Alternative Management Tactics for Combating Soilborne *Phytophthora* Diseases

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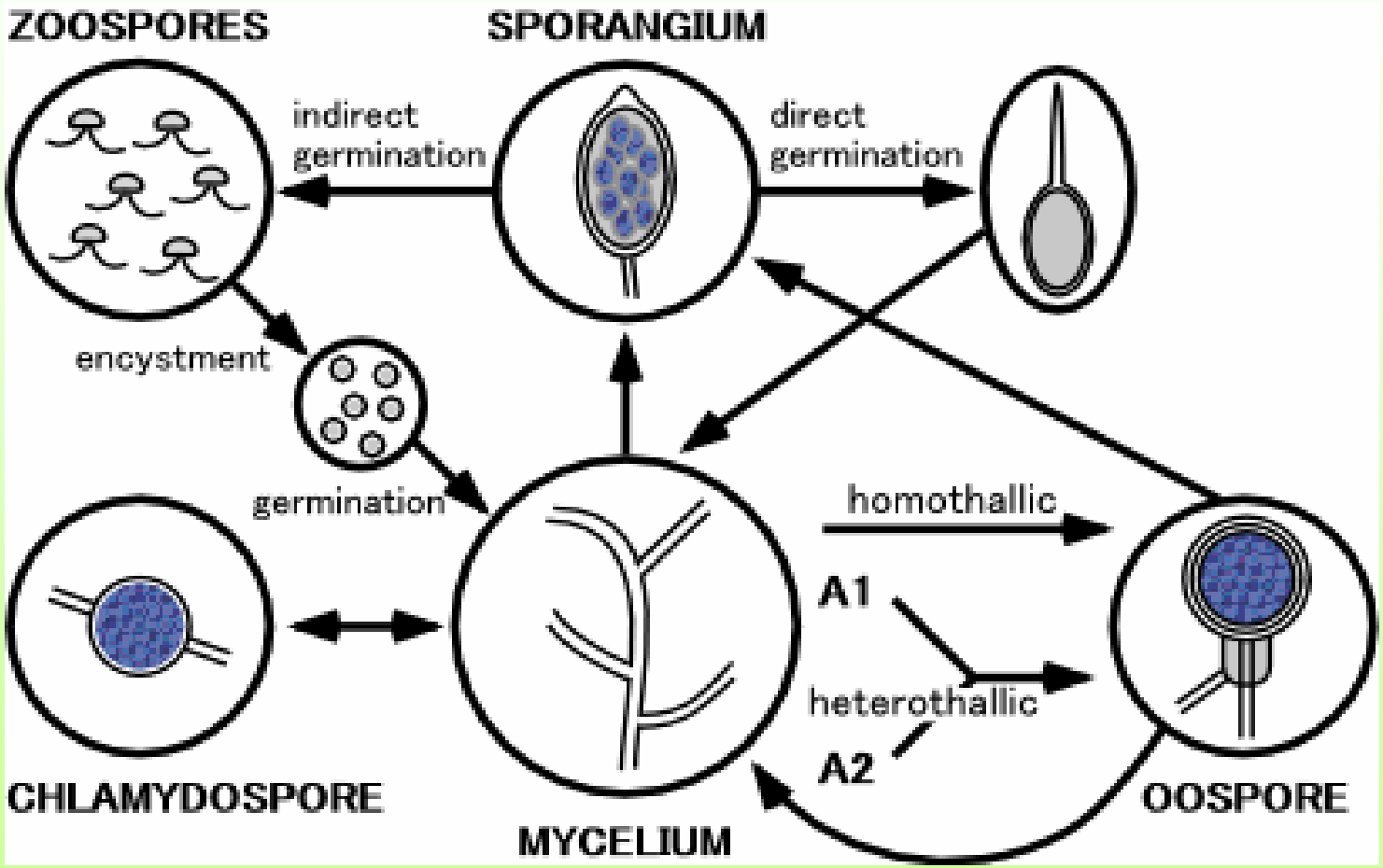
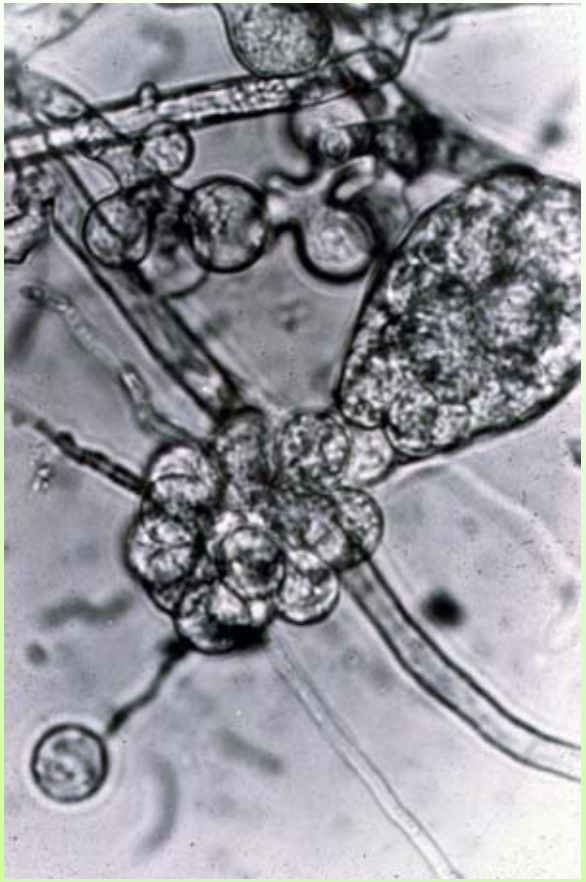
Avocado Root Rot

