GALLATIN GARDENER CLUB
APRIL 6, 2015

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Hands-on is the best way to learn, but we’ll use clickers because....

1. I just had my nails done 33%
2. Clicker training isn’t just for dogs 33%
3. There isn’t enough dirt on the floor to get a good soil sample 33%
Why should home gardeners know something about soil nutrition?

• To grow healthy plants and tasty vegetables
• To protect the environment
• For efficient use of resources (water and $)
Soil properties that influence water and nutrient availability

<table>
<thead>
<tr>
<th>Soil property</th>
<th>Water</th>
<th>Nutrients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texture/surface area</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>CEC (cation exchange capacity)</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>SOM (soil organic matter)</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
Soil texture

**Sand**: large pore space, low surface area = low water or nutrient holding capacity

**Clay**: small pore space, large surface area, often negative charge on surface = holds water and nutrients tight
Soil pH – which is true?

1. Has no influence on nutrient availability 33%
2. Is difficult to alter 33%
3. Most vegetables prefer pH > 7.5 33%
Soil pH – which is true?

1. Has no influence on nutrient availability
2. Is difficult to alter
3. Most vegetables prefer pH > 7.5
pH affects soil nutrient availability

Most Montana soils are:

1. Generally alkaline (pH > 7.0) 33%
2. Generally acidic (pH < 7.0) 33%
3. “Gumbo” = too difficult to sample 33%
Most Montana soils are:

1. Generally alkaline (pH > 7.0)
2. Generally acidic (pH < 7.0)
3. “Gumbo” = too difficult to sample

P, Fe, Mn, B, Cu & Zn might be limited
Why are MT soils high pH?

- Most MT soils are highly calcareous = alkaline.
- Even if surface soil isn’t alkaline, the subsoil usually is.
- Liming to increase pH doesn’t make sense in our soils.
- Can I lower my soil pH? Can add elemental-S, but likely not economical, and soil S and salt levels may become too high.

Mollisol – common in Montana and or semi-arid regions.
CEC = Cation Exchange Capacity

- A measure of the soil’s ability to hold onto and supply positive ions (e.g. NH$_4^+$) to a crop
- Many essential plant nutrients carry positive charges. e.g., Potassium (K$^+$) and Zinc (Zn$^{+2}$)
- High CEC indicates a fertile soil which has the capacity to attract and hold these nutrients
SOM = Soil organic matter

- Is <6% of soil by weight but controls >90% of the function
- Has high surface area

What does SOM do for soil?
- Increase CEC
- Can’t change soil pH or CEC of mineral soil very well, but can increase SOM to influence soil CEC and . . .

What else does SOM do for soil?
- As decomposes it releases nutrients bound in OM structure
- Holds water which helps nutrients move from soil to plant roots
SOM increases available water holding capacity

Hudson 1994
Questions?
How to evaluate soil nutrient status:
Visual assessment of tissue

• May identify what has been lacking to this point
• Hopefully caught before too late to correct
• Other issues can cause symptoms that look like nutrient deficiency symptoms
  ▪ Insects
  ▪ Salinity
  ▪ Moisture stress
  ▪ Disease
  ▪ Herbicides

Ontario Ministry of Ag., Food & Rural Affairs
How to evaluate soil nutrient status: soil test

- Tells you what is currently available in the soil
- Identifies nutrient deficiency or imbalance
- Helps calculate fertilizer rates
- Can increase yield and/or save on fertilizer costs, and decrease environmental risks
Soil testing

- Sample top 0-6 inches
- Combine 10 subsamples per 1000 sq. ft.
- Use probe, auger or tulip bulb planter
- Best done in early spring, but not when soil is wet, therefore in our climate perhaps best done in late fall (except this year)
- Air dry and send to reputable lab for analysis
FIGURE 2. Sample soil test report and fertilizer recommendations.

<table>
<thead>
<tr>
<th>Soil Test Results</th>
<th>Interpretation</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrate-N</td>
<td>Low</td>
<td>3 lb N/1000 sq ft</td>
</tr>
<tr>
<td>12 lb/acre</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Olsen Phosphorus</td>
<td>Medium</td>
<td>2 lb P₂O₅/1000 sq ft</td>
</tr>
<tr>
<td>15 ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium</td>
<td>Medium</td>
<td>1 lb K₂O/1000 sq ft</td>
</tr>
<tr>
<td>192 ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulfate-S</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>15 ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boron</td>
<td>Medium</td>
<td>0.02 lb B/1000 sq ft</td>
</tr>
<tr>
<td>0.5 ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>Very High</td>
<td></td>
</tr>
<tr>
<td>1.7 ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iron</td>
<td>Very High</td>
<td></td>
</tr>
<tr>
<td>47 ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manganese</td>
<td>Very High</td>
<td></td>
</tr>
<tr>
<td>10 ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zinc</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>1.3 ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soluble Salts</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>0.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organic Matter</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>3.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil pH</td>
<td>Medium/High</td>
<td></td>
</tr>
<tr>
<td>7.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEC</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>17.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil Texture</td>
<td>Sandy Loam</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What if lab doesn’t provide a recommendation (or is from another state)? Use Table 3 from MontGuide (MT200705AG)

