Production of Composts with Broad Spectrum Disease Suppressive Properties

Harry A.J. Hoitink

Professor Emeritus
Dept. of Plant Pathology
The Ohio State University, Wooster
TOPICS

- Fate of pathogens during composting
- Fate of biocontrol agents during composting, curing and utilization
- General Suppression (Phytophthora, Pythium, Thielaviopsis root rots)
- Specific Suppression:
  - 1) parasitism/predation (Rhizoctonia)
  - 2) systemic induced resistance (ISR)
- Potting mix formulation principles.
Suppression of Diseases with Composts

- **Root Diseases**: highly effective, practiced widely.

- **Foliar Diseases**: weak to strong results but significant effects are rare in commercial practice.
Weeds, insects and pathogens, but unfortunately most beneficial microorganisms also are destroyed by high temperature treatment during composting.
Fecal Pathogen Destruction During Composting

- Parasite egg sacs (*Ascaris*) are readily destroyed by self heating as are coliforms. However, coliforms may recolonize composts after peak heating unless their food base (soluble nutrients) has been destroyed during composting. Thus, stability apart from temperature/time relationships plays a major role in protection against coliforms!
Fate of Plant Pathogens

• Most plant pathogens are destroyed by heat exposure during composting. Heat resistant chlamydospores of *Fusarium* spp. may not during aerobic composting. However, these pathogens are destroyed if part of the process is anaerobic.....and this typically occurs during composting of vegetative crop residues.
Fate of Plant Pathogens cntd.

- TMV (tobacco mosaic virus) is not inactivated during composting. However, nematode vectors required for infection of roots with TMV are 1) killed during composting and 2) suppressed in compost-amended soils. Even so, be careful where composted vegetable wastes are utilized.
Fate of Plant Pathogens: References

Fate of Beneficial Microorganisms During Composting

• Most beneficial microorganisms (i.e. biocontrol agents, nitrifiers, mycorrhizae, etc.) are killed due to heat treatment (most do not survive temps > 37 C).

• Therefore, the microflora in most composts is similar to that in aerated steam-treated soil (Bacillus spores survive).
Succession of microorganisms during curing

- Composts produced near a forest on litter have 1) the greatest diversity of microorganisms and 2) the most broad spectrum plant disease suppressive effects.

- Most composting sites do not offer this diversity because curing piles are too large (temperatures too high for colonization by beneficial microorganisms).

- Long term curing in small windrows eventually allows many important organisms to colonize composts but this is not practical for most commercial operations.
Biocontrol Agents in Composts

- DNA analysis has confirmed that very few microorganisms introduced with composts into potting mixes or field soils become a part of the predominant microflora.

- Aerobic bacteria (Pseudomonas, Pantoea, Bacillus, Streptomyces spp.) establish peak populations during the first 48 hr after compost amendments. Until this time the substrate is conducive to diseases!
Biocontrol Agents in Composts

- Fungi such as *Trichoderma, Gliocladium* spp. etc. (the best fungal biocontrol agents), reach peak populations 5-14 days after amendment of substrates with compost.

- The best time to add biocontrol agent inoculants is immediately after the temperature of the organic matter in composts declines below 35 C (during mix preparation or potting of plants).

General Suppression

- Pathogens that produce small infective propagules (< 200 U diam.) are sensitive to microbiostasis (antibiotics).

- Microbiostasis prevails after compost-amended substrates have been fully colonized by beneficial microorganisms. This typically occurs naturally.

- This mechanism has a broad activity spectrum (Phytophthora and Pythium diseases, Coliforms, etc.)
Specific Suppression

- Applies to pathogens that produce large propagules (Botrytis, Sclerotium, Sclerotinia, Rhizoctonia, etc.) and to systemic control of diseases of above ground plant parts (ISR).

- Biocontrol of large pathogen propagules requires parasitism and this is based on many genes. ISR involves the activity of even more genes.
Specific Suppression (Rhizoctonia)

- Natural suppression of Rhizoctonia occurs in only 20% of compost-amended substrates. The rest are conducive.

- Compost-amended field soils often are more conducive to Rhizoctonia diseases than the control plots.
Rhizoctonia web blight in a commercial mix suppressive to Phytophthora root rot.
Why was Rhizoctonia not suppressed in the mix that controlled Phytophthora naturally?

