Impacts of Composts on Soil and Plant Health

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Historical Perspectives

It has been recognized for centuries that composts can support natural disease control.

However, composts differ widely in this ability. Furthermore, some batches kill plants; others inhibit or stimulate plant growth!

Result: Growers shied away from using composts in their operations until recently!
**Historical Perspectives (contd.)**

1970 - 1990
Research performed with tree bark and composted biosolids brought science to the field of compost quality.

1990 - 2002
Research with several types of composts further defined compost-induced disease suppression.

2002-
Standard analytical testing procedures for compost quality adopted by the US Composting Council (TMECC).

2003-
In spite of the data available on compost quality, interpretation of quality tests still poses challenges.
The 1960’s; The peak in chemical agriculture….

Taxus: Missing plants in heavy low lying soil killed by *P. citrophthora* and by *T. basicola* in sandier foreground.

and pollution!
Pacific NW soil planted to Rhododendrons after sawdust amendment. Note Phytophthora root rot.
Azaleas killed by Phytophthora root rot in a Sphagnum peat mix.
Phytophthora sporangium releasing zoospores in water from a peat potting mix
Phytophthora zoospores germinating in water from a peat potting mix

~10 μM
Conclusions: Fresh organic amendments severely increase plant diseases!

Sugars released by cellulose repress biocontrol and cause N immobilization!

To avoid this problem, OM should be composted before its use.
Substitution of peat with composted bark began in 1954. Natural suppression of root rots was observed immediately!
This Phytophthora root rot bioassay proved that natural suppression in compost mixes is effective.

Spring et al., 1980, Phytopathol. 70:1209-1212
Natural lysis (destruction) of *Phytophthora* sporangia in a composted bark potting mix
I. NATURAL SUPPRESSION

An example of how it is used in nurseries

- Aged Pine Bark 60 - 65%
- Composted Biosolids 8 - 12%
- Fibrous Sphagnum Peat 15%
- Silica Sand/Expanded Shale 5 - 10%
### Media Naturally Suppressive to Pythium and Phytophthora Root Rots

<table>
<thead>
<tr>
<th>Material</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aged Pine Bark</td>
<td>60 - 65%</td>
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Early days of natural root rot suppression.

Note skepticism in eyes of grower!
Seven-yr-old Taxus crop transplanted at 1-1.5 yr intervals to sustain natural suppression of root rot. Fungicides are not used in spite of its extreme susceptibility to Phytophthora root rot!
Natural Suppression formulation requirements:

**COMPOST**
- Fresh materials aggravate whereas composts suppress root rots; Stability must be \(< 0.5 \text{ mg CO}_2 \text{ g OM}^{-1} \text{ h}^{-1}\)
- \(\text{NH}_4\) content \(< 100 \text{ ppm}\)
- Salinity \(< 8-10 \text{ mmhos cm}^{-1}\)

**POTTING MIX**
- Incorporate compost at a rate that meets fertility and physical property requirements of potting mixes
- Moisture content \(> 50\% \text{ (w/w)}\) to enhance colonization by bacterial and fungal biocontrol agents so as to induce natural suppression
Phytophthora root rot disappeared as a problem in 1975 when composted hard wood bark media were introduced.

However: Rhizoctonia, Sclerotium, Phytophthora leaf blight and other foliar diseases caused major losses in years thereafter.

Can these diseases also be controlled by composts?

Phytophthora leaf blight and stem dieback of Rhododendron.
Factors Affecting Suppression of Plant Diseases with Composts

- Heat kill (Pathogens, Beneficial microorganisms, Weed Seeds, etc.)

- Organic Matter Decomposition Level (stability)
  - Fresh Materials - negative
  - Composted - positive
  - Pyrolyzed - negative

- Recolonization by microbes after peak heating

- Chemical and physical factors
Present Status: Compost-induced Plant Disease Suppression

I. General (Natural) Suppression
   (>90% of mature composts)
   - Phytophthora root rots
   - Pythium root rots

II. Specific suppression
   (20% of composts)
   - Rhizoctonia root roots

III. Induced systemic resistance
   (<2% of composts)
   - Foliar diseases
NATURAL (GENERAL) SUPPRESSION

Biological control due to interactions of many different microorganisms against one or more pathogens.

- Applies to pathogen propagules < 200 uM

- Sustained microbiostasis plays a key role

Examples: Pythium and Phytophthora root rots
General Suppression

- The concentration of microbial biomass and FDA activity best predict suppressiveness.

