Soil Building Practices and Forage Nutrient Management

Pondera County Workshop
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Today’s objectives

• Management practices to benefit soils
• Potential benefits from cover crops
• Cover crop management for optimal benefits
• Forage nutrient management
  ▪ N, P, K, and S
  ▪ Sources
  ▪ Application for high use efficiency
  ▪ Economic considerations
Average Soil Components

- Mineral: ~45%
- Air: ~25%
- Water: ~25%
- Organic matter: ~5%
Mineral ~ 45%
Air ~ 25%
Water ~ 25%
Organic matter ~ 5%

Practices to benefit soil

• Minimize disturbance
• Keep soil surface covered
• Nutrient mgt (soil test; 4Rs)
• Increase diversity
• Keep living root in soil

Perennial >> annual
Recrop >> fallow
Cover crops?
Soil Quality vs Soil Health

**Soil Quality** = properties that change little, if at all, with land use management practices

- Texture
- pH
- Cation Exchange Capacity

**Soil Health** = dynamic properties which may be subjective to measure

- Aggregation
- Microbial activity
- Tilth
- Nutrient availability
- Water holding capacity
- Compaction

Which is more likely to be influenced by cover crops?
MSU single species cover crop research since 1999 has found higher grain yields and/or protein after cover crops when:

1. Seeding winter legumes (vs spring legumes)
2. Seeding spring cover crops early (vs late)
3. Terminating at first bloom (vs pod)
4. Tilling cover crop (vs spraying)

Why?

• More N fixed (1)
• More time for soil water to be recharged and N to become released from residue (1, 2, 3)
• Faster N release and fewer N losses (4)
Our MT studies confirmed early Saskatchewan studies that termination timing is key, when water is limiting. Haying cover crop at early bloom produced higher sp. wheat yields the following year than harvesting pea when water or N limiting (Miller et al 2006).
Species diversity: does it increase benefits?

**Nitrogen Fixers**
- Spring Pea
- Common Vetch
- Lentil

**Fibrous Root**
- Oats
- Italian ryegrass
- Proso millet

**Tap Root**
- Purple top turnip
- Safflower

**Brassica**
- Daikon radish
- Winter canola
- Camelina

*Increase nitrogen*
*Add soil carbon*
*Reduce compaction, move nutrients upward*
*Potential disease control*
Spring wheat yield at Dutton vs previous year total biomass (cc + weed)

\[ SW \text{ yield} = (-7.25 \times \text{CC biomass}) + 46.4 \]

\[ R^2 = 0.72 \]

Housman, Tallman, et al., unpub data, Dutton
Cover Crop Cocktails Plot Study: Take home messages on yield and soil quality

- After one cycle, spring wheat grain yields higher after pea and N fixers than most other mixes.
- Higher cover crop biomass correlated with lower spring wheat yield, likely b/c of more water and N use.
- Relatively few soil health differences between pea and 8-species mix after one cycle; not unexpected.
- After two cycles, no soil health differences between pea and 8-species mix, but CCs increased microbial activity.
Cover Crop Cocktail Farm Study: 1 rotation of mixed CC reduced grain yield in 4 of 6 production years

Yield less after mixed cover crops on farmers’ fields, likely due to late termination and high water & N use by CCrop

6 site average yield loss after cccrop than fallow = 15 bu/acre
Spring wheat grain yield was lower after CC than fallow in four of six field-scale studies, protein results were varied.

High water use from late termination was likely cause of yield differences.
Questions?
Legume cover crops: They take time to influence subsequent wheat yield

Allen et al., 2011, Culbertson
SOM is lost after 10 years of fallow cropping

In top foot of soil

Soil organic matter (ton/acre)

- SOM in 2002
- F-W
- W-W
- Pgrain-w
- Pforage-w
- CC-W
- CRP

Engel, unpub data, MSU Post Farm, 2012
After 4 rotations pea GM provides same net return as fallow, with less N

Miller et al., 2015
Economic options

- Grazing may provide more immediate economic return and increase the rate of change in soil health. Currently under study at MSU-Northern.