Phytophthora: symptoms

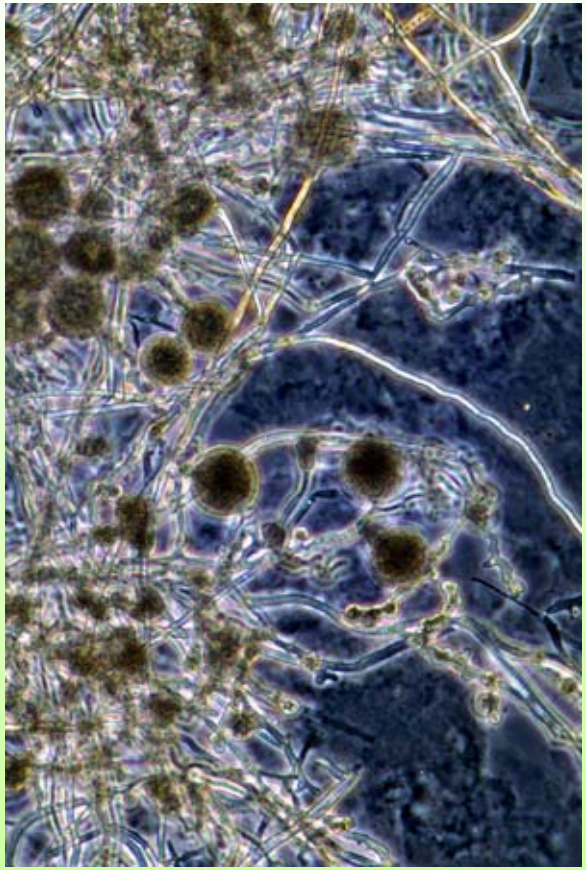
Generalized Phytophthora Life History



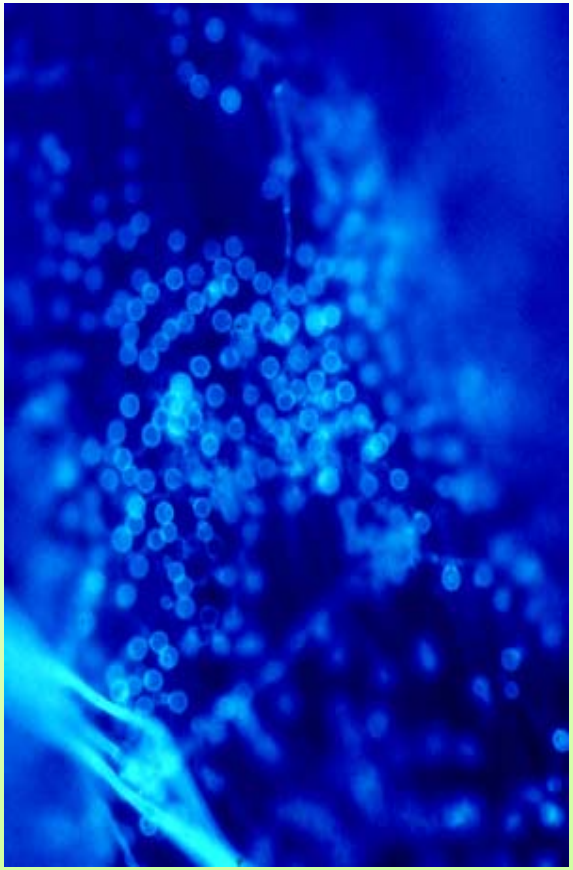
Phytophthora spore stages



Zoosporangia/spores



Chlamydospores



Zoospore cysts

Phytophthora Life History:where to attack the organism?

	concern
• Mycelium: coenocytic	+
• Spore walls: thickened, soil longevity	
chlamydospore	++
oospore	+++
• Cyst wall: High cellulose content	+++
• Zoosporangia:direct germination or…	+++
• Zoospore: naked protoplasts, ie no cell wall	++++

Some methods for control

- Biological Control
  - Mulch
  - Compost/Amendments
    - Tillage
- Calcium based Control
- Silicon
- Cultural Controls
- Phosphorus acids
- Mycorrhizae

Effects of organic mulches

- An attempt to explain the “Ashburner” system for mulching systems in California Avocado orchards
- The system suggests an enzymatic approach to control of the *P. cinnamomi.*
- Various glucanases are now know as defense eliciting proteins.
  - *Downer et al., 2001 Phytopathology 91:839-846. & 847-855.*

