Hay Fertility Management

Adapted from Brie Menjoulet’s Presentation
Agronomy Specialist
Hermitage, MO
We Will Look At…

- Soil properties and nutrient retention
- Soil testing and nutrient buildup
- Nutrient removal rates
- Legumes as an nitrogen source
- Fertilizer sources
- Fertilizer application
- Liming
Soil Composition

- Mineral Matter
  - Sand, silt, and clay
  - Nutrients
- Water
- Air
- Organic Matter
  - Residue from plants and animals
- Soil Organisms
Soil Texture

Best combination
Nutrient Movement & Retention

Is dependent on:
- The nutrient itself
- Overall soil health
- Soil texture (sand, silt and clay composition)
- Organic matter fraction
- Fertilizer type
- Application method
Plant Nutrients

- 16 essential nutrients
  - Carbon, Oxygen, and Hydrogen most abundant
    - Photosynthesis
- Nitrogen, Phosphorus, and Potassium
  - Plants uptake large amounts
  - Plants can only use certain forms of each nutrient
- Terms
  - Organic = living or once living
  - Inorganic/synthetic = manmade
Phosphorus (P) and Potassium (K)

- Chemical forms change in soil
- Plants uptake:
  - Phosphorus as phosphate - \( \text{P}_2\text{O}_5 \)
  - Potassium as potash - \( \text{K}_2\text{O} \)
- Not prone to leaching
- Clings to soil particle and organic matter
- Can be built up in the soil over time
Nitrogen (N)

- Complex cycle!
Nitrogen (N)

- Complex cycle!
- Forms in soil change frequently
  - Soil moisture level, organic fraction, temperature
  - We usually don’t soil test for N levels
- Little attraction to clays and organic matter
- Primary uptake forms:
  - Nitrate-Nitrogen $\text{NO}_3^-$
  - Ammonium-Nitrogen $\text{NH}_4^+$
Nutrient Needs/Removal

- The greater the yield, the greater the fertilizer need
- Nutrients must be replaced to sustain yield
  - Synthetic and/or organic fertilizers

<table>
<thead>
<tr>
<th>CROP</th>
<th>Nitrogen</th>
<th>P₂O₅</th>
<th>K₂O</th>
<th>Calcium</th>
<th>Magnesium</th>
<th>Sulfur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa*</td>
<td>60.0</td>
<td>15.0</td>
<td>60.0</td>
<td>28.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Red Clover*</td>
<td>56.0</td>
<td>12.5</td>
<td>45.0</td>
<td>24.0</td>
<td>6.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Sorghum-Sudan</td>
<td>40.0</td>
<td>15.0</td>
<td>55.0</td>
<td>10.0</td>
<td>6.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Cool Season Grass</td>
<td>45.0</td>
<td>12.0</td>
<td>50.0</td>
<td>10.0</td>
<td>4.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Warm Season Grass</td>
<td>35.0</td>
<td>10.0</td>
<td>35.0</td>
<td>10.0</td>
<td>5.0</td>
<td>3.5</td>
</tr>
<tr>
<td>Grass Pasture (per 100 cow days)</td>
<td>60.0</td>
<td>5.0</td>
<td>17.0</td>
<td>4.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>

*Most of the nitrogen is obtained from the atmosphere.
# Nutrient Removal for Hay

<table>
<thead>
<tr>
<th>Crop</th>
<th>N</th>
<th>P&lt;sub&gt;2&lt;/sub&gt;O&lt;sub&gt;5&lt;/sub&gt;</th>
<th>K&lt;sub&gt;2&lt;/sub&gt;O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa hay (6 ton)</td>
<td>270</td>
<td>90</td>
<td>270</td>
</tr>
<tr>
<td>Cool-season grass hay (3 ton)</td>
<td>150</td>
<td>40</td>
<td>145</td>
</tr>
<tr>
<td>Cow-calf pair</td>
<td>10</td>
<td>7</td>
<td>1</td>
</tr>
</tbody>
</table>