- NRCS provides incentives for growing cover crops
Conclusions

- In short term (1 CC-cycle studies), grain yield and protein are generally equal or less than after fallow.
- Early termination (by ~ first pea bloom) is key to preventing yield and protein losses.
- In short term studies, there does not appear to be yield or soil quality advantages of mixes over pea.
- In long term (4+ cycles), yield, protein, and net revenue can be higher after cover crops than fallow, especially at low N rates, likely from more available N.
- Cover crops provide resilience to uncontrollable factors such as weather and markets
- Cover crop value to soil health, subsequent crops, and possibly land value is expected to increase over time.
Questions?

On to *fertilizing forages*
Focus of N or P and K depends on % legume in stand

Yield increases and net returns greatest if < 36% alfalfa in stand and soil N < 5 lb N/acre (Malhi et al. 2004)
MT guidelines for forages

- Based on yield goal and soil tests
  - Recommendations by testing lab
  - Or tables given in *Fertilizer Guidelines for MT Crops* (EB0161)
Example soil test report – Conrad, MT, October 2015

<table>
<thead>
<tr>
<th>ANALYTE</th>
<th>RESULTS</th>
<th>LOW</th>
<th>MEDIUM</th>
<th>optimum</th>
<th>V. HIGH</th>
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<tr>
<td>ORGANIC MATTER %</td>
<td>3.2</td>
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<td>EST N RELEASE lbs/A</td>
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<td>NITRATE-N ppm</td>
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<tr>
<td>SUB-SOIL NO₃-N 1 ppm</td>
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<tr>
<td>SUB-SOIL NO₃-N 2 ppm</td>
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<tr>
<td>P, PHOSPHORUS ppm</td>
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<td>BICARB-P ppm</td>
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<td>P, PHOSPHORUS ppm</td>
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<td>POTASSIUM ppm</td>
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<td>MAGNESIUM ppm</td>
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<td>SULFUR ppm</td>
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<td>ZINC ppm</td>
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<td>MANGANESE ppm</td>
<td>3690</td>
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<td>IRON ppm</td>
<td>20</td>
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<tr>
<td>COPPER ppm</td>
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<tr>
<td>BORON ppm</td>
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<td>SODIUM ppm</td>
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<td>SOLUBLE SALTS ppm</td>
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<td>pH</td>
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<td>BUFFER INDEX</td>
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</table>

**Ideally:**
- OM > 3%
- bicarb-P > 16 ppm
- Salts < 4
- Ideally, 6 < pH < 7.5

**Suggested Fertility Guidelines:**
- NITROGEN (N)
  - CARRYOVER N (11) lbs
- PHOSPHATE (P₂O₅)
- POTASH (K₂O)
- MAGNESIUM (Mg)
- SULFUR (S)
- ZINC (Zn)
- MANGANESE (Mn)
- IRON (Fe)
- COPPER (Cu)
- BORON (B)

**Surface Nitrate Depth:** 0-6

The above analytical results apply only to the sample(s) submitted. Samples are retained a maximum of 30 days.
Example soil biological activity test report – Conrad, MT, October 2015

Soil B.R.A.N. Test

- **Biological Quality Result**: Value: 4.06
  - **0-1**: Very Low Soil Microbial Activity
    - Associated with dry sandy soils and little to no organic matter.
  - **1-2.5**: Low Soil Microbial Activity
    - Soil is marginal in terms of biological activity and organic matter.
  - **2.5-3.5**: Medium Soil Microbial Activity
    - Soil is in moderately balanced condition.
  - **3.5-4**: Ideal Soil Microbial Activity
    - Soil is well supplied with organic matter and has an active population of microorganisms.
  - **> 4**: Unusually High Soil Microbial Activity
    - Soil has very high level of microbial activity. May have excessive organic matter.