Mulch Transect Studies

Surface of mulch

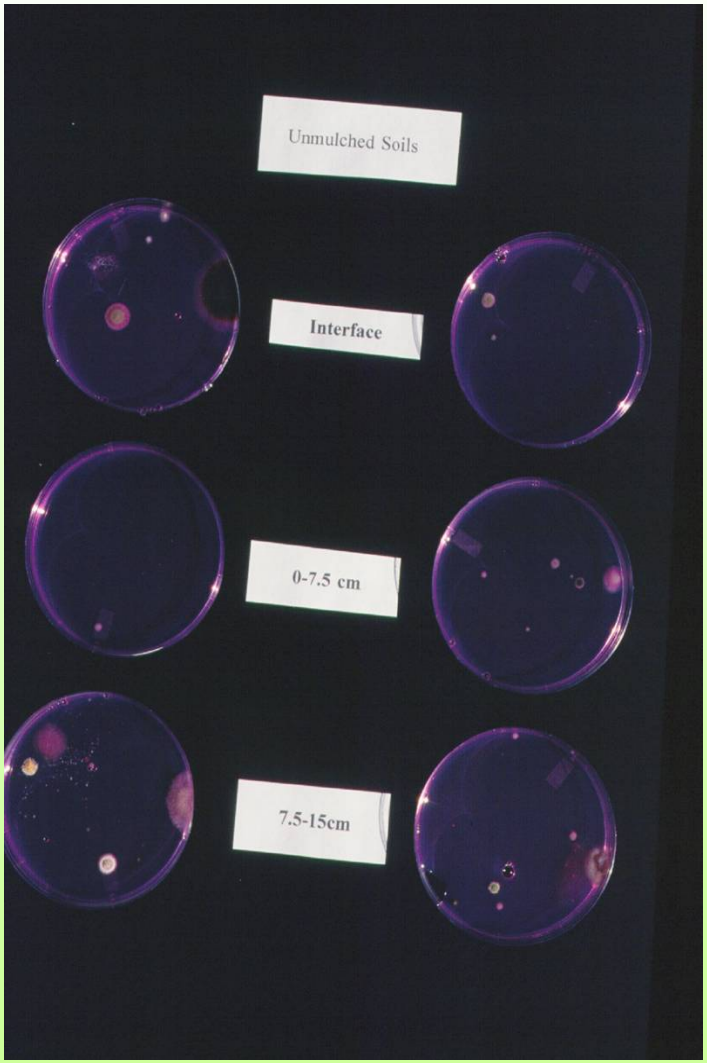
Mid mulch

Interface

0-7.5 cm

7.5-15cm

Soil Fungi



Log CFU

35ab

4.1d 45a

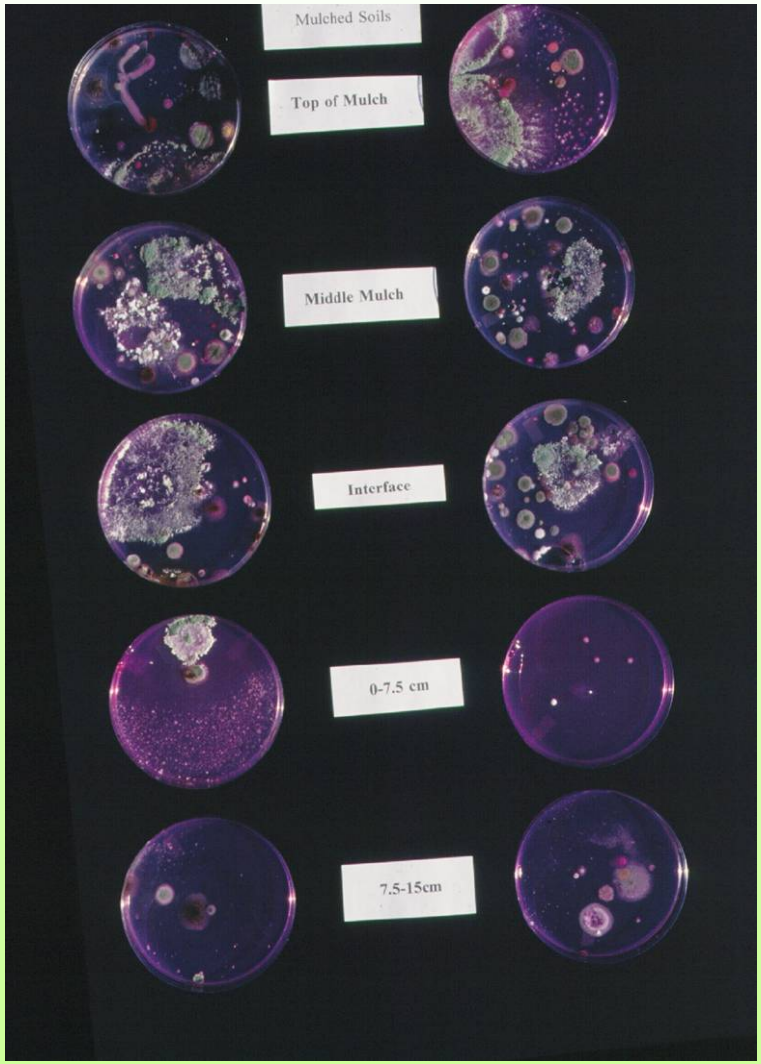
27bc

2.9d

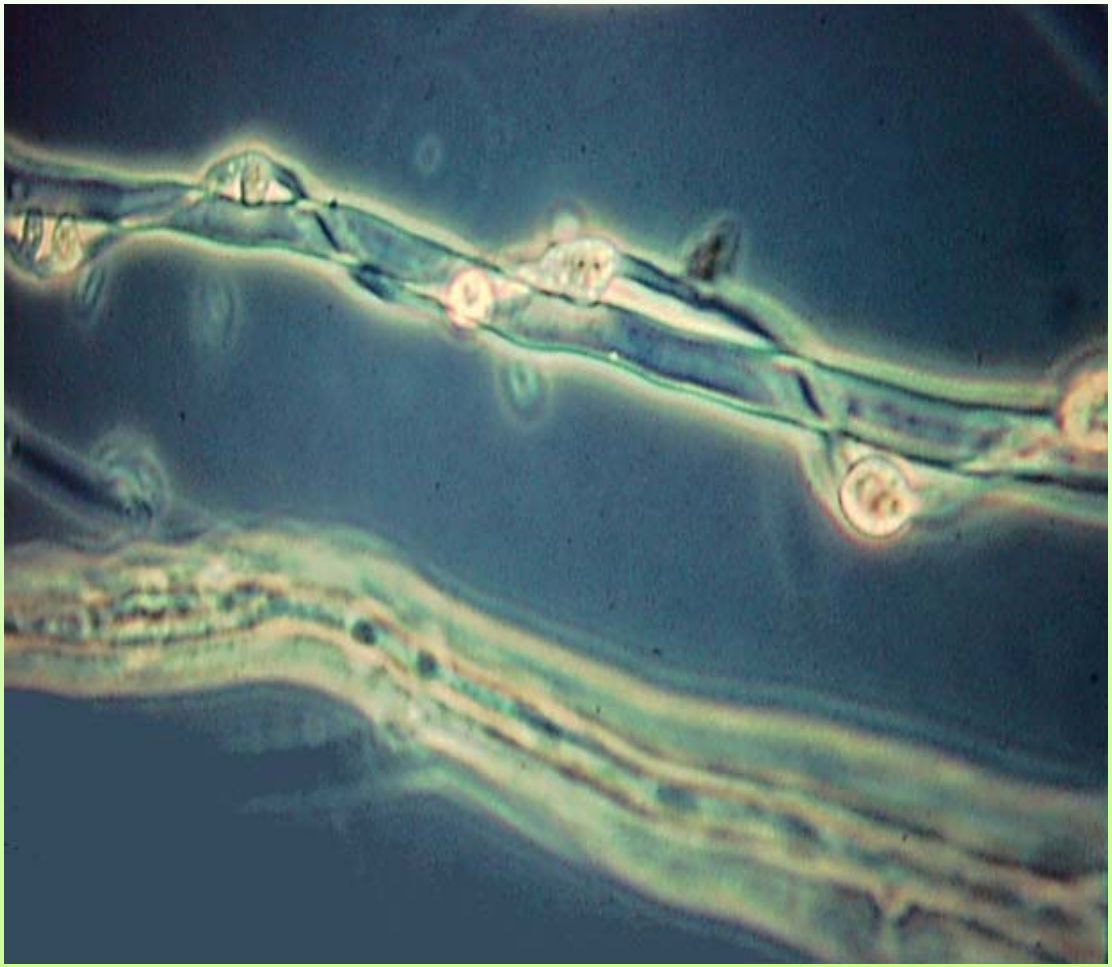
10cd

3.4d

6.4d



- Many mulch fungi are hyperparasites.
- *Trichoderma, Gliocladium, Penicillium etc.*



Roots

- Trees produce abundant roots in mulch layers
- These roots are generally free of *Phytophthora*.
- Mulch layers are where cellulase enzyme systems are most concentrated.

