Compost for the Small and Midsize Farm

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Motivations: Why use Compost?

• Nutrients
• Stable Soil Organic Matter (SOM)
  – Including a growing medium
• Soil Biology

Composting as an essential Resource Management Strategy and not as a Waste Management Strategy

Participant Identification

• Compost producers or suppliers?
• Vegetable and fruit farmers?
• Field crop, forage, and grain farmers?
• Animal husbandry / manure managers?
• Others?
• Making compost on farm?
• Purchasing compost?
• Readily available nutrients (N, K, Ca, ?)
• Slowly releases nutrients (N, P, K, Ca, Mg, S)
• Micronutrients
• Soil pH
• Cation exchange capacity

Rates of Compost Application

<table>
<thead>
<tr>
<th>Rate</th>
<th>Cu yd/acre</th>
<th>Ton/acre</th>
<th>Cu ft/100 sqft</th>
<th>Gal/100 sqft</th>
<th>Inches deep</th>
<th>Lbs N (1%N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>2</td>
<td>1</td>
<td>0.1</td>
<td>0.75</td>
<td>dusting</td>
<td>20</td>
</tr>
<tr>
<td>Mod</td>
<td>5</td>
<td>2.5</td>
<td>0.25</td>
<td>2</td>
<td>dusting</td>
<td>50</td>
</tr>
<tr>
<td>Mod</td>
<td>10</td>
<td>5</td>
<td>0.50</td>
<td>4</td>
<td>0.075 (1/16)</td>
<td>100</td>
</tr>
<tr>
<td>High</td>
<td>20</td>
<td>10</td>
<td>1.0</td>
<td>8</td>
<td>0.12 (1/8)</td>
<td>200</td>
</tr>
</tbody>
</table>

Assumes moist weight of 1000 lbs/cu yd
Not exactly equivalent rates due to rounding.

Does just estimating the amount of NPK applied explain the benefits of compost?

Historically, a critical or negative portrayal of organic farming and gardening was that you can’t apply enough nutrients by applying organic matter or compost so why bother (the preverbal NPK mentality).
What are the additional benefits of adding compost?

Organic Matter Pools

- **Active SOM**
  - Disease suppression
  - Macro-aggregation
  - Nutrient supply

- **Stable SOM (Humus)**
  - Cation Exchange Capacity
  - Micro-aggregation

**Organic Compost**

**Fertilizer**

**Conventional**

**Relationship of total soil C to 150-d mineralizable pools of C and N**

**Soil Organic Matter Types or Fractions**

- Living
- Fresh
- Decaying
- Long Term (Humus)

**Compost vs. Cover Crop Effects on SOM**

- **Compost**
  - Tons/acre OM: 10
- **Cover Crop**
  - Tons/acre OM: 5

Months after soil incorporation: 0, 6, 12
Compost and Green Manure  
1 +1 > 2 ? Added Benefits?

How many lbs of SOM/acre?

- Acre furrow slice = 2,000,000 lbs Soil
- 1% OM = 20,000 lbs/acre organic matter
- 1 ton of compost = 2000lbs so OM increases 10%
- 10 ton of compost = 20,000 lbs so OM doubles to 2%

Stable SOM/Compost Contributions to Physical Properties

- Increased water absorption
- Increased water retention
- Improved drought tolerance
- Reduced soil erosion
- Improved root health

Organic Matter Increases Water Absorption and Retention

From Attra Publication

Water Absorption Increases

Water Retention Increases

Figure 3. Effect of straw rate on water infiltration on a silt loam soil ( ).

Figure 2. Available water content with increasing soil organic matter ( ).
SOM/Compost Contributions to Physical Properties

- Rodale Institute: 1 lb of carbon can lead to 40 lbs of water held
- OM is about 40% carbon.
- So, 1% OM = 20,000 lbs OM/40%C
  = 8000 lbs C x 40 lbs water/lb C
  = 320,000 lbs water = 40,000 gallons
- 10 ton/acre OM ~= 40,000 gallons per acre extra water holding capacity?

Compost Uses and Application

- Transplants
- High Tunnels
- Field Production
  - Higher rates
  - Lower rates

Soil Blocks

Compost Top Dressing
Compost Extracts or Tea

High Tunnels

Factors influencing application rate include tractor speed, spreader settings and compost characteristics (moisture)

Uniform application can be a challenge, particularly at low rates. How uniform is necessary?

- 5 gal bucket / 20 sq ft to 1 cubic foot / 20 sq ft (7.5 gal)
- 5 cubic foot / 100 sq ft
- 3 to 4 cu yd / 30x96 hoophouse
- 80 yd/acre or 40 ton/acre
- No leaching from rain
- No freezing of the ground

With Manure Spreader
It is easier to see the uniformity of application on a cultivated field, compared to a field with crop residue.

For lower rates of application, lime or fertilizer application equipment may be more practical.