- **CO2-C Result**: Value: 71.63 ppm
  - **0-5**: Little Biological Activity
    - Soil is depleted of organic matter and microbial activity
  - **6-30**: Moderate to Low
    - Low in organic matter and microbial activity
  - **31-60**: Moderate Level
    - Soil is approaching ideal levels, applications of active organic matter still recommended
  - **61-100**: Moderate to High
    - Ideal balance of biological activity and adequate organic matter level
  - **> 100**: High N Potential
    - Soil: Soil is well supplied with organic matter

- **Approximate Quantity of Nitrogen (N) Release per Year (average climate)**: Value: 57.3 lbs/A
  - **10-20**: Low
  - **20-30**: Medium
  - **30-40**: High
  - **> 40**: Very High

*Methods: Microbial Activity - Solvita Soil Biomass, Organic Matter - Loss on Ignition, N Release - Calculation based on CO2-C Result

The above analytical results apply only to the sample(s) submitted. Samples are retained a maximum of 30 days.
<table>
<thead>
<tr>
<th>LAB NUMBER</th>
<th>SAMPLE IDENTIFICATION</th>
<th>ORGANIC MATTER</th>
<th>PHOSPHORUS</th>
<th>POTASSIUM</th>
<th>MAGNESIUM</th>
<th>CALCIUM</th>
<th>SODIUM</th>
<th>pH</th>
<th>CATION EXCHANGE CAPACITY</th>
<th>PERCENT BASE SATURATION</th>
<th>SOLUBLE SALTS</th>
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<tr>
<td>69246</td>
<td>ROY B</td>
<td>2.6 M</td>
<td>44 VH</td>
<td>104 VH</td>
<td>50 VH</td>
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<td>79 VH</td>
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<td>196 L</td>
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<td>46 VH</td>
<td>429 VH</td>
<td>2837 VH</td>
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<td>6 VL</td>
<td>76 VH</td>
<td>9 L</td>
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<td>1084 VH</td>
<td>3517 M</td>
<td>7.6</td>
<td>27.5</td>
<td>3.1</td>
</tr>
</tbody>
</table>

- Should be higher than 16
- Should be less than 4. Middle 2 are saline.
- Should be less than 15. These 3 are sodic.
Adding N – having alfalfa in mix may be best source of N

Malhi et al. 2002, Eckville, Alberta
17.5” avg annual and 10.5” May-Aug precip
Dryland grass response to single N application

Intro: rhizomatous > bunch
50 lb N ≈ 100 lb N

Lorbeer et al. 1994, Jacobsen et al. 1996
Havre, dryland grasses
single fall broadcast N lb/acre
Dryland grass response to single N application

Lorbeer et al. 1994, Jacobsen et al. 1996

Havre, dryland grasses
single fall broadcast N lb/acre

Introduced > native

Cumulative Increase over Control (ton/acre)

Year

Lorbeer et al. 1994, Jacobsen et al. 1996
Havre, dryland grasses
single fall broadcast N lb/acre
Challenges to high N use efficiency in perennial systems

- Difficult to incorporate N
- Plant residue
  - intercepts fertilizer
  - increases volatilization
  - can tie up N
Incorporate immediately with water to increase N recovery (likely a volatilization effect).

Eckville, Alberta
Brome grass, Malhi et al. 1995
Trade-off between yield and forage nitrate

Bromegrass, Vimy, Alberta
Penny et al. 1990 and MT200505AG
Questions?

On to *Timing*
Timing depends on source

- Readily available [urea (46–0–0), urea ammonium nitrate (28–0–0)]
  - Grass: shortly after green up
- Slowly available (manure, slow-release N)
  - take time to become available
  - apply well before needed – e.g. fall
Grass: provide N shortly after green-up

Percent of Maximum Uptake

approximate start of jointing stage

Plant Growth

Willamette Valley, Oregon  Hart et al. 1989
Fertilization strategy

• If a field containing < 75% legumes will be rotated into a different crop soon, consider N for immediate gain

• If goal is low input, long-term sustainable production rather than prime quality hay, adequate P and K are key and cheaper than re- or interseeding

• If you need to buy hay or rent pasture, you should consider fertilizing
Summary

- Nitrogen, phosphorus, potassium, and sulfur can all increase forage yields.
- Economic benefits often aren’t realized in the first year (so don’t base advice on 1 yr studies!)
- Soil testing is essential for determining fertilizer needs.
- Select the right rate, source and timing.
Resources

On soil fertility website under *Extension Publications*

http://landresources.montana.edu/soilfertility/

- *Nutrient Management for Forages: N* (EB0217);
- *Nutrient Management for Forages: PKSMicros* (EB0216)
- *Enhanced Efficiency Fertilizers* (EB0188)
Questions?

Additional info at:

http://landresources.montana.edu/soilfertility/

Photo by Ann Ronning