Organisms seen in Mulches

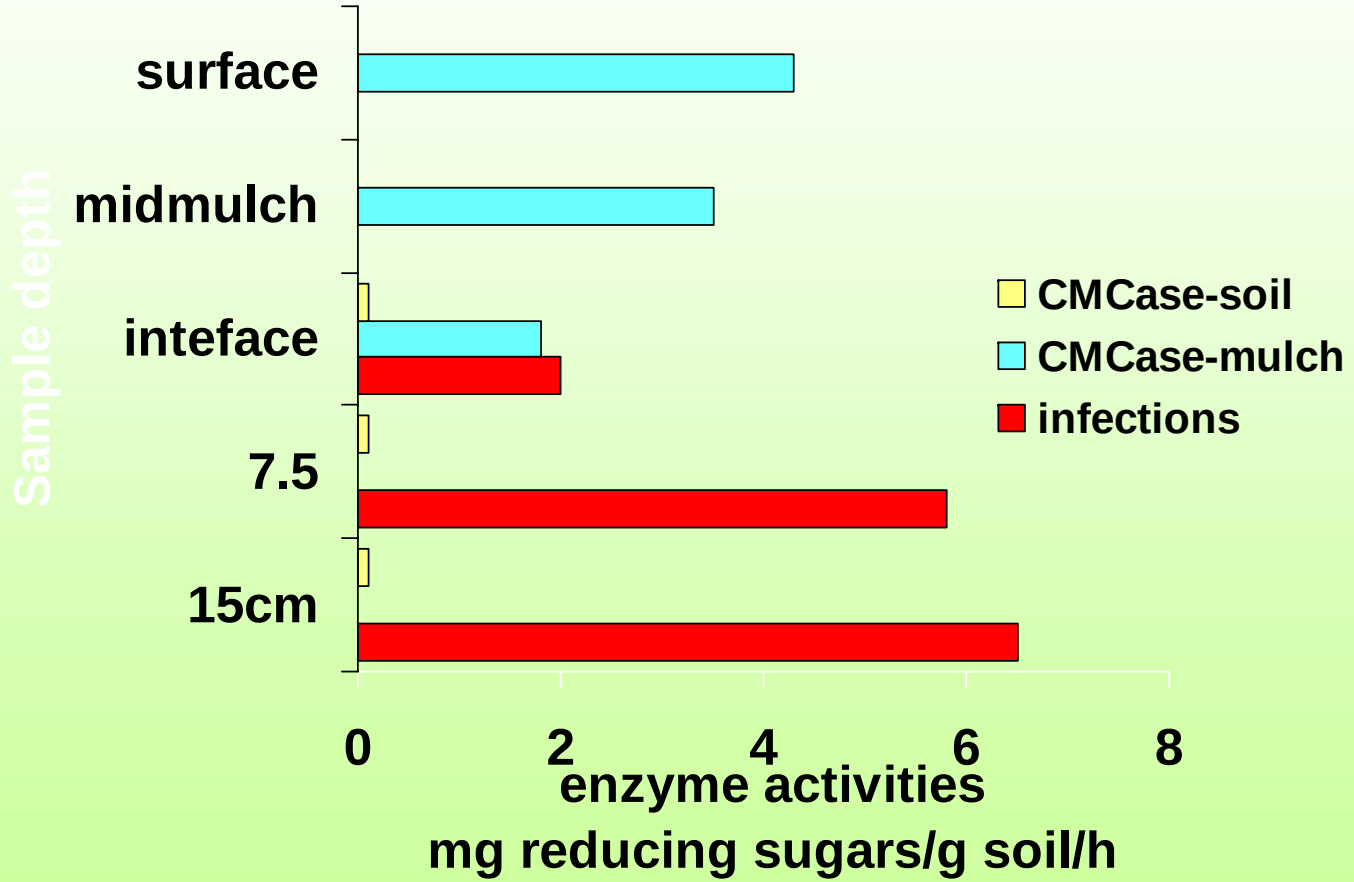
Deutermycotina
abundant spores
Basidiomycotina
abundant biomass