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UNIVERSITY OF MISSOURI
Extension
### Nutrient Replacement for Hay

**Fertilizer costs based on removal for cool-season grass hay**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Fertilizer Value per Ton</th>
<th>Nutrient Value per Acre (3 ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium Nitrate</td>
<td>31.95</td>
<td>95.85</td>
</tr>
<tr>
<td>Phosphate (DAP)</td>
<td>6.48</td>
<td>19.44</td>
</tr>
<tr>
<td>Potash</td>
<td>27.50</td>
<td>82.50</td>
</tr>
</tbody>
</table>

**Total nutrient value: $62.59/ton of hay harvested**
Legumes

- ~ 80% of atmosphere is N-gas ($N_2$)
  - Remember the uptake forms
- Nodules are home to nitrogen-fixing bacteria
  - Bacteria convert $N_2$ to $\text{NH}_3$
- Most fixed N goes to host plant
- They will save you $$$$$$$$
  - Dilution and lessening of fescue endophyte
Nodules on Legume Root System
## Legumes

Dry matter yields of tall fescue-red clover vs tall fescue with N fertilizer (Lexington, KY, 2-yr average)

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Yield, lb/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tall fescue-red clover</td>
<td>11,100</td>
</tr>
<tr>
<td>6 lb seed/A</td>
<td></td>
</tr>
<tr>
<td>Tall fescue + nitrogen</td>
<td></td>
</tr>
<tr>
<td>0 lb N/A</td>
<td>3900</td>
</tr>
<tr>
<td>90 lb N/A</td>
<td>6700</td>
</tr>
<tr>
<td>180 lb N/A</td>
<td>9900</td>
</tr>
</tbody>
</table>

Adapted from Southern Forages
Legumes

Adapted from Utah State University

- Yield response without legumes:
  - Price of N application is not worth the minimal yield response

- 20 to 30% legumes provide sufficient N for grasses

Figure 1. The effect of nitrogen rate on tall fescue and mixed fescue-clover yield.
## Nitrogen Fixation by Legumes

<table>
<thead>
<tr>
<th>Legume</th>
<th>N Fixed (lb/A/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>150-250</td>
</tr>
<tr>
<td>Red Clover</td>
<td>75-200</td>
</tr>
<tr>
<td>Ladino Clover</td>
<td>75-150</td>
</tr>
<tr>
<td>Annual Lespedeza</td>
<td>50-150</td>
</tr>
</tbody>
</table>

Adapted from Southern Forages

- **At $0.71/lb for ammonium nitrate:**
  - Legumes fix between $35 and $177 of N/ac/yr

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## Nutrient Replacement

**Fertilizer costs based on removal for cool-season grass/clover mixed hay**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Fertilizer ($/lb)</th>
<th>Removal Rate (lb/ton)</th>
<th>Nutrient Value per Ton</th>
<th>Nutrient Value per Acre (3 ton)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium Nitrate</td>
<td>0.71</td>
<td>45</td>
<td>31.95</td>
<td>95.85</td>
</tr>
<tr>
<td>Phosphate (DAP)</td>
<td>0.54</td>
<td>12</td>
<td>6.48</td>
<td>19.44</td>
</tr>
<tr>
<td>Potash</td>
<td>0.55</td>
<td>50</td>
<td>27.50</td>
<td>82.50</td>
</tr>
</tbody>
</table>

Total costs: **$33.98/ton** with legumes as the N source
# Legume Establishment Considerations

## Soil Test Information

<table>
<thead>
<tr>
<th></th>
<th>Very Low</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
<th>Very High</th>
<th>Excess</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH (salt pH)</td>
<td>4.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium (K)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfur (SO₄-S)</td>
<td>ppm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>ppm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manganese (Mn)</td>
<td>ppm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>ppm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>ppm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Nutrient Requirements

