SOIL FERTILITY MANAGEMENT BASICS

Organic Soil Amendments and Fertilizers
HERBERT FAMILY
ORGANIC FARM

FROM OUR FIELDS TO YOUR TABLE

WWW.HERBERTFAMILYORGANICFARM.COM
What are Your Objectives for Soil and Crops?

- Increase soil organic matter
- Improve soil tilth
- Enhance nitrogen availability
- Increase nutrient holding capacity
- Build and maintain active microbial populations
- Suppress crop disease
- Create a ‘balanced soil’ environment
Soil Management Relies on a Biological Complex

The main function of soil organisms is to break down the remains of plants and other organisms. This process releases energy, nutrients, and carbon dioxide, and creates soil organic matter.

- Bacteria
- Fungi
- Actinomycetes
- Mycorrhizae
- Insects
- Nematodes
- Clay-humus
Organic additions
(manure, compost, crop residues)

Below ground
(roots and poop)

Rapid Decay
(Sugars, proteins)

Slow Decay
(Cellulose, lignin)

Decomposition (microbes)

Soil

Microbes
Plants

Active SOM

Slow SOM

Resistant SOM

Nutrients (N,P,S)

Microbial

Humus
Organic Matter Management Concepts

Critical factors that control the rate of decay, nutrient release, and conservation of OM in soil

- Soil texture, temperature, and moisture
- The ‘quality’ of organic matter additions
  C:N ratio and lignin content (L:N ratio)
- Quantity of organic matter
- Placement of materials
- Tillage
Important Amendments are not Exclusively Organic

- Limestone
- Gypsum
- Elemental Sulfur
- Boron
- Chilean nitrate
- Mined Potassium
- Processed macro- and micronutrients
- Rock dusts and some BD preparations
Soil structure – Aeration, root penetration, water

Soil with Structure
- Granular
- Blocky

Soil without Structure
- Single Grain
- Massive
Soil structure

- Aggregation is a natural process caused largely by biological activity
- Soil organic matter is an important binding agent for soil structure
- Some soils have inherent excellent structure due to clay types and OM
Organic Amendments - Disease Suppression

- Basal plate end-rot (compost)
- Sclerotinia (compost)
- Verticillium (compost and cover crop)
- Pythium (cover crop)
- Nematodes (cover crop)
- Powdery mildew (compost tea)
RAW and AGED MANURES

Benefits
Organic Matter
NPK – Micronutrients
Nitrogen availability
Beneficial microbes

Challenges
Salinity – Ammonia toxicity
Moisture Content (Handling/Transport)
Microbial pathogens
Nutrient Runoff
### Nitrogen and other Macronutrients

#### Manures Vary in Composition and Quality

<table>
<thead>
<tr>
<th>Source</th>
<th>Nitrogen (as excreted)</th>
<th>Nitrogen (after losses)</th>
<th>Phosphorus (as excreted)</th>
<th>Phosphorus (after losses)</th>
<th>Potassium (as excreted)</th>
<th>Potassium (after losses)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef Cows</td>
<td>10.95</td>
<td>3.3</td>
<td>3.79</td>
<td>3.23</td>
<td>8.25</td>
<td>7.44</td>
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<tr>
<td>Milk Cows</td>
<td>10.69</td>
<td>4.3</td>
<td>1.92</td>
<td>1.65</td>
<td>6.7</td>
<td>6.04</td>
</tr>
<tr>
<td>Heifers &amp; Heifer Calves</td>
<td>6.06</td>
<td>1.82</td>
<td>1.3</td>
<td>1.1</td>
<td>5.03</td>
<td>4.53</td>
</tr>
<tr>
<td>Steers, Calves, Bulls</td>
<td>10.98</td>
<td>3.3</td>
<td>3.37</td>
<td>2.86</td>
<td>7.87</td>
<td>7.08</td>
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<tr>
<td>Breeding Hog &amp; Pig</td>
<td>13.26</td>
<td>3.32</td>
<td>4.28</td>
<td>3.62</td>
<td>7.85</td>
<td>7.04</td>
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<tr>
<td>Other Hog &amp; Pig</td>
<td>11.3</td>
<td>2.82</td>
<td>3.29</td>
<td>2.8</td>
<td>7.95</td>
<td>7.16</td>
</tr>
<tr>
<td>Hens&amp;Pullets - Laying Age</td>
<td>26.93</td>
<td>18.46</td>
<td>9.98</td>
<td>8.5</td>
<td>10.44</td>
<td>9.4</td>
</tr>
<tr>
<td>Pullets under 3 Mo.</td>
<td>27.2</td>
<td>13.6</td>
<td>10.53</td>
<td>8.95</td>
<td>11.41</td>
<td>10.27</td>
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<tr>
<td>Broiler</td>
<td>26.83</td>
<td>16.1</td>
<td>7.8</td>
<td>6.61</td>
<td>10.49</td>
<td>9.48</td>
</tr>
<tr>
<td>Turkeys for Slaughter</td>
<td>32.36</td>
<td>16.18</td>
<td>11.83</td>
<td>10.06</td>
<td>11.61</td>
<td>10.44</td>
</tr>
<tr>
<td>Turkey Hens for Breeding</td>
<td>22.41</td>
<td>11.2</td>
<td>13.21</td>
<td>11.23</td>
<td>7.6</td>
<td>6.84</td>
</tr>
</tbody>
</table>
COMPOSTS