Distribution is influenced by the weight and moisture content of the compost.
How much does it cost to purchase and apply compost?

How does the cost of purchasing compare to the cost of making compost?

Cost Estimates and Examples
(Assumes bulk density is 1000 lbs/yd moist.)

<table>
<thead>
<tr>
<th>Rate</th>
<th>$ / Ton</th>
<th>$ / cu yd</th>
<th>$ / acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ton</td>
<td>50</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>5 tons</td>
<td>50</td>
<td>25</td>
<td>250</td>
</tr>
<tr>
<td>10 tons</td>
<td>50</td>
<td>25</td>
<td>500</td>
</tr>
<tr>
<td>20 tons</td>
<td>50</td>
<td>25</td>
<td>1000</td>
</tr>
</tbody>
</table>

Composting Methods – So Many Options!

- Fast or Slow?
- Patient or No?
- Cool or Hot?
- Seeds or not?
- Shallow Sheet or Piled Deep?
- Walled Containers, Open Piles or Long & Winding Windrows?
- Turned Weekly or Weakly Turned?
- Pitchfork or Loader or Dedicated Turner?
Data from Will Brinton – Composting for Sustainability

<table>
<thead>
<tr>
<th>Method</th>
<th>Cow Manure @ 120 Days</th>
<th>Poultry Manure @ 150 Days</th>
<th>Cost in $/wet ton</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Organic Matter Loss (%)</td>
<td>Nitrogen Loss (%)</td>
<td>Organic Matter Loss (%)</td>
</tr>
<tr>
<td>No-Turn</td>
<td>70</td>
<td>51</td>
<td>75</td>
</tr>
<tr>
<td>Bucket Loader</td>
<td>78</td>
<td>60</td>
<td>79</td>
</tr>
<tr>
<td>Turner at each 2 wk</td>
<td>73</td>
<td>53</td>
<td>79</td>
</tr>
<tr>
<td>Turner 2x per week</td>
<td>80</td>
<td>64</td>
<td>88</td>
</tr>
</tbody>
</table>

Pallet Compost: hay, straw, wood shavings, peat, etc – after 7 months with no turning or mixing but water has to be added.

Pile made April 8, 2006
Picture Sept 27, 2006
6 months, no turning

January 2007

1 bale of each + ~ 100 gal water
Each ¼ bale absorbed about 5 gallons
160°F in 3 days (October 10, 2011)

Pear Tree Farm Transplant & Tea Mix

Amount of comfrey and soil shown used per bale of others.

These components are readily available to make a very reproducible mix, low N, good fungal activity

Comfrey Wood Shavings Straw, Peat, Hay1, Hay2, Soil

These components are readily available to make a very reproducible mix, low N, good fungal activity

Amount of comfrey and soil shown used per bale of others.
Cleaned up with a pitch fork, heats well.

Piles Constructed May 30, 2009
Picture Taken June 25, 2009

6 hay @ $3 = $12
3 straw @ $2 = $6
3 shaving @ $6 = $18
3 peat @ $10 = $30
Total = $66
40" x 40" x 48" = 1.6 cu yd ($66)

What is the cost for Transplant Mix?
Compost Example

<table>
<thead>
<tr>
<th>Material</th>
<th>Quantity</th>
<th>$/Unit</th>
<th>$ Total</th>
<th>Est. cu yd</th>
</tr>
</thead>
<tbody>
<tr>
<td>straw</td>
<td>40 bales</td>
<td>$3.00</td>
<td>$120</td>
<td>15</td>
</tr>
<tr>
<td>wood shavings</td>
<td>20 bales</td>
<td>$5.00</td>
<td>$100</td>
<td>6</td>
</tr>
<tr>
<td>sphagnum peat</td>
<td>10 bales (3.8)</td>
<td>$12.00</td>
<td>$120</td>
<td>2.5</td>
</tr>
<tr>
<td>alfalfa hay</td>
<td>20 bales</td>
<td>$4.00</td>
<td>$80</td>
<td>7</td>
</tr>
<tr>
<td>grass hay</td>
<td>20 bales</td>
<td>$3.00</td>
<td>$60</td>
<td>7</td>
</tr>
<tr>
<td>leaf mold</td>
<td>8 cu yd</td>
<td>15</td>
<td>$120</td>
<td>15</td>
</tr>
<tr>
<td>veg/weed “compost”</td>
<td>8 cu yd</td>
<td>10</td>
<td>$80</td>
<td>10</td>
</tr>
<tr>
<td>field soil</td>
<td>8 cu yd</td>
<td>5</td>
<td>$40</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>$720</td>
<td>68</td>
</tr>
</tbody>
</table>
### Small Batch Compost Example