Phanerochaete chrysorhiza

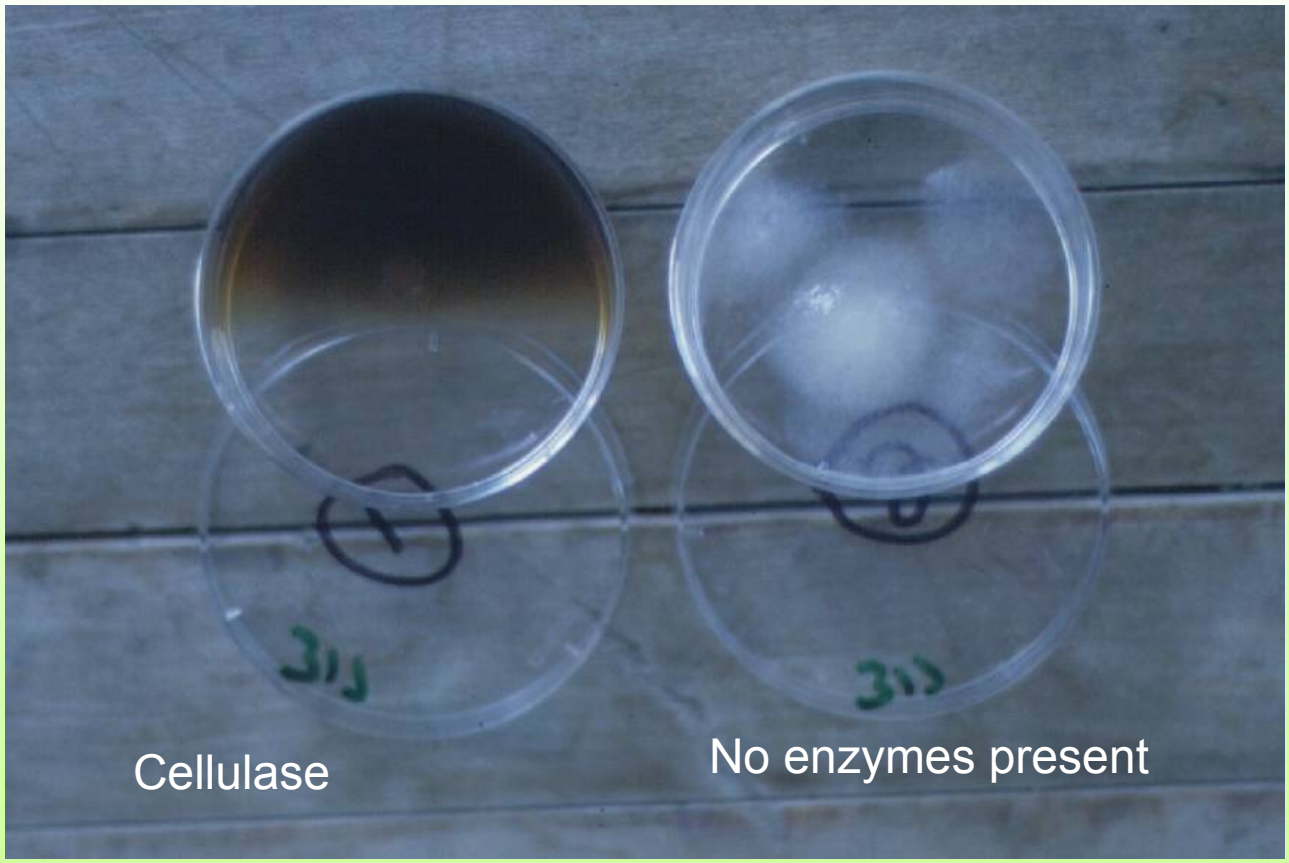
Ceraceomyces tessulatus

Mulch full of fungi

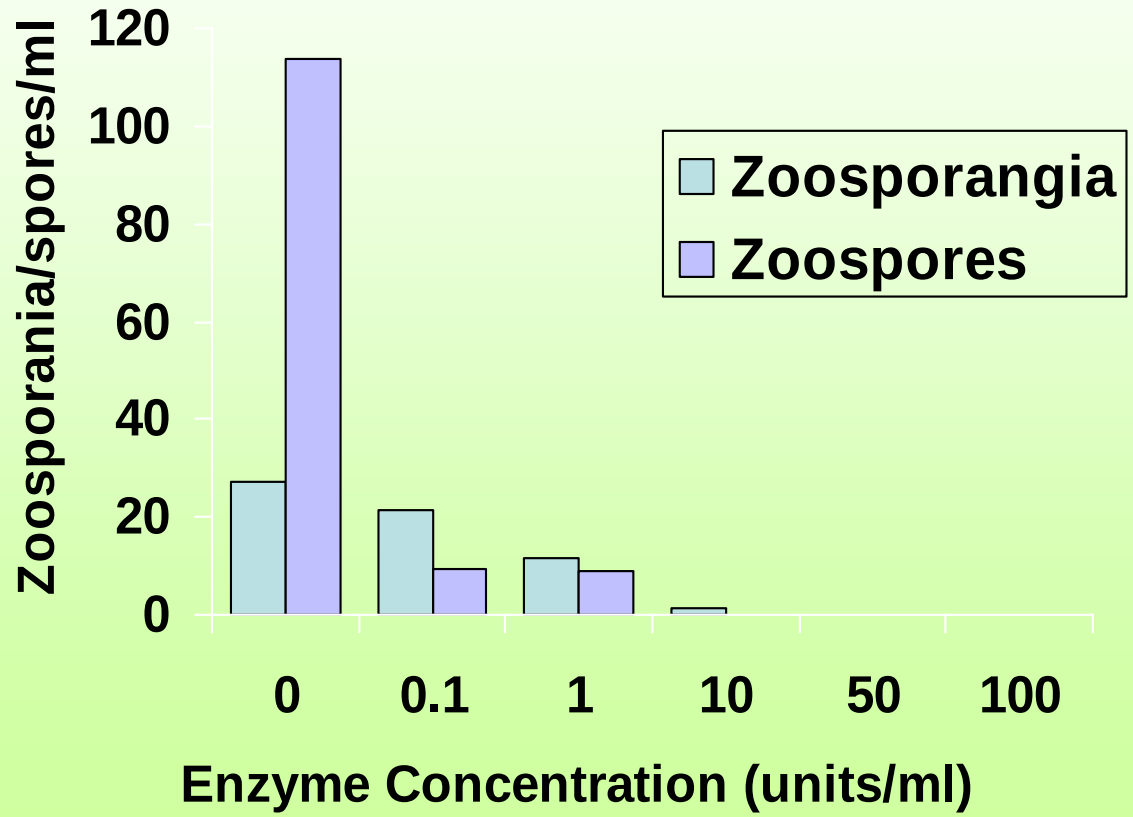
Enzyme activities in transect profile



Enzyme meltdown



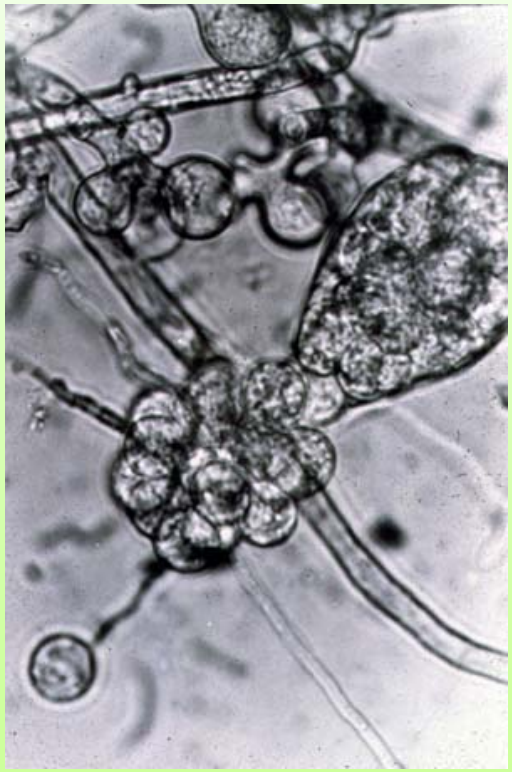
Cellulase effects on Zoosporangia/spore production

