Building Soil Health

Weston Miller,
OSU Extension Service
Preview of presentation

• Soil building with organic matter
  – Compost
  – Cover crops

• Nitrogen management

• Soil preparation techniques
Components of Soil Mixture

- Air: 25%
- Water: 25%
- Mineral Particles: 45%
- Organic Matter: 5%

- Organisms: 10%
- Roots: 10%
- Humus: 80%
Tilth

• the state of aggregation of a soil especially in relation to its suitability for crop growth
  – [http://www.m-w.com/dictionary](http://www.m-w.com/dictionary)

• Our job as gardeners/farmers:
  – Maintain and enhance tilth in soil through addition of composted organic material (balanced) and regimented care
Soil Structure

• Micropores / Macropores
• Individual particles together = peds
• Aggregation- bio activity = binding agent
• Compaction-
  – Many ways to destroy soil structure
Soil Structure is Improved by Soil Life

- Aggregation from biological activity influences:
  - Soil porosity (spaces) & permeability (water entry)
  - Water movement & holding capacity
  - Improves root growth
  - Improves environment for beneficial organisms
- Role of organic matter
Soil Aggregates
“The best single overall strategy for nutrient management... is to enhance organic matter levels in soils” (BSBC)

- increases CEC (holds onto cations)
- mineralizes N, P, S and B
- chelates micronutrients (Zn, Cu, Mn, etc.) keeping them plant available.
Soil Building

• Goal is to provide food for soil biology

• Soil biology:
  – creates favorable structure
  – makes nutrients available to plants
  • Mineral from parent soil
  • Organic matter / amendments
Soil Fungi
Soil Bacteria
Organic matter, microbes, roots coexist in soil in close proximity
“Feed plants by feeding the plants”
“Feed plants by feeding the soil”
# Types of Soil Organic Matter

<table>
<thead>
<tr>
<th>Pool</th>
<th>Size/Age (years)</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biologically Active</td>
<td>Small 1-5</td>
<td><strong>Meat</strong>: nutrient mineralization, macro-aggregation, disease suppression</td>
</tr>
<tr>
<td>Protected</td>
<td>Intermediate 5-30</td>
<td><strong>Bones</strong>: soil structure, porosity, water relations</td>
</tr>
<tr>
<td>Stable</td>
<td>Large 50-10,000</td>
<td>Micro-aggregation, CEC, fate of compounds, color</td>
</tr>
</tbody>
</table>
Build soil over time

- Compost
- Cover crops
- Organic fertilizers
- Digging techniques
Organic equilibrium

- Organic matter & soil C accumulate over time
- Soil fertilizer (e.g. N mineralization) increases over time

MAINTENANCE PHASE

SOIL BUILDING PHASE
2-4 years or more
**HOT STUFF**
- High N (>2.5%), high N availability
- Raw manure, blood meal, feather meal
- Little contribution to organic matter, use sparingly, do not exceed N and P requirements

**COOL STUFF**
- Medium N (1.5-2.5%), low N availability
- Compost, leaf mulch and cover crops
- Allow time to decompose and add in large amounts

**WOODY STUFF**
- Low N (<1.5%), 0 or negative N
- Straw, bark and sawdust
- Can immobilize N, use as mulch or long before planting a crop
Carbon-rich Organic Matter

Soil Microbes Compete for Nutrients
Quantity:
2-3 parts soil: 1 part amendment

- rototilling
- digging

Courtesy Linda McMahan
Using Compost

• Mature compost is a stable organic material that builds the active OM pool (humus)
• N release is very slow, but it is steady and can accumulate over time
• Desired characteristics vary with use: potting soil or field application?
### Using Compost

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Field Applied</th>
<th>Potting Soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stability</td>
<td>Low OK</td>
<td>High</td>
</tr>
<tr>
<td>Particle size</td>
<td>Large OK</td>
<td>Small</td>
</tr>
<tr>
<td>Nutrient &amp; salt content</td>
<td>Higher</td>
<td>Lower</td>
</tr>
<tr>
<td>Weed seeds &amp; other</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>contaminants</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost</td>
<td>Low</td>
<td>High</td>
</tr>
</tbody>
</table>
Cover Crops

- Reduce erosion
- Protect soil structure
- Increase organic matter
- Fix atmospheric N
- Supply N w/o supplying P
- Scavenge residual N
- Reduce weed pressure
- Nectar and pollen for beneficial insects

Management challenges?
Types of Cover Crops

- **Legumes**: clovers, vetches, peas, beans
  - Fix atmospheric N
  - Put on most biomass in the spring
  - Provide pollen and nectar

- **Grasses**: oats, rye, wheat, triticale, Sudhan
  - Scavenge soil N
  - Provide C and build organic matter

- **Forbs**: buckwheat, phacelia, mustards
  - Scavenge soil N
  - Provide C and build organic matter
  - Provide pollen and nectar
Cover Crop Niches

After perennial cover

Winter CC

Relay CC

Summer CC

January

July

January

July

January
Winter Cover Crop Choices

- Annual rye
- Common vetch
- Austrian field peas

3-way mixture

- Crimson clover
Winter Cover Crop
Practicality in Garden Setting?
Extreme measures to deal with mature winter cover crops

