Organic Matter-Mediated General Suppression

Alex Stone, Dept. of Horticulture
"..the manure increases the number and activities of competitive organisms which inhibit the growth and development of the root rot fungus."
OM-Mediated General Suppression

- is generated by many types of OM
- is generated immediately after high rate amendment
- is of fairly short duration
- is positively related to microbial (FDA) activity

Stone et al, 2004
The Soil Food Web

Organic Matter
Waste, residue, and metabolites from plants, animals, and microbes

Plants
Plants

First trophic level:
Photosynthesizers

Second trophic level:
Decomposers
Mutualists
Parasites, pathogens
Root-feeders

Third trophic level:
Shredders
Predators
Grazers

Fourth trophic level:
Predators

Fifth and higher trophic levels:
Higher level predators

from the USDA Soil Biology Primer
Suppression of Pythium Diseases: Containers
# Biological Carrying Capacity

Relative to the biocontrol of Pythium root rot; based on grower observations and laboratory measurements

<table>
<thead>
<tr>
<th>Compost Type</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardwood bark compost</td>
<td>2-3 yr</td>
</tr>
<tr>
<td>Sawdust-bedded cow manure compost</td>
<td>1 yr</td>
</tr>
<tr>
<td>Pine bark compost</td>
<td>6-12 mo</td>
</tr>
<tr>
<td>Light peat (H2 - H3 on the von Post decomposition scale)</td>
<td>2-10 mo</td>
</tr>
<tr>
<td>Dark peat (H4)</td>
<td>0-1 wk</td>
</tr>
</tbody>
</table>

*sensu Boehm et al, 1993*
Peat System: Proportion of Culturable Community Engaged in Biocontrol

Boehm et al, 1997

• Suppressive peat: 10% of culturable species with activity against Pythium DO

• Conducive peat: <1%

• Composted hardwood bark - 25%
Suppression of Pythium DO in a Sawdust-Bedded Dairy Manure Compost
Compost System

Trends in suppressiveness to Pythium root rot of cucumber in a compost- and a peat-amended mix.

<table>
<thead>
<tr>
<th>Time after potting (days)</th>
<th>15</th>
<th>186</th>
<th>274</th>
<th>375</th>
<th>426</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compost</td>
<td>1.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.4&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Peat</td>
<td>2.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>3.8&lt;sup&gt;d&lt;/sup&gt;</td>
<td>3.1&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2.5&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

LSD<sub>0.05</sub> = 0.70
Duration of Decomposition (days)

POM Concentration (mg DM cm\(^{-3}\))

- Fine POM
- Mid-size POM
- Coarse POM
- Total POM
<table>
<thead>
<tr>
<th></th>
<th>160-200 ppm carbonyl/carboxyl</th>
<th>110-160 ppm aromatic</th>
<th>45-110 ppm O-alkyl</th>
<th>10-45 ppm alkyl</th>
<th>as determined by proportion of 160-200 and 45-110 ppm spectral areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>compost day 4</td>
<td>4</td>
<td>12</td>
<td>70</td>
<td>12</td>
<td>suppressive</td>
</tr>
<tr>
<td>compost LF day 83</td>
<td>7</td>
<td>20</td>
<td>55</td>
<td>18</td>
<td>suppressive</td>
</tr>
<tr>
<td>compost LF day 391</td>
<td>7</td>
<td>20</td>
<td>54</td>
<td>19</td>
<td>suppressive</td>
</tr>
<tr>
<td>compost LF day 506</td>
<td>10</td>
<td>23</td>
<td>51</td>
<td>16 ??</td>
<td>conducive</td>
</tr>
<tr>
<td>total soil LF(^3)</td>
<td>6-12</td>
<td>16-28</td>
<td>39-57</td>
<td>16-26</td>
<td>suppressive/conducive?</td>
</tr>
<tr>
<td>free soil LF(^2)</td>
<td>5-7</td>
<td>14-18</td>
<td>55-63</td>
<td>18-25</td>
<td>suppressive?</td>
</tr>
<tr>
<td>occluded soil LF(^2)</td>
<td>7-11</td>
<td>15-20</td>
<td>33-45</td>
<td>28-45</td>
<td>conducive?</td>
</tr>
<tr>
<td>L horizon (forest soil)(^4)</td>
<td>5-8</td>
<td>14-23</td>
<td>54-58</td>
<td>16-22</td>
<td>suppressive?</td>
</tr>
<tr>
<td>Of horizon (forest soil)(^4)</td>
<td>5-11</td>
<td>15-22</td>
<td>39-55</td>
<td>23-28</td>
<td>borderline?</td>
</tr>
<tr>
<td>Oh horizon (forest soil)(^4)</td>
<td>7-11</td>
<td>13-23</td>
<td>44-48</td>
<td>23-34</td>
<td>conducive?</td>
</tr>
<tr>
<td>Aeh horizon (forest soil)(^4)</td>
<td>7-11</td>
<td>9-25</td>
<td>39-42</td>
<td>25-42</td>
<td>conducive?</td>
</tr>
</tbody>
</table>

\(^2\) from Golchin et al, 1994; \(^3\) from Baldock et al, 1992; \(^4\) from Hempfling et al, 1987 and Kögel-Knabner et al, 1988; forest soil horizons
Poinsettias are Nice, but Real Farmers Grow Snap Beans
Vegetable Rotation
potato/snap bean/cucumber
Hancock Amended-Sand Field Trial: Suppression of Diseases caused by *Pythium* spp.