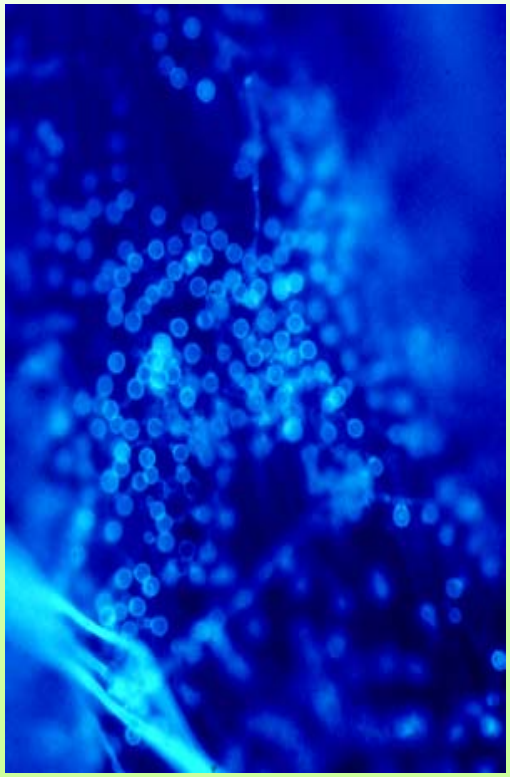


Obvious difference significant according to Tukey's HSD P = .05

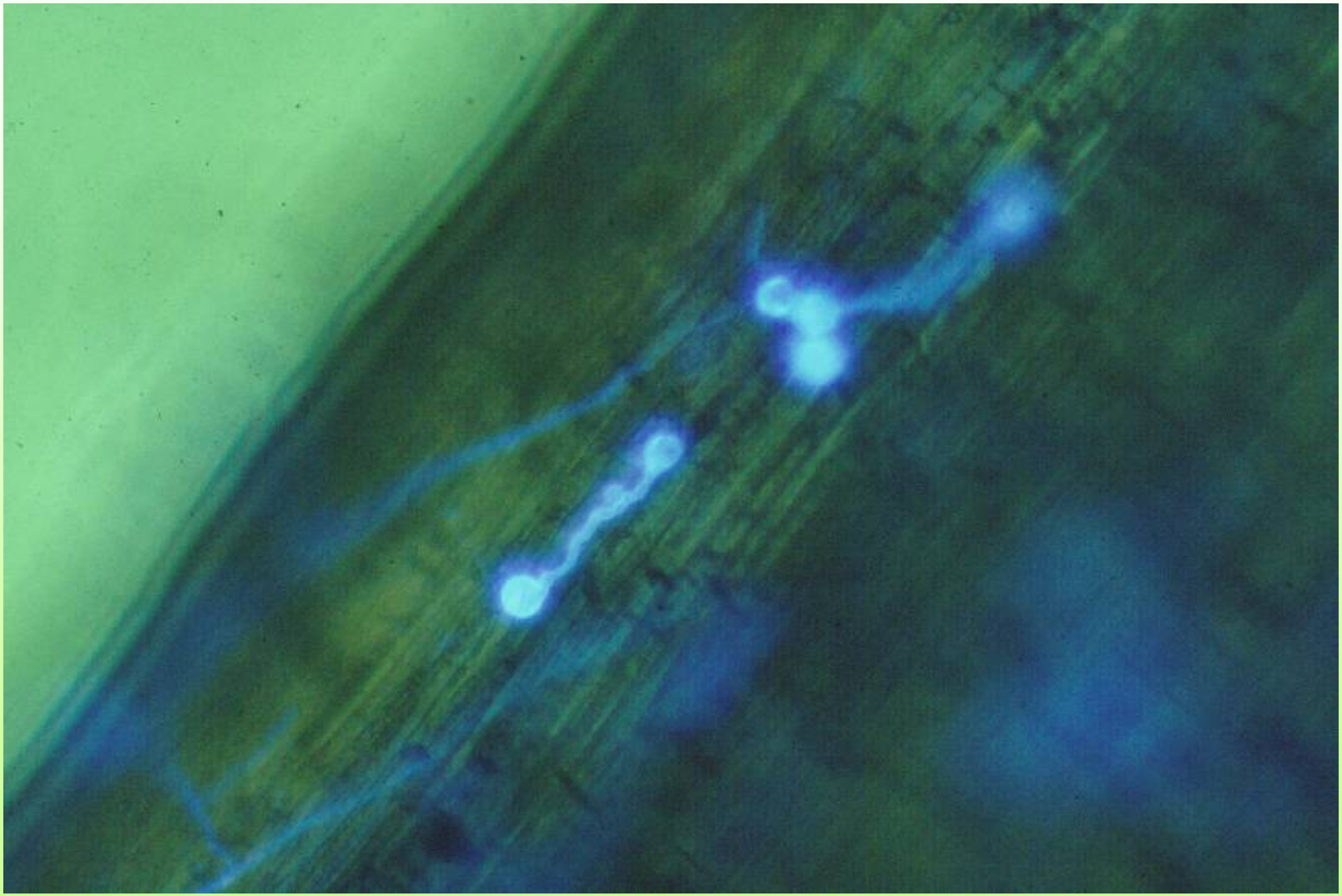
Zoospores → Cysts

- Zoospores will encyst on roots in the zone of elongation “en masse”