- Cut down with scythe or weed whacker
- Chop in as best you can
- Add slow-release fertilizer
- Cover with black plastic or burlap for 4-6 weeks, depending on soil temperature
Summer Cover Crops: Daikon, Buckwheat
Phacelia tanacetifolia native - borage fam.
Sudhan grass: mid-September
Winter-killed Sudhan grass
Relay sewn red clover
Seeded July (last cultivation)
Photo mid-October
Relay seeded red clover the following April
How Soil pH Affects Availability of Plant Nutrients

- NITROGEN
- PHOSPHORUS
- POTASSIUM
- SULPHUR
- CALCIUM
- MAGNESIUM
- IRON
- MANGANESE
- BORON
- COPPER & ZINC
- MOLYBDENUM

pH Scale: 4.0 to 10.0

Strongly Acid | Medium Acid | Slightly Acid | Very Slightly Acid | Very Slightly Alkaline | Slightly Alkaline | Medium Alkaline | Strongly Alkaline
Soil pH is Key

![Graph showing the effect of soil pH on the relative yield of various vegetables. The x-axis represents Soil pH ranging from 5.6 to 6.8, while the y-axis represents Relative Yield ranging from 0 to 120. The graph includes lines for Beets, Spinach, Rutabaga, Turnip, Radish, Lettuce, and Green bean. The graph is courtesy of John Hart, OSU Crop & Soil Science.](image-url)
To Increase Soil pH

- Lime (Calcium carbonate)
  - Per soil test recommendations
  - Or 5 # / 100 sq. ft.
  - Dolomite also has Mg
  - Apply in fall
Nitrogen is generally limiting nutrient in metro area soils

http://www.microsoil.com/
Organic Nitrogen Leaching
Nitrate $\text{NO}_3^-$
Ammonium $\text{NH}_4^+$
Plant Uptake
Organic Nitrogen
Leaching
N$_2$ or N$_2$O
Ammonia NH$_3$
Mineralization and Immobilization

Organisms consume other organisms and excrete inorganic wastes.

Organic nutrients are stored in soil organisms and organic matter.

Inorganic nutrients are usable by plants, and are mobile in soil.

Organisms take up and retain nutrients as they grow.
Seasonal Soil Nitrate (NO$_3$) Levels

- **0-5 ppm**
  - Jan
  - Apr
  - Jul
  - Oct
  - Jan

- **20-40 ppm**
  - Apr
  - Jul
  - Oct
Organic nitrogen management is complex since N sources are difficult to predict and they all interact together.

<table>
<thead>
<tr>
<th>N Gains</th>
<th>N Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil N mineralization</td>
<td>Plant uptake</td>
</tr>
<tr>
<td>Compost and cover crops</td>
<td>Leaching</td>
</tr>
<tr>
<td>Fertilizers</td>
<td>Volatilization</td>
</tr>
</tbody>
</table>

If you ignore non-fertilizer N-sources, you are probably over-applying N and spending too much on fertilizer.
Synthetic Fertilizer

- Follow instructions
- Incorporate in soil at planting
- Side dress during growing season
- Most cost-effective
Organic Fertilizers (pg 51)

• Mostly slow release (3-4 months) depending on soil temperature
  – N- many choices
  – P- soft rock phosphate, bone meal
  – K- green sand, kelp meal

• Blood meal, fish, and other animal products can burn

• Compost builds nutrients long-term
## Organic Fertilizers (pg. 51)

<table>
<thead>
<tr>
<th>Material</th>
<th>% N</th>
<th>% P</th>
<th>% K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton seed meal</td>
<td>6-7</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Blood meal</td>
<td>12-15</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Alfalfa</td>
<td>2</td>
<td>0.5</td>
<td>2</td>
</tr>
<tr>
<td>Bat guano</td>
<td>10</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Fish meal</td>
<td>10</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Fish emulsion</td>
<td>10</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Bone meal</td>
<td>1-4</td>
<td>12-24</td>
<td>0</td>
</tr>
<tr>
<td>Rock phosphate</td>
<td>0</td>
<td>25-30</td>
<td>0</td>
</tr>
<tr>
<td>Greensand</td>
<td>0</td>
<td>0</td>
<td>3-7</td>
</tr>
<tr>
<td>Kelp meal</td>
<td>1</td>
<td>.1</td>
<td>2-5</td>
</tr>
</tbody>
</table>

*Sustainable Gardening, Pg 51*
Water-in with Soluble Fertilizer
Accumulation of plant-available N (PAN) from organic sources

Year 1

2

3

4

5

Courtesy of Dan Sullivan OSU Crop & Soil Science
Preferred Hand-digging tools

- Spade
- Spading fork
- Broad fork/ U-bar
- Rake
- Digging board
Broad Fork U-bar

Notice head trench
Digging Board
Walk Behind Tractors
Avoid tillage pan
Sheet Mulch: Longer-term bliss

- Wet soil thoroughly
- High nutrient material
- Overlapping cardboard or newspaper
- 3-4” compost
- Wait 3-4 months
  - Worms eat lawn
- Beware perennial weeds
Sheet Mulching

• Earth Worms
  – Surface feeders
  – Till soil from underneath cardboard
• Supply lots of nutrients to encourage migration
Preview of presentation

• Soil building with organic matter
• Nutrient management
• Soil preparation