Benefits
Organic Matter
Nitrogen availability
Slower nutrient release
Beneficial microbes
Microbial pathogen reduction
Reduced salinity/toxicity
Reduced moisture content
Decreased pollution risk

Challenges
Costs
Reduced nutrient release
Quality Assurance
FACTORS AFFECTING COMPOST QUALITY

- Raw organic feedstocks and proportions
- Initial and final particle-size
- Degree of initial blending
- Desired production time
- Size of piles/windrows
- Moisture management
- Aeration – Frequency and equipment
- Curing
## COMPARISON OF YARD WASTE AND MANURE COMPOSTS

<table>
<thead>
<tr>
<th>Sample</th>
<th>OM</th>
<th>Total N</th>
<th>C/N</th>
<th>NH$_3$-N [ppm]</th>
<th>pH</th>
<th>Salts [mmhos]</th>
<th>N+P+K</th>
<th>Moisture</th>
<th>&lt; 2 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yard</td>
<td>40.3</td>
<td>1.6</td>
<td>15</td>
<td>231</td>
<td>7.2</td>
<td>4.0</td>
<td>4.2</td>
<td>29.4</td>
<td>72.4</td>
</tr>
<tr>
<td>Blend</td>
<td>49.5</td>
<td>2.0</td>
<td>13</td>
<td>734</td>
<td>8.6</td>
<td>8.3</td>
<td>7.0</td>
<td>32.2</td>
<td>79.2</td>
</tr>
<tr>
<td>Poultry</td>
<td>40.0</td>
<td>3.9</td>
<td>7</td>
<td>5578</td>
<td>9.2</td>
<td>14.1</td>
<td>7.6</td>
<td>37.5</td>
<td>71.4</td>
</tr>
</tbody>
</table>
Cover and Green Manure Crops

**Benefits**

- Organic Matter
- Nitrogen and Phosphorus availability
- Microbial activity
- Selective pathogen reduction?

**Challenges**

- Reduced soil moisture content
- Potential for nitrogen tie-up
- Incorporation and decomposition
- Stimulation of diseases (e.g. *Pythium*)
Critical factors that control the rate of Nitrogen (N) release

- Soil texture, temperature, and moisture
- The ‘quality’ of organic matter additions
  C:N ratio, L:N ratio, and water-solubility
- Quantity of organic matter
- Placement of materials
- Tillage
Organic additions
(manure, compost, crop residues)

N-fixation
(legumes and bacteria)

Soil

Soil Organic Nitrogen

Plants and soil microbes
Organic additions (manure, compost, crop residues)

N-fixation (legumes and bacteria)

Soil

Decomposition (microbes)

Soil Organic Nitrogen

NH₄⁺ ammonium

Uptake

Plants and soil microbes

Organic fertilizer (meals, emulsions)
**Organic additions**
- (manure, compost, crop residues)

**N-fixation**
- (legumes and bacteria)

**Organic fertilizer**
- (meals, emulsions)

**Soil**
- Decomposition (microbes)

**Soil Organic Nitrogen**
- Mineralization (microbes)
- Uptake

**Plants and soil microbes**

**NH$_4^+$**
- ammonium

**NO$_2^-$**
- nitrite

**Gaseous Nitrogen**

**Nitrification (microbes)**
Organic fertilizer
(meals, emulsions)

Organic additions
(manure, compost, crop residues)

N-fixation
(legumes and bacteria)

Soil

Soil Organic Nitrogen

NH₄⁺
ammonium

NO₂⁻
nitrite

NO₃⁻
nitrate

Plants and soil microbes

Gaseous Nitrogen

Leaching

Decomposition (microbes)