<table>
<thead>
<tr>
<th>Cropping Options</th>
<th>Yield Goal</th>
<th>N</th>
<th>P₂O₅</th>
<th>K₂O</th>
<th>Zn</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 OVERSEEDING LEGUMES</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>110</td>
<td>45</td>
<td></td>
</tr>
</tbody>
</table>

## Limestone Suggestions

<table>
<thead>
<tr>
<th>Material (ENM)</th>
<th>Effective Neutralizing Material (ENM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1170</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Magnesium (EMg)</th>
<th>Effective magnesium (EMg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>***</td>
</tr>
</tbody>
</table>
# Minimum Soil Fertility

<table>
<thead>
<tr>
<th>Species</th>
<th>pH(s)</th>
<th>P</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cool-season grass</td>
<td>5.0</td>
<td>20</td>
<td>200</td>
</tr>
<tr>
<td>Warm-season grass</td>
<td>5.0</td>
<td>20</td>
<td>200</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>6.5</td>
<td>40</td>
<td>300</td>
</tr>
<tr>
<td>Red Clover</td>
<td>6.0</td>
<td>25</td>
<td>250</td>
</tr>
<tr>
<td>White Clover</td>
<td>5.5</td>
<td>25</td>
<td>250</td>
</tr>
<tr>
<td>Birdsfoot Trefoil</td>
<td>5.5</td>
<td>20</td>
<td>225</td>
</tr>
<tr>
<td>Lespedeza</td>
<td>5.0</td>
<td>20</td>
<td>200</td>
</tr>
</tbody>
</table>
Manures

• The good:
  – Adds organic matter
    • Helps improve many aspects of soil health
  – Adds micronutrients
  – Current price = $24 to $35/ton dumped

• The bad:
  – Transportation costs
  – Availability
  – Nutrient variability
# Nutrient Concentration of Manures

Research adapted from Dr. John Lory, University of Missouri

<table>
<thead>
<tr>
<th>Source</th>
<th>Units</th>
<th>N</th>
<th>P$_2$O$_5$</th>
<th>K$_2$O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poultry Litter</td>
<td>lbs/ton</td>
<td>69</td>
<td>82</td>
<td>37</td>
</tr>
<tr>
<td>Beef Feedlot</td>
<td>lbs/ton</td>
<td>24</td>
<td>23</td>
<td>30</td>
</tr>
<tr>
<td>Dairy Slurry</td>
<td>lbs/1000 gal</td>
<td>25</td>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td>Pig Slurry</td>
<td>lbs/1000 gal</td>
<td>58</td>
<td>40</td>
<td>24</td>
</tr>
<tr>
<td>Pig Effluent</td>
<td>lbs/acre-in</td>
<td>135</td>
<td>102</td>
<td>192</td>
</tr>
</tbody>
</table>

Research adapted from Dr. John Lory, University of Missouri
N, P, and K in Poultry Litter

20 to 60% of N can be lost when surface applied

Plants take up phosphate ($P_2O_5$), not phosphorus ($P$) - 80% Available Yr. 1 (100% by Yr.2)
\[ P \times 2.27 = P_2O_5 \]

Plants take up potash ($K_2O$), not potassium ($K$) - 100% Available Yr. 1
\[ K \times 1.2 = K_2O \]
Fertilizer Value

Formula:
\[ \text{lbs/ton} \times \text{availability} \times \text{price/lb} = \text{fertilizer value} \]

Nitrogen: \[ 55 \times 0.6 \times 0.71 = \$23.43/\text{ton} \]
Phosphate (DAP): \[ 78 \times 1.0 \times 0.54 = \$42.12/\text{ton} \]
Potash: \[ 55 \times 1.0 \times 0.55 = \$30.25/\text{ton} \]

Total value: \[ \$95.80/\text{ton} \]
Meeting the Removal Need?