- *Rhizoctonia* produces large 1-2 mm diameter structures (sclerotia). Few organisms can kill them!!

- Such large pathogens are not suppressed by bacteria that commonly colonize composts naturally and produce antibiotics to control *Phytophthora*. Parasitism is essential for control of *Rhizoctonia* and these organisms are more rare in compost environments.

- **Result:** Biocontrol agents (e.g. *Trichoderma*) that suppress Rhizoctonia must be inoculated into composts to suppress Rhizoctonia consistently!
Part 2. Control of Foliar Diseases with Composts

- Most composts do not protect above ground plant parts against diseases. Under high fertility (low C/N composts) foliar disease often is increased!

- Even so, several reports show foliar disease control after compost applications (powdery and downy mildew of grape).

- Recent literature shows that a low percentage of composts increases the resistance of plants to diseases.

- Question: Can this idea be scaled up commercially in agriculture?
Natural compost-induced systemic resistance in plants (ISR)

Most composts do not induce resistance naturally.
Compost-induced ISR

• Less than 2% of all types and batches of composts naturally induce ISR.

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

• Controlled inoculation with ISR-active biocontrol agents is essential for consistent systemic disease control.

ISR laboratory example; Botrytis blight of begonia

Conclusion: Compost improves ISR activity!

Horst et al., 2005 Plant Disease 89: 1195-1200.
Trichoderma as compost inoculant

T382  Control

Rhododendron Roseum Elegans
Phytophthora blight on rhododendron foliage
What is the mechanism that supports ISR?

- *Trichoderma hamatum* 382 increases the concentration of extensins and of 44 other proteins in tomato
- This biocontrol agent primes the plant to defend itself against disease.

ISR Conclusions

- Biocontrol agents must be inoculated into composts for consistent effects.
- Resistance in some plants cannot be activated and control in most plants is partial.
- Nutrition (N, etc.) probably affects efficacy.
Can ISR be scaled up commercially?

- Botrytis: Yes
- Powdery mildew: Yes
- Phytophthora blights: Yes/No
- Botryosphaeria on Myrica: Yes
- Cyclamen Fusarium wilt: Yes
- Anthracnose on Euonymous: No
- Cytospora?: Probably yes!

Hoitink et al, 2006 Phytopathology 96 (186-189).
Potting Mix Formulation Principles

- Use high quality composts that will be available on a consistent basis.
- Determine the maximum amendment rate for the compost based on its chemical and physical properties.
- Test this and lower volumetric amendment rates in plant growth bioassays suitable for the grower’s crops.
- Inoculate the best choices with an ISR-indicating biocontrol agent that also is capable of parasitism.
- Test best treatments in cropping cycles.
Typical Compost Amendment Rates (v/v ; %) in Floriculture (1-6 week crops)

- Light Spagnum peat ..........up to 100%
- Coir (coconut husks)......... up to 100%
- Composted pine bark.........up to 100%
- Composted rice hulls.........up to 100%
- Composted sewage sludge 0.5 - 2 kg m⁻³
Typical Compost Amendment Rates (v/v ; %) in Floriculture
(3-4 month crops)

Light Sphagnum peat..................up to 100%
Coconut husks..........................up to 100%
Composted pine bark..................30 - 50 %
Composted rice hulls..................30 – 50%

Composted pig, dairy manure....up to 5 %
Vermicomposts........................??????
Typical Compost Amendment Rates (v/v ; %) for Woody Plants (5-18 month crops*)

- Pine bark and or rice hulls .......... up to 90%
- Composted greenwastes ........... up to 25 %
- Sand/stone/expanded products ...... 5-10%

- Composted sewage sludges .......... 8-12 %
- Composted dairy, pig manures ........ 5-10%

* Repot at least before 18 months
Summary

• Composts can provide control of plant diseases.

• Some root diseases can be controlled rather easily but quality control is critical, others require controlled inoculants.

• Foliar diseases and stress diseases can be affected as well but inoculants must be used to improve efficacy.

• Fertility, salinity and soil physical factors as well as plant genotype play major roles in efficacy.

• Conclusion: biocontrol is an integrated type of disease control that requires lots of quality control.