Mineralization (microbes)

Uptake

Nitrification (microbes)
### COMPARISON OF CARBON QUALITY OF SOME ORGANIC MATERIALS (washed)

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>Protein</th>
<th>Celluloses</th>
<th>Lignin</th>
<th>Inorganic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cottonseed meal</td>
<td>50.0</td>
<td>13.5</td>
<td>5.4</td>
<td>3.3</td>
</tr>
<tr>
<td>Alfalfa hay</td>
<td>11.1</td>
<td>39.6</td>
<td>12.5</td>
<td>3.4</td>
</tr>
<tr>
<td>Blood meal</td>
<td>89.2</td>
<td>0.0</td>
<td>0.0</td>
<td>2.9</td>
</tr>
<tr>
<td>Horse manure</td>
<td>6.3</td>
<td>45.3</td>
<td>17.3</td>
<td>8.5</td>
</tr>
<tr>
<td>Cow manure</td>
<td>10.1</td>
<td>32.3</td>
<td>20.8</td>
<td>15.2</td>
</tr>
<tr>
<td>Humus product</td>
<td>16.2</td>
<td>4.1</td>
<td>31.6</td>
<td>28.5</td>
</tr>
</tbody>
</table>

From: Rubins and Bear, 1942
| MATERIAL           |   | UNWASHED |   | WASHED |   |   |   |   |   |   |   |
|--------------------|---|----------|---|--------|---|---|---|---|---|---|   |
|                    |   | Total    |   | Insoluble |   | N | Total | C:N Ratio |   | N |   |
|                    |   | Nitrogen |   |   N      |   | Release | Nitrogen |          |   | Release |   |
| Cottonseed meal    |   | 7.2      |   | 93.0    | 49| 8.7  | 5.4 | 50 |
| Soybean meal       |   | 7.6      |   | 84.2    | 61| 10.3 | 4.7 | 58 |
| Alfalfa hay        |   | 2.8      |   | 52.5    | 28| 2.2  | 20.8| 4  |
| Wheat straw        |   | 0.3      |   | 61.7    | -16| 0.25 | 107|-16 |
| Bone meal          |   | 4.2      |   | 99.8    | 7 | 4.3  | 3.5 | 6  |
| Blood meal         |   | 13.8     |   | 97.5    | 60| 14.7 | 3.5 | 51 |
| Fish meal (acid)   |   | 8.5      |   | 68.1    | 56| 8.4  | 5.3 | 33 |
| Peruvian guano     |   | 14.0     |   | 43.9    | 80| 14.4 | 1.3 | 67 |
| Chicken manure     |   | 2.3      |   | 32.9    | 30| 1.0  | 36.4|-19 |
| Horse manure       |   | 1.5      |   | 80.0    | -19| 1.3  | 32.7|-19 |
| Cow manure         |   | 2.0      |   | 69.7    | 5 | 1.8  | 24.4|-10 |
| Humus product      |   | 2.5      |   | 100.0   | 3 | 2.7  | 13.7| 3  |
NITROGEN RELEASE POTENTIAL RELATED TO MATURITY OF COMPOSTS
### TIMING OF N RELEASE IN RELATION TO SPRING LETTUCE SCHEDULE

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N released (lbs/day)</td>
<td>N released (lbs/day)</td>
<td>N released (lbs/day)</td>
</tr>
<tr>
<td>Sandy loam soil</td>
<td>13 0.15</td>
<td>75 0.39</td>
<td>110 0.46</td>
</tr>
<tr>
<td>Yard compost [IM]</td>
<td>2 0.02</td>
<td>90 0.47</td>
<td>140 0.58</td>
</tr>
<tr>
<td>Blend compost [M]</td>
<td>45 0.53</td>
<td>110 0.59</td>
<td>188 0.78</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Material</th>
<th>Post-harvest [190 to 240 Days]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lbs/day</td>
</tr>
<tr>
<td>Sandy loam soil</td>
<td>0.84</td>
</tr>
<tr>
<td>Yard compost [IM]</td>
<td>1.16</td>
</tr>
<tr>
<td>Blend compost [M]</td>
<td>1.70</td>
</tr>
</tbody>
</table>
WHAT MIGHT BE IMPORTANT TO KNOW ABOUT COMPOST BEFORE BUYING?