- NMR and IR spectra predict carrying capacity and species composition relative to biocontrol

Rhizoctonia web blight in a mix suppressive to Phytophthora root rot
Why was Rhizoctonia not suppressed in the mix that controlled Phytophthora?

- Rhizoctonia is a very common pathogen in soil that produces large 1-2 mm diameter structures.

- Such large pathogens are not suppressed by bacteria that control Phytophthora and commonly colonize composts after peak heating.

- Specific biocontrol agents that naturally suppress Rhizoctonia do not consistently colonize composts!

- Therefore, they must be introduced. T22 is the most widely used Trichoderma in this market.
Pathogens and most beneficial microorganisms are killed by natural heating during composting. Thus, biocontrol agents must colonize composts after peak heating to induce specific suppression.

Composts produced adjacent to forests have broad spectrum disease suppressive effects. However, composting sites are far from natural environments.

Thus, 98% of all composts are deficient in natural disease suppression.
III. Compost-Induced Systemic Resistance (ISR)

- Less than 2% of all types and batches of composts tested naturally induced ISR.

- Specific *Bacillus* strains and *Trichoderma* isolates are the most ISR-active microorganisms in composts.

Systemic control of Botrytis blight on Begonia

Horst et al., 2003 Phytopathology 93: S37
Systemic control of gray mold of Begonia cv Barbara provided Trichoderma hamatum 382 (T382).

<table>
<thead>
<tr>
<th>Potting Mix</th>
<th>Control Treatment</th>
<th>Disease Severity (AUDPC)</th>
<th>Salability</th>
</tr>
</thead>
<tbody>
<tr>
<td>peat</td>
<td>control</td>
<td>1137.3a</td>
<td>4.0a</td>
</tr>
<tr>
<td>peat</td>
<td>Chlorothalonil</td>
<td>451.6b</td>
<td>3.8a</td>
</tr>
<tr>
<td>peat</td>
<td>T382</td>
<td>285.6b</td>
<td>3.2b</td>
</tr>
<tr>
<td>SD compost (5%)</td>
<td>T382</td>
<td>160.4b</td>
<td>2.4c</td>
</tr>
</tbody>
</table>

Conclusion

- ISR induced by T382 is more effective in compost-amended than in peat potting mixes.

- The same has been reported for control of Fusarium crown rot of tomato and for Phytophthora blight of cucumber.

Can ISR be scaled up commercially?

- Rhodo Phytophthora blight: Yes/No
- Cyclamen Fusarium wilt: Yes
- Anthracnose on Euonymous: No

Phytophthora Blight of Rhododendron
T382
Natural Mix (Control)
Suppression of Phytophthora Dieback on Rhododendron cv English Roseum induced by Trichoderma hamatum 382

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Disease Severity (^a)</th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dieback (%)</td>
<td>Plants Killed (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>Std. Dev.</td>
<td>Mean</td>
<td>Std. Dev.</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>16.9</td>
<td>11.8</td>
<td>4.2</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>T382 (^b)</td>
<td>6.3</td>
<td>5.1</td>
<td>1.1</td>
<td>1.3</td>
<td></td>
</tr>
</tbody>
</table>

\(p = 0.05\)  \(p = 0.002\)

Control

Trichoderma (T382)

Fusarium wilt of Cyclamen
Fusarium wilt Suppression; Nutritional Impacts

• Low C/N composts negate the suppressive effects of Trichoderma against Fusarium wilts

• High C/N composts (>14) support suppression

• Mechanism: Ammonium to Nitrate N ratio
ISR Conclusions

- ISR active biocontrol agents must be inoculated into composts for consistent efficacy

- Substrate matters! (pyrolyzed composts do not support efficacy)

- Nutrition (N, etc.) affects efficacy.
Overall Conclusions

- **Formulation of disease suppressive products requires expert knowledge of compost quality!**
  
  - Biological control of root diseases with composts based on natural suppression is practiced widely.
  
  - Specific suppression requires inoculation.
  
  - Some foliar and vascular diseases controllable by ISR-active composts.
  
  - ISR still is a novel field of science.
Advise for Banana Diseases

• Grow new plants in suppressive ISR-active biocontrol agent-fortified plug mixes

• Use high C/N composts fortified with Trichoderma as mulches at planting of new crops