<table>
<thead>
<tr>
<th>Soil Test</th>
<th>Organic Matter (%)</th>
<th>Organic Matter (%)</th>
<th>Organic Matter (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrate - N</td>
<td>Location</td>
<td>&lt; 1.5</td>
<td>1.5 – 3.0</td>
</tr>
<tr>
<td>lbs /acre</td>
<td></td>
<td></td>
<td>lbs/1000 sq.ft.</td>
</tr>
<tr>
<td>&lt;20</td>
<td>Lawn</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Tree/shrub</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Garden</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>20-40</td>
<td>Lawn</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Tree/shrub</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Garden</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>40-80</td>
<td>Lawn</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Tree/shrub</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>Garden</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>&gt;80</td>
<td>All</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Sample calculation

N required for soil with 3.4% organic matter and 12 lb N/acre soil test result (< 20 lb N/acre): 3 lb N/1000 sq ft (Table 3)

APPLICATION RATE:

- Using a 10-15-10 fertilizer, 10% N (0.10 lb N/lb fertilizer), 15% P₂O₅ and 10% K₂O

- To calculate the amount of 10-15-10 fertilizer to apply:

  (Required Amount of N) ÷ (Amount N/lb Fertilizer) = Amount of Fertilizer to Apply /1000 sq ft

  (3 lb N/1000 sq ft) ÷ (0.10 lb N/lb fertilizer) = 30 lb of 10-15-10/1000 sq ft
Sample calculation continued: P and K

If you add 30 lb of 10-15-10/1000 sq ft

**How much P does this apply?**
Fraction of $\text{P}_2\text{O}_5$ in 10-15-10 Fertilizer = 15% = 0.15 $\text{P}_2\text{O}_5$/lb fert.
30 lb of 10-15-10/1000 sq ft x 0.15 = 4.5 lb $\text{P}_2\text{O}_5$/1000 sq ft

**How much K does this apply?**
Fraction of $\text{K}_2\text{O}$ in 10-15-10 fertilizer = 10% = 0.10 $\text{K}_2\text{O}$/lb fert.
30 lb of 10-15-10/1000 sq ft x 0.10 = 3 lb $\text{K}_2\text{O}$/1000 sq ft
Using this data from a soil report and Table 3 from Montguide (slide x on your handout), how much N required for a garden?

N ppm x 2 = N lb/acre

1. 3 lb/1000 sq. ft. 33%
2. 2 lb/1000 sq. ft. 33%
3. 1 lb/1000 sq. ft. 33%
Your turn

Using this data from a soil report and Table 3 from Montguide (slide x on your handout), how much N required for a garden? N ppm x 2 = N lb/acre

1. 3 lb/1000 sq. ft.
2. 2 lb/1000 sq. ft.
3. 1 lb/1000 sq. ft.

Lab recommended initial 1.5 lb/1000 sq. ft., with up to an additional 1 lb split evenly over the growing season.

<table>
<thead>
<tr>
<th></th>
<th>OM %</th>
<th>Nitrate –N ppm</th>
<th>P ppm</th>
<th>K ppm</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>3.6</td>
<td>18</td>
<td>77</td>
<td>788</td>
<td>7.5</td>
</tr>
</tbody>
</table>
How much 10-10-15 fertilizer is needed?

(Required lb N = 2) ÷ (lb N/lb Fertilizer) = Amount of Fertilizer to Apply /1000 sq ft

1. 30  25%
2. 20  25%
3. 10  25%
4. Mental math at this hour?!  25%

Response Counter
How much 10-10-15 fertilizer is needed?

(Required lb N = 2) ÷ (lb N/lb Fertilizer) = Amount of Fertilizer to Apply /1000 sq ft

1. 30
2. 20
3. 10
4. Mental math at this hour?!

\[(2 \text{ lb N/1000 sq ft}) ÷ (0.10 \text{ lb N/lb fertilizer}) = 20 \text{ lb of 10-10-15/1000 sq ft}\]
P and K

<table>
<thead>
<tr>
<th></th>
<th>OM %</th>
<th>Nitrate –N ppm</th>
<th>P ppm</th>
<th>K ppm</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>3.6</td>
<td>18</td>
<td>77</td>
<td>788</td>
<td>7.5</td>
</tr>
<tr>
<td>Optimal maximum</td>
<td></td>
<td></td>
<td>30</td>
<td>500</td>
<td></td>
</tr>
</tbody>
</table>