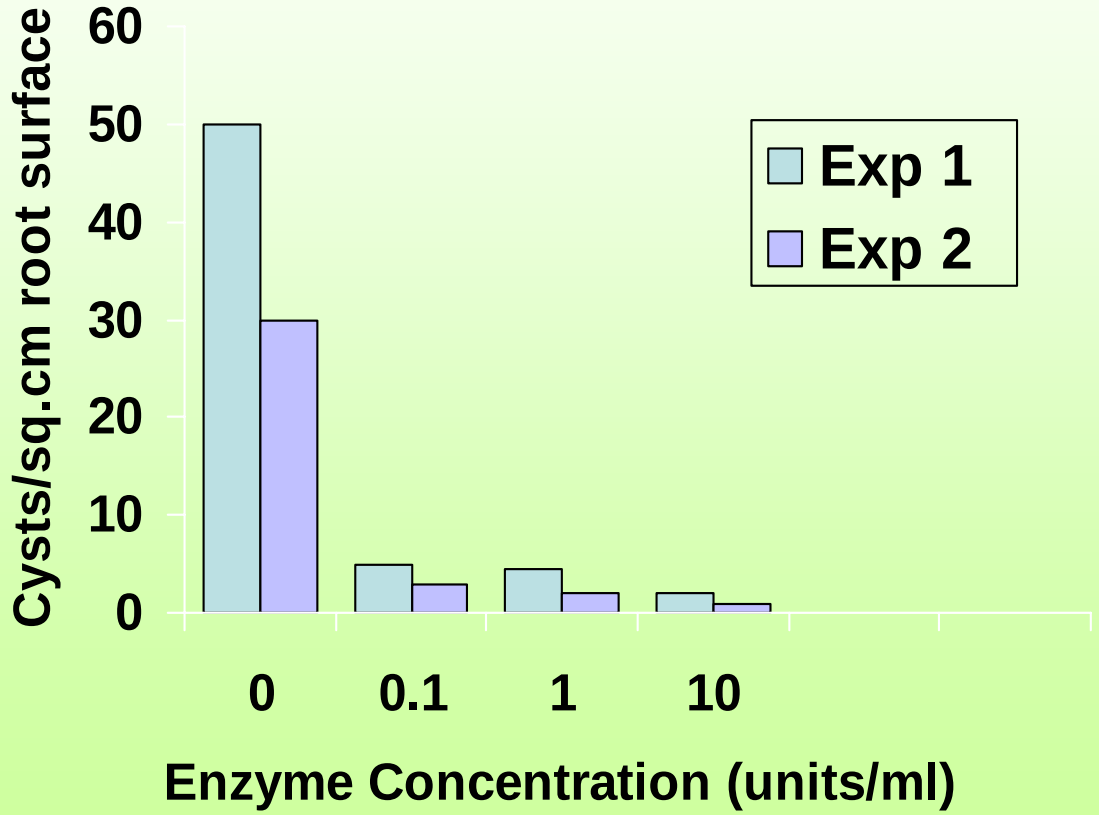




Cysts germinate and then infect after penetration of the root



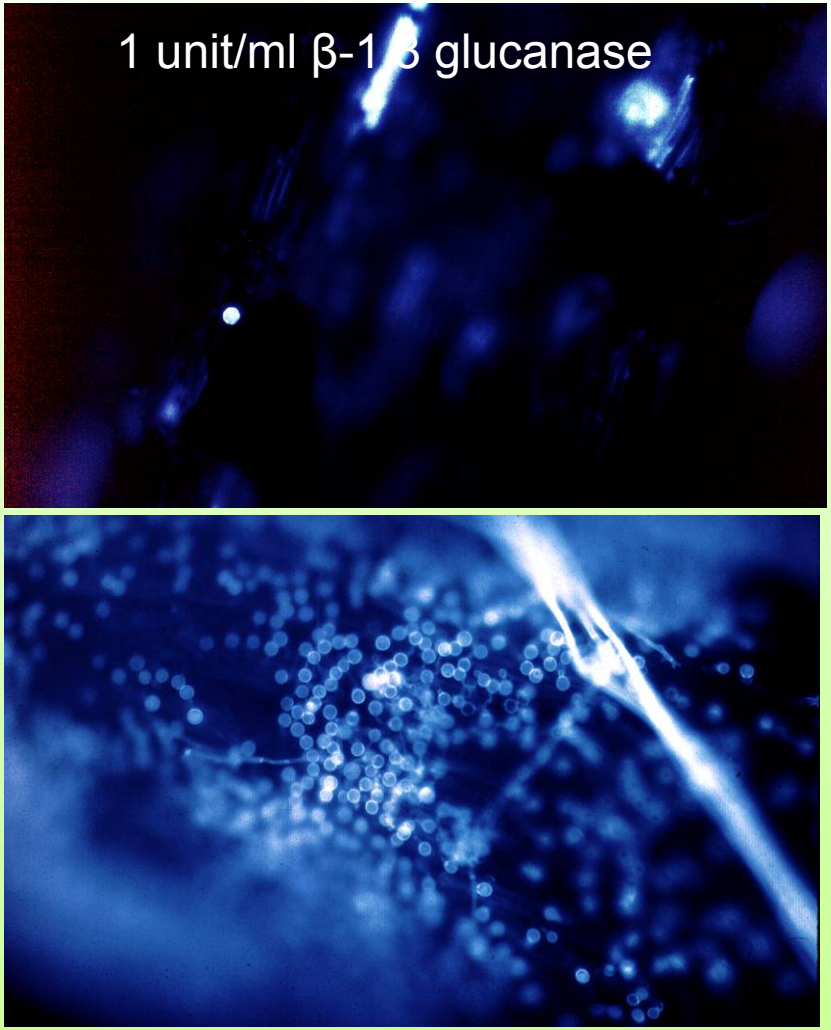
β-1,3 glucanase effects on encystment on excised roots



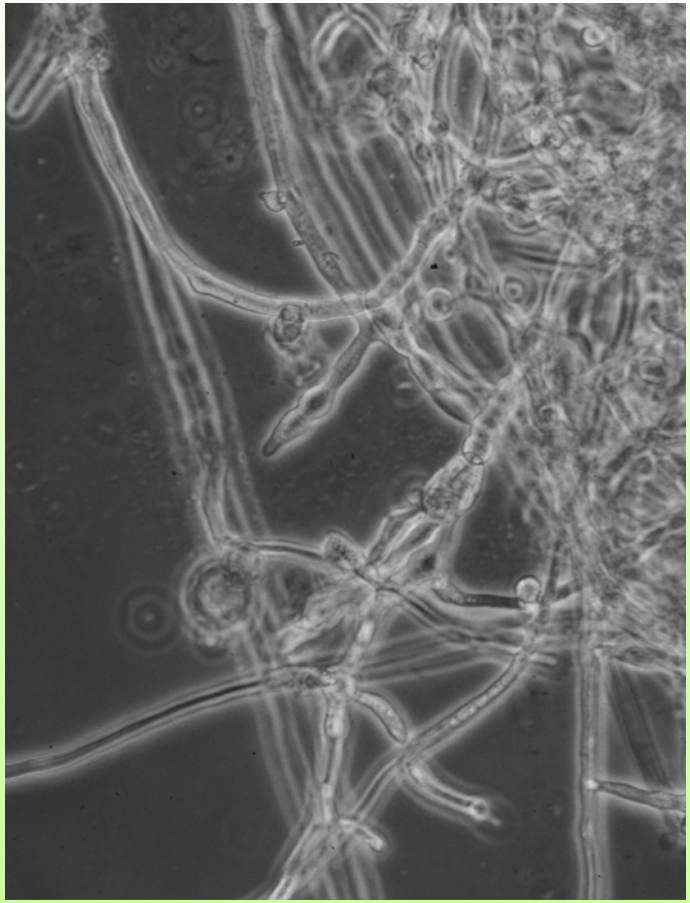
Zoospore encystment

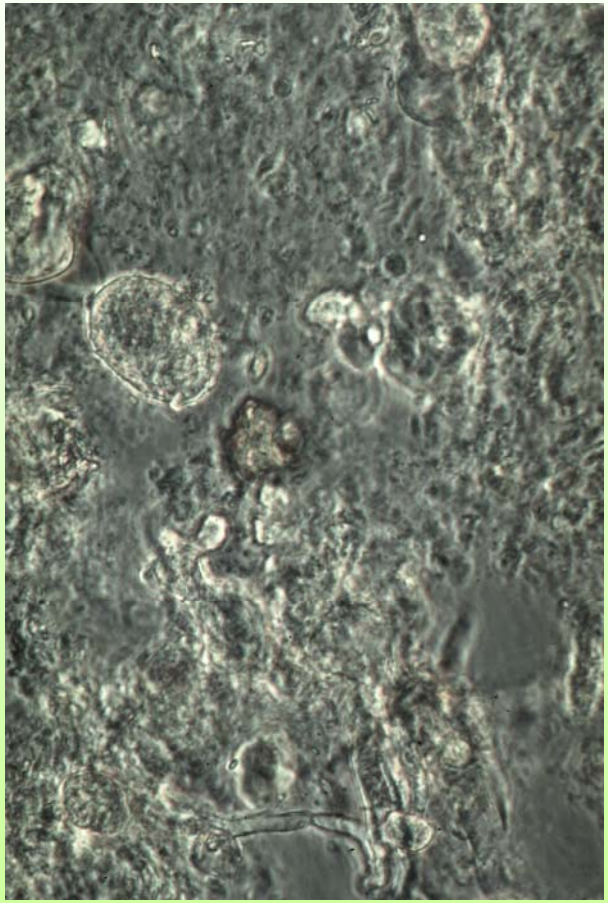
High glucanase levels prevent zoospore encystment on roots.