- Scenario:
  - 3 ton hay/acre harvested
  - Nutrients removed:
    - N = 135 lb/ac
    - P2O5 = 36 lb/ac
    - K2O = 150 lb/ac
  - 2 ton litter/acre applied
    - N = 33 lb avail./ton x 2 ton = 66 lb/ac
    - P2O5 = 78 lb/ton x 2 ton = 156 lb/ac
    - K2O = 55 lb/ton x 2 ton = 110 lb/ac
Hay Feeding Impacts Nutrient Cycling
Forage Systems Research Center Study – Linneus, MO

Investigators: John Lory, Dave Davis, Rob Kallenbach, Justin Sexton

- 3 Treatments; 3 Replications
  - Stationary Hay Rings
  - Moved Hay Rings
  - Bales Unrolled Around Pasture
- 13 cows per treatment with one collared
- 15 fescue bales fed to 13 cows in 42 days
- 1st Year – Last Winter – No data yet
Treatment 1

Hay Ring in
Set Feeding Area

Treatment 2

Move Hay Ring
Every Other Day

40’ X 40’

Treatment 3

Unroll Hay in a
New Spot Daily

20’ X 40’
Stationary Ring

Moving Ring

Unrolling Hay
Move Hay Feeding Sites Often

- Regularly move feeders and feeding areas around the pasture.
- Do not use the same pasture for supplemental feeding every year.
Unrolling Hay

- Allows “boss” cows and timid cows to eat together
- Less hoof damage to feeding area because it is larger
- Controls the amount of hay allotted by portioning bales
- Distributes fertilizer nutrients back on field
Liming

“The poor man’s fertilizer”

• For cool-season grass:
  – 5.5 to 7.0

• For legumes:
  – 6.0 to 7.5

• Limit application to 2 to 3 ton/acre/year
Soil pH

- pH scale = 0 to 14
  0 = Strong Acid
  7 = Neutral
  14 = Strong Base
- For best plant growth and nutrient availability:
  pH = 6.2 to 6.5
# Liming for Efficient Fertilizer Use

<table>
<thead>
<tr>
<th>pH (salt)</th>
<th>Nitrogen %</th>
<th>Phosphorus %</th>
<th>Potassium %</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>30</td>
<td>23</td>
<td>33</td>
</tr>
<tr>
<td>4.5</td>
<td>53</td>
<td>34</td>
<td>52</td>
</tr>
<tr>
<td>5.0</td>
<td>77</td>
<td>48</td>
<td>77</td>
</tr>
<tr>
<td>5.5</td>
<td>89</td>
<td>52</td>
<td>100</td>
</tr>
<tr>
<td>6.5</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
Application Timing

- P, K, and lime take time to work into the root zone
- N doesn’t stick around
- Are there legumes present?
- How low are your current levels?
- Availability and price of fertilizer

“Well, lemme think. ...You’ve stumped me, son. Most folks only wanna know how to go the other way.”
Consequences of Forgoing Fertilizer

- Reduced forage production
- Reduced persistence of desirable species
- Excessive weeds and brush
- Reduced forage quality
- Yield loss
Quality Sampling

- **BE CONSISTENT**
  - Sample every 3 to 5 years
  - Sample at the same time every year
  - Depth
- **Avoid sampling soon after applying fertilizer, lime, compost or manure**
  - Best to wait 1 year (at least 4-6 months)
- **Avoid sampling hot spots**
Management History Can Influence a Soil Test
Take Home Points:

- Get to know your soil
  - Take soil tests
  - Set realistic goals
- Nitrogen is **not** easily retained in the soil and should be added just before times of greatest need
- **P** and **K** levels can be built up in the soil
- Nutrients must be replaced
- **Legumes** can save you **N** fertilizer costs
  - Weed control should be considered prior to overseeding
Take Home Points:

• Manures are a good source of fertilizer and organic matter
  – Be cautious of excessive P levels
  – Nutrient levels vary with different sources
  – Help improve overall soil health
The End