<table>
<thead>
<tr>
<th>Material</th>
<th>Lbs/cu ft (dry)</th>
<th>Cu ft comp/meal</th>
<th>Lbs</th>
<th>% N</th>
<th>Lbs N</th>
<th>% C</th>
<th>Lbs C</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass hay (G)</td>
<td>9</td>
<td>5.5 / 7</td>
<td>40</td>
<td>2.0</td>
<td>0.8</td>
<td>45</td>
<td>18</td>
<td>1 @ $3</td>
</tr>
<tr>
<td>Alfalfa hay (G)</td>
<td>9</td>
<td>5.5 / 7</td>
<td>50</td>
<td>3.0</td>
<td>1.5</td>
<td>45</td>
<td>23</td>
<td>1 @ $4</td>
</tr>
<tr>
<td>Straw (B)</td>
<td>10</td>
<td>10 / 14</td>
<td>60</td>
<td>0.7</td>
<td>0.42</td>
<td>50</td>
<td>30</td>
<td>2 @ $3</td>
</tr>
<tr>
<td>Wood Shavings (B)</td>
<td>15</td>
<td>6.5 / 16</td>
<td>80</td>
<td>0.18</td>
<td>0.14</td>
<td>55</td>
<td>44</td>
<td>2 @ $5</td>
</tr>
<tr>
<td>Aged Leaves (B)</td>
<td>15</td>
<td>6.5 / 8</td>
<td>100</td>
<td>1.0</td>
<td>1.0</td>
<td>40</td>
<td>40</td>
<td>2 @ $2</td>
</tr>
<tr>
<td>Spaghnum Peat (N)</td>
<td>8</td>
<td>3.8 / 6</td>
<td>(40)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$10</td>
</tr>
<tr>
<td>Soil (N)</td>
<td>80</td>
<td>3.8 / 3.8</td>
<td>(300)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>42 / 62</strong></td>
<td><strong>750</strong></td>
<td><strong>3.86</strong></td>
<td></td>
<td></td>
<td><strong>154</strong></td>
<td></td>
<td><strong>$40/yard</strong></td>
</tr>
</tbody>
</table>

**Cover Piles – Prevent Leaching**

**Windrows For Large Scale**

**Large Scale Windrows**

**Unfed or Molded Hay**
Lots of Straw Roundbales

The Composting Process

Water → Heat → CO₂

Organic Matter → Minerals → Water → Micro-organisms

Raw Materials → Compost Pile → Finished compost

Seven Manageable Factors

- What Microbes are present
- Substrate Carbon: Nitrogen Ratio
  - Density (weight), moisture
  - Availability, particle size
- Oxygen (Porosity and Bulk Density)
- Moisture
- Temperature
- pH
- Time

Microbial Populations Change Over Time

A = mesophilic 
B = thermophilic 
C = mesophilic 
D = maturation

Active Phase

Curing Phase

Temperature

Time

Which microbes?

- Bacteria
- Actinomycetes
- Fungi
- Amoeba
- Protozoa
- Nematodes
- Together are the “Soil Food Web”

Manageable Factors and Organisms

<table>
<thead>
<tr>
<th>Factor</th>
<th>Bacteria</th>
<th>Fungi</th>
</tr>
</thead>
<tbody>
<tr>
<td>C:N</td>
<td>Favored &lt;20:1</td>
<td>Favored &gt; 25:1</td>
</tr>
<tr>
<td>Water</td>
<td>High Moisture</td>
<td>Low Moisture</td>
</tr>
<tr>
<td>Oxygen</td>
<td>Survive low O₂</td>
<td>Need &gt;6%</td>
</tr>
<tr>
<td>Temperature</td>
<td>Up to 170F</td>
<td>Most &lt; 140F</td>
</tr>
<tr>
<td>pH</td>
<td>Slow at &lt;5</td>
<td>Ok at pH &lt;5</td>
</tr>
<tr>
<td>Time</td>
<td>Faster Reproduction</td>
<td>Slower Reproduction</td>
</tr>
</tbody>
</table>
C:N of Manure Varies by Diet
glass vs alfalfa vs grain

Ease with which carbon compounds are broken down:

- Carbohydrates  
- Hemicellulose  
- fats/oils  
- cellulose, chitin  
- lignin  

1:1  
2:1  
3:1

Carbon:Nitrogen Ratio Effects on Composting

Graph showing temperature (°C) over days of decomposition for different C:N ratios (30:1, 40:1, 60:1).
Convective aeration

Warm air

Ambient air

Air Flow and Pile Size

No O₂

>10 ft.

Adequate O₂

6-8 ft.

Water Content Effects on Aeration

Adequate moisture with air-filled pores

Excessive moisture with water-filled pores

Adapted from T. Richard
Summary: Manageable Factors

- Microbes
- Carbon: Nitrogen
  - Density (weight), moisture
  - Availability, particle size
- Oxygen (Porosity and Bulk Density)
- Moisture
- Temperature
- pH
- Time

The Composting Process

Organic Matter, minerals, water, microbes

Water → Heat → CO₂

Raw Materials → Compost Pile → Finished compost