available N in soil
Growing zones

Leghemoglobin
($N_2$ fixing zone)

Inactive zone

Attachment point
Alfalfa root

Picture from Michael Russelle, USDA-ARS
# Host-bacteria Specificity

<table>
<thead>
<tr>
<th>Host</th>
<th>Rhizobia</th>
</tr>
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<tbody>
<tr>
<td>Soybean</td>
<td><em>Bradyrhizobium japonicum</em></td>
</tr>
<tr>
<td>Alfalfa</td>
<td><em>Sinorhizobium meliloti</em></td>
</tr>
<tr>
<td>Trefoil</td>
<td><em>Mesorhizobium loti</em></td>
</tr>
<tr>
<td>Vetch</td>
<td><em>Rhizobium leguminosarum bv viciae</em></td>
</tr>
<tr>
<td>Clovers</td>
<td><em>bv trifolii</em></td>
</tr>
</tbody>
</table>

**BUT** Kura clover more picky than others
## N$_2$ Fixation in Mixed Stands

<table>
<thead>
<tr>
<th>Species</th>
<th>N$_2$ Fixed (lb./a)</th>
<th>Ndff (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year 1</td>
<td>Older</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>70 – 80</td>
<td>120 – 180</td>
</tr>
<tr>
<td>Birdsfoot trefoil</td>
<td>30 – 60</td>
<td>80 – 150</td>
</tr>
<tr>
<td>Red clover</td>
<td>10 – 90</td>
<td>40 – 330</td>
</tr>
<tr>
<td>White clover</td>
<td>1 - 100</td>
<td>20 – 300</td>
</tr>
</tbody>
</table>

*Ledgard and Steele, 1992; West and Mallarino, 1996*
Benefits of Legumes

• Provide N

• Increase forage quality
  • Less fescue = less endophyte
  • Legume forage quality ≥ fescue

• Better yield distribution
Legume/Tall Fescue Mix

- Legumes:
  - Start growth 2 weeks after CSG
  - Deeper rooted species continue growth in summer
  - Enhance CSG yield
  - Enhance forage quality in spring

Herd feed requirement

Forage yield

April  June  August  October
The Benefit of Legumes in Grass Pastures

Virginia
Transfer of Fixed N to Grass

- 10 - 50 lb. N/acre/yr
- 10 - 20% of the N fixed is transferred
- 10 - 50% of grass N is from legume

(West and Mallarino, 1996)
Legume/Grass Cycle

- **L** for Legume
- **G** for Grass

1. Recently Fixed Soil N
2. Available Soil N in
3. Soil N available

The cycle shows the interaction between Legumes and Grasses in fixing and utilizing nitrogen in the soil.
Steele and Shannon, 1982
Nitrogen Fertilizer for Tall Fescue/Legume Mix

- N fertilizer increases grass growth – hurts legume
  - N fertilized grass smothers legume
  - Without fertilizer N grass growth limited, legume thrives on N fixation
  - Few studies show N response when legume exceeds 25% of stand (but that’s a LOT of legume)

- If you use fertilizer N apply small amounts at times when legumes are dormant
  - Apply in early spring
  - August application less harmful to legume component
  - Harvest or graze in a timely fashion.
Legume/Tall Fescue Mix

Forage yield

Herd feed requirement

April June August October
Tall Fescue

Optimum nitrogen rate (lb./acre)

- Columbia, MO
- Wright Co., MO
- Arkansas
- Kentucky
- Georgia #1
- Georgia #2

Costs:
- $40/ton
- $20/ton

$40/ton

$20/ton
Should I Fertilize?

Depends on:
• Forage species
• Soil test levels
• Other limitations
• Forage value
Should I Fertilize?

- Fertilizing on a budget
  - Lime 1\textsuperscript{st}, address Phosphorus (P) 2\textsuperscript{nd}, Potassium (K) 3\textsuperscript{rd}
  - Target very low and low testing soils
  - Moderate P levels (≥20 lb. \(P_2O_5/\text{acre}\)) reduces grass tetany on fescue
  - Manure can be a excellent fertilizer
Maintenance Applications

- Grazing systems
  - Low P and K removal
  - Monitor with soil testing
- Nitrogen losses necessitate annual inputs
  - Maintain legumes in your pasture
  - Fertilizer or manure applications
Should I Fertilize?

- Grass/legume mixture
  - pH 6 - 7
  - P and K at least medium
  - No fertilizer N

- Spring vs. Fall N
  - Only apply spring N if you are short on spring pasture or are haying
  - Apply 40 - 60 lb./acre in August for stockpiling
Making Fertilizer Pay

• Fertilize when the plant has a capacity to respond

• Use fertilizer to increase forage at times when more forage is needed (summer, fall, winter)

• Maximize forage utilization (short grazing period)

• High performing animals and high prices make it easier to pay for fertilizer

• It is easier to make money with cheap fertilizer
Fertilizer Pays with Better Utilization

- Continuous grazed systems
  - 30% utilization of forage
  - Animals consume 600 lb. of every ton of forage

- Management intensive grazing (>8 paddocks)
  - 50 to 70% utilization
  - Animals consume 1,000 to 1,400 lb. of every ton of forage
Making Fertility Pay on Pasture

- Use fertilizer to increase forage at times when more forage is needed—TIMING

- You are only paying for fertility if it allows you to **feed less hay** or **sell more beef/milk**.