20 lb of 10-10-15/1000 sq ft

How much P does this apply?
20 lb of 10-10-15/1000 sq ft x 0.10 = 2 lb P₂O₅/1000 sq ft

How much K does this apply?
20 lb of 10-10-15/1000 sq ft x 0.15 = 3 lb K₂O/1000 sq ft

Is this advisable?
Both P and K are already high.  What can you do?
Questions?
Organic vs. conventional

- Feed the plant or feed the soil that feeds the plant

- Not all “organic” material is certified organic
Conventional/chemical
• No carbon
• Easy to store
• Higher nutrient concentration
• Custom formulated
• Easy to use
• Liquid or solid available

Compost/manure
• Bulkier
• Nutrient content low but diverse
• Nutrient content difficult to quantify
• Supplies organic matter

Both are available in forms that supply specific nutrients (e.g. bone/blood meal for P)
Application considerations

• Conventional
  ▪ Apply and incorporate before maximum uptake which is BEFORE max biomass – most nutrients are in the plant early and move within plant to the maturing fruit
  ▪ Sideband P and K near, but not with the seed
  ▪ Side dress additional N mid season, if needed

• Organic material
  ▪ Takes time to decompose and become available
  ▪ N may be tied up in the short term
Considerations when fertilizing with manure

- Easy to over apply N, P, and K
- Rapid excess buildup of P and K if fertilizing to meet N needs
  - Of 67 Midwest gardens 92% had excess P and 88% excess K after just 1 to 6 years of ‘uninformed’ fertilization with composted dairy manure (Hansen unpub data, Ohio State Univ)
  - Feed to P and K demands
  - Use legumes or source such as blood meal to supply N
Approximately how much total N, P, and K does 1” of manure compost supply?

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>P$_2$O$_5$</th>
<th>K$_2$O</th>
</tr>
</thead>
<tbody>
<tr>
<td>lbs/1000 sq. ft.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Removed annually</td>
<td>3.4</td>
<td>0.3</td>
<td>3.2</td>
</tr>
<tr>
<td>Added by 1” manure</td>
<td>40</td>
<td>15</td>
<td>40</td>
</tr>
<tr>
<td>Added by 1” manure</td>
<td>6</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>

50% 50% 50%
Approximately how much total N, P, and K does 1” of manure compost supply?

<table>
<thead>
<tr>
<th></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>Removed annually</td>
<td>3.4</td>
<td>0.3</td>
<td>3.2</td>
</tr>
<tr>
<td>Added by 1” manure</td>
<td>40</td>
<td>15</td>
<td>40</td>
</tr>
<tr>
<td>Added by 1” manure</td>
<td>6</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>
Nutrients removed by one season’s harvest of the edible portion of garden vegetables

<table>
<thead>
<tr>
<th>Crop</th>
<th>N</th>
<th>P$_2$O$_5$</th>
<th>N:P ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broccoli</td>
<td>3.8</td>
<td>0.2</td>
<td>37:1</td>
</tr>
<tr>
<td>Lettuce</td>
<td>2.2</td>
<td>0.3</td>
<td>18:1</td>
</tr>
<tr>
<td>Pepper</td>
<td>3.2</td>
<td>0.3</td>
<td>26:1</td>
</tr>
<tr>
<td>Sweet corn</td>
<td>3.6</td>
<td>0.5</td>
<td>18:1</td>
</tr>
<tr>
<td>Tomato</td>
<td>4.1</td>
<td>0.5</td>
<td>19:1</td>
</tr>
<tr>
<td>Average</td>
<td>3.4</td>
<td>0.3</td>
<td>23:1</td>
</tr>
</tbody>
</table>

One local composted manure tested had a total N:P of 6:1

Morris, Ping, and Durgy. University of Connecticut.

Adding organic material is good, but...

how can you increase soil organic matter without adding too much P and K?

- Add organic matter high in C (dry leaves, wood shavings, straw, peat), but remember, high C ties up N
- Add organic matter based on plant’s P needs and add N with chemical fertilizer, organic fertilizer such as blood meal, or plant legumes
Questions?
Summary

• Understanding soils leads to wise nutrient use and promotes maximum plant health and yields
• Soil testing is an important tool to help prevent or correct plant growth problems
• The foundation of a healthy garden is a healthy soil
• With good soil fertility you can grow big pods
Questions?

For additional information on:

Home garden soil testing and fertilization guidelines
http://landresources.montana.edu/soilfertility/home-gardening.html

Soil testing (Module 1)
Nutrient deficiency symptoms (Module 9)
http://landresources.montana.edu/NM/Modules/