Organic Fertility

Soil and soil management is the foundation of organic production. Organic growing systems are soil based, care for the soil and surrounding ecosystems and provide support for a diversity of species while encouraging nutrient cycling and mitigating soil and nutrient losses.

IFOAM Norms, 2002
Modern notions of soil fertility
1850s

• Justis von Liebig disproves the ‘humus theory’ and formulates the law of the minimum

• Louis Pasteur proves decay is a biotic process

“Humus benefits the soil in three ways: mechanically, as a plant food, and by fundamentally modifying the soil bionomics. Of the three, this last, hitherto largely ignored, is probably the most important”.

Lady Eve Balfour- In "The Living Soil" 1943
Corn Yield Trends in Morrow Plots are Influenced by Soil Quality

Theoretical functions describing the influence of soil quality on yield response and input use efficiency:

- $Y_a$: initial or optimal state
- $Y_b$: reduced input use efficiency
- $Y_c$: reduced yield potential
- $Y_d$: reduced input use efficiency and yield potential

From Cassman, K.G. PNAS. 1999; 96: 5952-5959.
What would Liebig think?
Nutrient cycling through organic reservoirs

During transition one accumulates nutrient stocks held in and supplied from an organic matter reservoir

MIT

Mineralization, Immobilization, Transformation
Fundamental shift of decomposer community to the left

Adapted from Schimel and Bennett, 2004

Changing the nature of nutrient cycles
Organic and occluded P

Inorganic and labile P

Organic and occluded P

Inorganic and labile P

Plants source organic
Modify Plant-Microbe Relations

- Reliance on N fixation as a source of N
- Mycorrhizal associations
- Plant induced liberation of nutrients
- General suppression of soil borne disease

Enhance the physical ecology

- This supports the biotic community
- Promotes the efficient cycling of matter and energy while
- helping soils and resident organisms to resist stress
**Biologically Active SOM**

**Physically Active SOM**

**Chemically Reactive And Humified SOM**

**INPUTS**

- Cation Exchange
- Pesticide Sorption, Efficacy

**Nutrient Supply**

- Disease Suppression
- Erosion Resistance
- Water Holding Capacity

**Grand unified field theory**

<table>
<thead>
<tr>
<th>Organic N</th>
<th>A. Simple agronomic systems that rely on inorganic N/ P and are frequently C limited</th>
</tr>
</thead>
<tbody>
<tr>
<td>C. Natural and diversified systems that are C rich and N/P limited</td>
<td>B. Diversified systems that are C and N/P rich</td>
</tr>
</tbody>
</table>

**NO₃**

- Limited competition, Net mineralization important

**NH₄⁺**

- Plants and microbes actively compete and partner
"..the manure increases the number and activities of competitive organisms which inhibit the growth and development of the root rot fungus."

All SOM is not created equal

- **Biologically active matter**
  associated with nutrient supply or microbial growth

- **Physically active or sequestered matter**
  associated with substrate accessibility and soil structure

- **Chemically active or inactive matter**
  explains or influences material persistence and it’s chemical reactivity including exchange and sorption-de sorption properties.
Active Fractions

- Biologically active
  - Plant available-N, N mineralization, Amino sugar N
  - Microbial respiration, biomass size, ratios
  - Particulate organic matter
  - Microbial activity, substrate decay potential

- Physically active
  - Particulate organic matter
  - Aggregation
  - Residue
  - Carbohydrates, Amino sugar N

Particulate (Macro) Organic Matter

Sensitive to management

Indicator of root inputs

Stabilizes macro aggregates

Positively related to soil N supply

Substrate supporting biological growth
Rotation, POM

Wander et al. 1996

Brown vs Green Manure
Quantity and quality of labile SOM in organic and conventional soils

- 9 long-term farming systems trials NA
  - 10 years old on average
  - All include organic and conventional systems

Emily Marriott’s M.S. thesis

Types of Farming Systems

- Conventional
  - Fertility from synthetic fertilizers
  - 8 sites
- Manure-based organic
  - Fertility from compost or manure
  - 7 sites
- Legume-based organic
  - Fertility from N₂ fixing legumes
  - 3 sites
Stepwise multiple regression

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Model</th>
<th>Partial R² values‡</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>adjusted R² value</td>
<td>MAT</td>
</tr>
<tr>
<td>All systems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOC</td>
<td>0.788***</td>
<td>0.211</td>
</tr>
<tr>
<td>IL-N</td>
<td>0.789***</td>
<td>0.239</td>
</tr>
<tr>
<td>POM-C</td>
<td>0.398***</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

| Organic systems    |                   |     |     |        |        |     |
| SOC                | 0.851***          | 0.222 | n.s. | 0.608 | 0.049 | n.s.|
| IL-N               | 0.857***          | 0.231 | n.s. | 0.570 | 0.083 | n.s.|
| POM-C              | 0.615***          | n.s. | n.s. | n.s.  | n.s.  | 0.639|
Diagnostic for soil condition

POM Quantity and Quality

High Proportion of SOC  Lower C/N ratio

Low N availability  High N availability

Is your soil a type A?
Consider

- Amendments
- Rotation
- Nutrient budgeting
- Visual assessment or tissue testing

Mgt: Organic matter: the meat and the bone

Oshins, 1999
# Soil Stewardship

- Tighten the nutrient cycle,
- Increase nutrient and water use efficiency,
- Suppress diseases and pests, including weeds,
- Resist degradation,
- Buffer environmental onslaughts,
- Produce healthy plants, people and animals

<table>
<thead>
<tr>
<th>Raw Manure</th>
<th>Composted Manure</th>
</tr>
</thead>
<tbody>
<tr>
<td>• High available nutrients: N forms, P, K, etc.</td>
<td>• Low available nutrients, esp. N</td>
</tr>
<tr>
<td>• Heterogeneous, high volume</td>
<td>• Relatively Homogeneous, reduced volume</td>
</tr>
<tr>
<td>• Very biologically active</td>
<td>• Biologically stable</td>
</tr>
<tr>
<td>• Wet with strong odor</td>
<td>• Moist-dry with non-offensive odor</td>
</tr>
<tr>
<td>• Contains weed seeds, pathogens</td>
<td>• Weed seeds, pathogens killed</td>
</tr>
<tr>
<td>• 60-90 day time restriction</td>
<td>• No time restrictions</td>
</tr>
</tbody>
</table>

Illustration from National Geographic
Testing and budgeting

• Sample at a consistent time point

• Consistent depth

• Baseline samples
Take home message

• Soils should source organic
• The do this when inorganic amendments are not easily available
• It is much easier to build biologically active than physically active SOM
• Accumulation of physically active C provides evidence that you have reduced the type A tendencies of your soil