<table>
<thead>
<tr>
<th>Treatment</th>
<th><em>Potato</em> (98)</th>
<th><em>Cucumber</em> (99)</th>
<th><em>Snap Bean</em> (99)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pythium Leak Incidence</td>
<td>Pythium Damping-off index</td>
<td>Aerial Pythium Incidence</td>
</tr>
<tr>
<td>PS L</td>
<td>6.3 a</td>
<td>1.9 b</td>
<td>3.0 b</td>
</tr>
<tr>
<td>PS H</td>
<td>5.1 b(^1)</td>
<td>1.4 b</td>
<td>1.7 b</td>
</tr>
<tr>
<td>PSC L</td>
<td>10.3 a</td>
<td>1.6 b</td>
<td>1.5 b</td>
</tr>
<tr>
<td>PSC H</td>
<td>4.8 b(^1)</td>
<td>1.8 b</td>
<td>1.7 b</td>
</tr>
<tr>
<td>PSB L</td>
<td>4.1 b(^1)</td>
<td>1.7 b</td>
<td>1.9 b</td>
</tr>
<tr>
<td>PSB H</td>
<td>8.7 a</td>
<td>1.7 b</td>
<td>1.7 b</td>
</tr>
<tr>
<td>Control</td>
<td>13.1 a</td>
<td>3.1 a</td>
<td>15.0 a</td>
</tr>
<tr>
<td>LSD (P=0.05)</td>
<td>9.7</td>
<td>0.7</td>
<td>6.6</td>
</tr>
</tbody>
</table>
Common root rot of snap bean (Aphanomyces euteiches and Pythium spp).
Root rot of sweet corn
A Complex of Soilborne Microorganisms Causes Root Rot

Pythium arrhenomanes, Phoma terrestris, Drechslera sp.

Hoinacki et al, 2004
• Can we suppress sweet corn root rot through raw and composted manure amendments?
SOM is Compositionally and Functionally Heterogeneous

<table>
<thead>
<tr>
<th>Pool</th>
<th>Size/Age (yrs)</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biologically Active</td>
<td>Small/1-5</td>
<td>The Meat: nutrient mineralization, macro-aggregation, disease suppression</td>
</tr>
<tr>
<td>Protected</td>
<td>intermediate/ 5-30</td>
<td>The Bones: soil structure, porosity, water relations</td>
</tr>
<tr>
<td>Stable</td>
<td>Large/50-10,000</td>
<td>Micro-aggregation, CEC, fate of ionic and non-ionic compounds, color</td>
</tr>
</tbody>
</table>
\[ y = 2.23 - 0.06x \]

\[ R^2 = 0.42 \]

Disease severity vs. Free particulate organic matter (mg cm\(^{-3}\)).

A) Darby et al, 2006
A) $y = 2.23 - 0.06x$

$R^2 = 0.42$

Disease severity

Free particulate organic matter (mg cm\(^{-3}\))

Darby et al, 2006
Disease severity

Free particulate organic matter (mg cm⁻³)

\[ y = 2.23 - 0.06x \]

\[ R^2 = 0.42 \]

Darby et al, 2006
Relationship between fPOM and severity of root rot of sweet corn.

Darby et al, 2006
FDA activity is a good indirect measure of organic matter quality

\[ y = 5.51 - 1.49x \]
\[ R^2 = 0.73 \]

Darby et al., 2006
FDA activity and other general microbial indicators increase with the increase in POM (4th year of serial amendment).
Review Chapter

• Stone, Scheuerell and Darby, 2004
• Chapter 5: Suppression of soilborne diseases in field agricultural systems.
• In: Soil Organic Matter in Sustainable Agriculture. CRC Press.

www.ecofarmer.us (go to publications)
Cover Crops: A Tool to Improve Soil and Plant Health
Kenagy On-Farm Trial

- Winter cover crops planted Sept 15-16, 2004
- One approx. 60 ft. wide swath per treatment across pivot
  - Oats “Saia” (40 lbs/A)
  - Arugula (3.5 lbs/A)
  - Mustard mix “Caliente” (6 lbs/A)

  The cover crop biomass averaged 3.5 dry tons per acre with no differences among treatments.

- Flailed March 25, 2005
- Sweet corn SSJ+ planted June 23, 2005
Kenagy Corn Root Rot

Nodal root necrosis (percent)

Control
Arugula
Caliente
Oats

Time (weeks after planting)

0 10 20 30 40 50 60 70

4 6 8 10 12 14 16

*