<table>
<thead>
<tr>
<th>Constituents</th>
<th>Analytical Values</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Matter (%)</td>
<td>37.7</td>
<td>Average</td>
</tr>
<tr>
<td>Total Nitrogen (%)</td>
<td>2.3</td>
<td>Excellent</td>
</tr>
<tr>
<td>Ammonium-Nitrogen (ppm)</td>
<td>170</td>
<td>OK</td>
</tr>
<tr>
<td>Nitrate-Nitrogen (ppm)</td>
<td>1400</td>
<td>High</td>
</tr>
<tr>
<td>Total Phosphorus (%)</td>
<td>0.84</td>
<td>Excellent</td>
</tr>
<tr>
<td>Total Potassium (%)</td>
<td>1.7</td>
<td>Excellent</td>
</tr>
<tr>
<td>Boron (ppm)</td>
<td>32</td>
<td>Good</td>
</tr>
<tr>
<td>Lead (ppm)</td>
<td>36</td>
<td></td>
</tr>
<tr>
<td>Zinc (ppm)</td>
<td>180</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>6.7</td>
<td>OK</td>
</tr>
<tr>
<td>Salinity (EC) (mmhos)</td>
<td>7.2</td>
<td>Restricts some uses</td>
</tr>
<tr>
<td>C:N Ratio</td>
<td>9.8</td>
<td>Good to excellent</td>
</tr>
<tr>
<td>Particle Size Distribution (%)</td>
<td>38.9 &gt; ¼ inch</td>
<td>Restricts some uses</td>
</tr>
<tr>
<td>Maturity</td>
<td>Mature to very mature</td>
<td>Restricts some uses</td>
</tr>
<tr>
<td>E. coli – Salmonella (MPN)</td>
<td>&lt; 2 and &lt;3</td>
<td>Very clean</td>
</tr>
</tbody>
</table>
What are Your Objectives for Soil and Crops?

• Increase soil organic matter
  High applications of bulky organics
  Grass cover crops (root mass)
  Higher C:N or L:N amendments
  Reduce tillage
  How much time do you have?
What are Your Objectives for Soil and Crops?

• Improve soil tilth
  - Avoid working wet soil – reduce tillage
  - Encourage microbial activity
  - Grass cover crops (root mass)
  - Crop rotation
**What are Your Objectives for Soil and Crops?**

- **Enhance nitrogen availability**
  - Apply soluble fertilizers
  - Green manure cover crops
  - Early plowdown
    - *Green, pre-flowering, low L:N*
  - Exploit wet-dry cycles w/tillage
  - Build organic matter
What are Your Objectives for Soil and Crops?

- Increase nutrient holding capacity

Be patient – Humus building is slow
What are Your Objectives for Soil and Crops?

• Build and maintain active microbial populations
  - Provide regular and diverse food
    - Crop rotation
    - Grass and legume cover crops
    - Active microbial composts
  - Avoid working wet soil
  - Avoid concentrating raw manures
  - Maintain uniform moisture
What are Your Objectives for Soil and Crops?

- Suppress crop disease
  - Management not control
  - Understand ecology of diseases
  - Practice ‘informed rotations’
  - Choose specific cover crops
  - Avoid planting soon behind heavy manure applications
  - Avoid old, mineralized composts
  - Avoid sole reliance on any input
  - Diversify, diversify
What are Your Objectives for Soil and Crops?

- Create a ‘balanced soil’ environment
  - Observe crop health
  - Learn what is ‘missing’
  - Consider organic and inorganic
  - Know your materials
  - Manage irrigation
  - Avoid excessive applications
THANK YOU
**Microbial Pathogens in ‘For-market’ Composts**

**Feedstocks:**
- Yard wastes
- Manures
- Food and Process Wastes

11 of 31 samples [34\%] had a negative pathogen index score

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Limit (MPN/g)</th>
<th>Detection Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fecal Coliform</td>
<td>0 – 20,000,000</td>
<td>42,000</td>
</tr>
<tr>
<td>E. coli</td>
<td>0 – 20,000,000</td>
<td>37,000</td>
</tr>
<tr>
<td>E. Coli strain 157 (Pos-Neg)</td>
<td>3 Positives</td>
<td></td>
</tr>
<tr>
<td>Salmonella</td>
<td>all &lt; 0.9 or zero</td>
<td></td>
</tr>
<tr>
<td>Fecal Streptococci</td>
<td>0 – 23,000,000</td>
<td>5,300,000</td>
</tr>
<tr>
<td>Listeria</td>
<td>0 – 430</td>
<td>88</td>
</tr>
<tr>
<td>Clostridium perfringens</td>
<td>0 – 76,000</td>
<td>3,400</td>
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</tbody>
</table>