Sustainable Soil-Borne Disease Management

Research at Kentucky State University

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Kentucky State University Organic Agriculture Working Group
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Brings together researchers, teachers, and extension agents whose work relates to organic agriculture.

Post Carbon Institute
Reduce Consumption: Produce Locally
Types of Soil-Borne Diseases

- **Phytophthora**
- **Fusarium**
- **Aspergillus**
- **Sclerotinia**
Soil-Borne Diseases

Susceptible Host

Disease-causing Pathogen

Favorable Environment

Disease Outbreak!
Soil-borne Disease Management

- Decrease Host Susceptibility
  - Control of Pathogen
  - Manage Environment
  - Disease Control

Control of Pathogen
- Resistant Varieties
- Crop Rotation
- Inter-Planting
- Induced Resistance

Manage Environment
- Fumigants and Fungicides
- Control of Pathogen
- Proper Seeding and Spacing
- Proper Irrigation
- Early/Late Plantings

Disease Control
- Fungicides (copper), Biofumigation, Solarization
- Crop Rotation
- Disease-Suppressive Soil
- Sanitation
- Ventilation and wind flow
Soil-borne Disease Management
Decrease Host Susceptibility

“Induced Resistance”
“Soil-Borne Diseases Result from a reduction of biodiversity of soil organisms.”

A TEASPOON of native grassland soil contains:

• 600-800 million individual bacteria of 10,000 species
• Miles of fungi of 5,000 species
• 20-30 nematodes of 100 species
• 10,000 individual protozoa of 100 species

Source: [www.attra.org](http://www.attra.org)

Publication: “Sustainable Management of Soil-Borne Diseases”
Soil-borne Disease Management

Control of Pathogen

“A Disease-Suppressive Soil”

A Disease-Suppressive Soil has:

• A biodiversity of soil microbes
• Large populations of active microbes (“active carbon”)
• Good drainage and texture

• Pathogens cannot become established
• Pathogens get established but produce no disease
• Disease is produced for a short time and then declines

Direct Parasitism

Competition

Induced Resistance

Direct Inhibition by Secretions
“Wow, SOUNDS great...but what about REALITY?”
Research at Kentucky State University

• Evaluation of control strategies for *S. sclerotiorum*.
  • Soil Solarization and Biofumigation
  • Strategies suitable for high tunnel systems in Kentucky.
  • Follow National Organic Program guidelines.
Sclerotinia sclerotiorum  “White Mold”
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*Sclerotinia sclerotiorum*

Large reproductive bodies RESIST “disease-suppressing soils”.
Sclerotinia sclerotiorum  “White Mold”
SOIL SOLARIZATION

Clear plastic is used to raise soil temperatures and kill pests and/or weeds.
SOIL SOLARIZATION

Things to consider:

• Day length.
• Tillage/Soil preparation.
• Soil structure: large clumps can create pockets that do not heat up.
• Soil moisture: wet soil conducts heat quickly and uniformly.
• Soil moisture: dry seeds resist heat better than wet seeds.
• Sanitation: remember field edges and pathways.
• What about my beneficial soil microbes?
SOIL SOLARIZATION

Research: Evaluating the effect of solarization on *Sclerotinia sclerotiorum*
SOIL SOLARIZATION

• Forty sclerotia placed in each “bag”.

• Treatments: solarized plots and control plots.

• Soil depth: bags buried at 0, 5, 10, and 15 cm in each plot.

• Bags solarized for 2, 4, and 6 week periods.
SOIL SOLARIZATION

- Treated sclerotia put in petri dishes with sterilized soil.
- Plates incubated at optimal temperature and light for sclerotia germination.
- Counts of germinated sclerotia recorded.
Number of Germinating Sclerotia (of 40) after 6 Weeks in the Soil
SOIL SOLARIZATION

Our Results:

• Effectively decreased the number of live sclerotia (of S. sclerotiorum).

• Effectiveness of solarization decreases with depth.

• Effect was reached after 4 weeks of solarization.

• Effectiveness depends on temperatures achieved.

• Soil samples will reveal “active carbon” lost to solarization.
BIOFUMIGATION

Uses a natural defense mechanism of Brassica plants to decrease pest populations in the soil.
BIOFUMIGATION

• Cover crop of mustards at flowering stage maximizes biomass and glucosinolate content.
  • Thorough chopping releases more isothiocyanates.
    • Immediate incorporation into soil.
      • Adequate moisture to retain isothiocyanates.
BIOFUMIGATION

Research Questions/Objectives:

• What are the best mustards for biofumigation?

• How susceptible is *S. sclerotiorum* to glucosinolates?

• How much biomass is needed to release the amount of glucosinolates that will control *S. sclerotiorum*?

• What cultural practices can release this amount of glucosinolates into the soil?

• Can we grow mustards in the field, and bring chopped mustards into high tunnel for biofumigation?
What are the best mustards for biofumigation?

• Which mustards produce a lot of biomass in our climate?

• Which mustards have high levels of glucosinolates?

• “Pacific Gold”

*Late winter plantings in the high tunnel.*
How susceptible is *S. sclerotiorum* to glucosinolates?

*Working with isolated glucosinolates...*

• What rate of biofumigation has been successful with other diseases? (Grams of glucosinolates per Petri dish)

• Tested this rate at 2, 1, 0.5, 0.25, and 0X on Petri dishes of *S. sclerotiorum*.

• Found that a the rate (1X) was effective at suppressing sclerotia germination.

• Translated this “lab” rate (glucosinolates per petri dish) to a “field” rate (grams of biomass per square meter of soil) for use in later field studies.
Germination of *S. sclerotiorum* After Exposure to Glucosinolate Concentrations

**Accession**

**Exposure**

- 0
- 0.125
- 0.25
- 0.5
- 1

**Average of 1/30/08 Count**

- 0
- 0.5
- 1
- 1.5
- 2
- 2.5
- 3
- 3.5
- 4
- 4.5
- 5
- 5.5
- 6
- 6.5
- 7
- 7.5
- 8
- 8.5
- 9
- 9.5
- 10
- 10.5
- 11
- 11.5
- 12
- 12.5
- 13
- 13.5
- 14
- 14.5
- 15
- 15.5
- 16
Oospore Germination of *P. capsici* After Exposure to Glucosinolate Concentrations
What cultural practices can release this amount of glucosinolates into the soil?
Remaining questions:

• *What is the effect of growing a cover crop of mustards inside a high tunnel on S. sclerotiorum?*

• *How does this compare to a cover crop that does not produce glucosinolates?*

• *Silly researchers…? Do mesh bags protect sclerotia from biofumigation?*
BIOFUMIGATION

• Glucosinolate extracts kill *S. sclerotiorum* in the lab, but we do not know if/how glucosinolates are effective in the field.

• Disease suppression following a biofumigant crop could be due to higher levels of organic matter, glucosinolate breakdown (biofumigation), other factors involved with mustard growth/decomposition, or some combination of these.

• Pacific Gold and other mustards are strong cover crops, with large biomass and pollen production, which can be integrated into a whole-farm pest management approach.
BIOFUMIGANTS

When used as a cover crop, potential benefits include:

• Reduction in soil-dwelling pest populations following exposure to glucosinolates.

• Increase in soil organic matter.

• Beneficial insect habitat and pollen/nectar source.