Encystment must occur on roots for an infection to occur.



Enzymatic degradation of *P. cinnamomi*





Mulch effects

- Mulches provide the fungi necessary to create an environment destructive to *Phytophthora*.
- This is due to both biological control via hyperparasites and enzymatic degradation of the the pathogen in the mulch layers.

Compost effects on Disease suppression

- Amendments
- Bedding plants as a model system
- Found wherever color plants are planted continuously.
- Fungal and nematode pathogens are predominant.

Bedding Plant diseases in composts

- Treatments
  - No amendment
  - Sand
  - Yardwaste fresh
  - Yardwaste composted

Amendment Plots

compost

fresh yardwaste

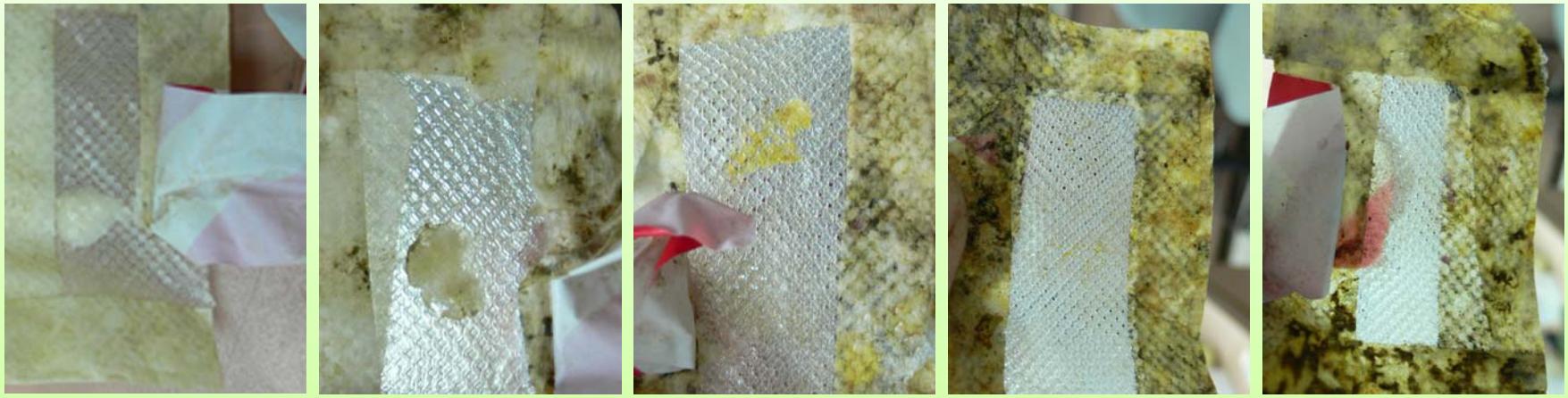
sand

unamended

Buried inoculum study

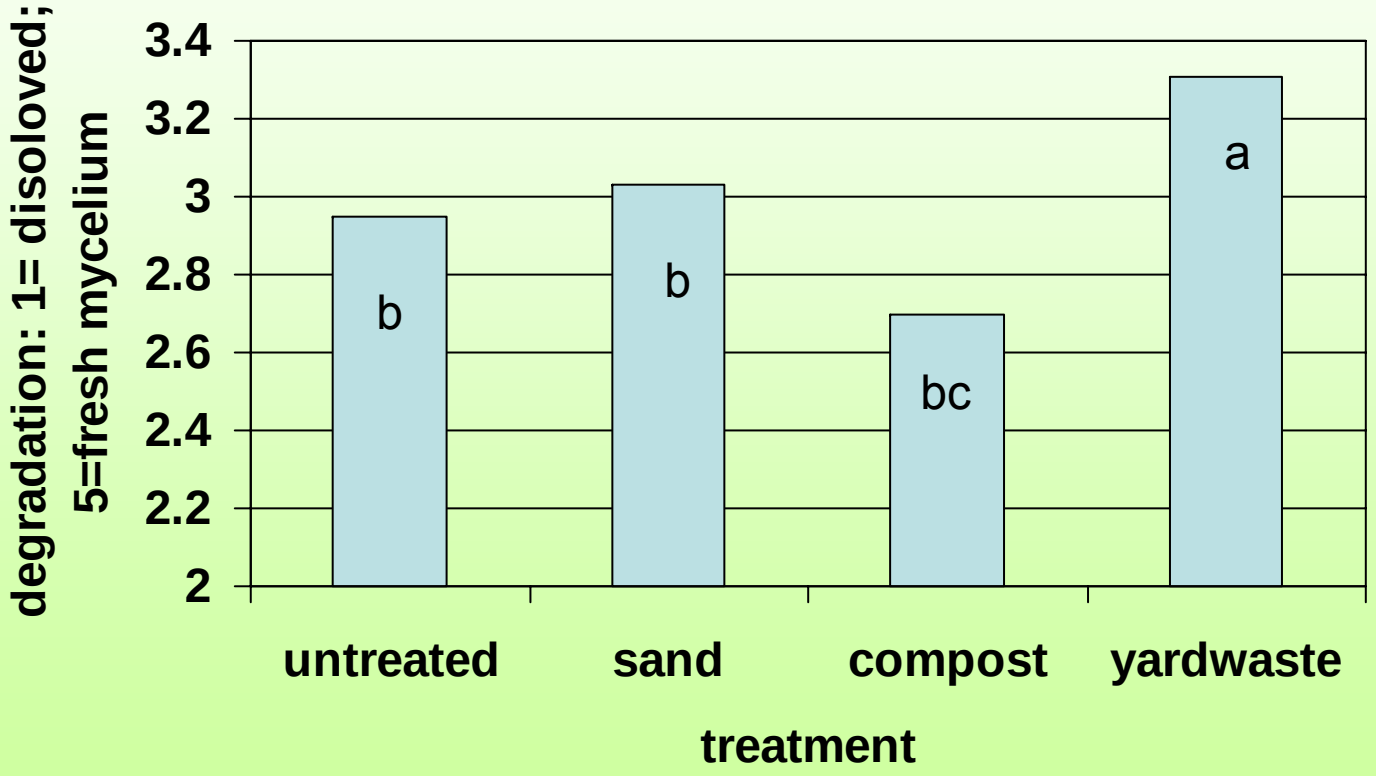
Mycelium Integrity Rating Scale

5 4 3 2 1

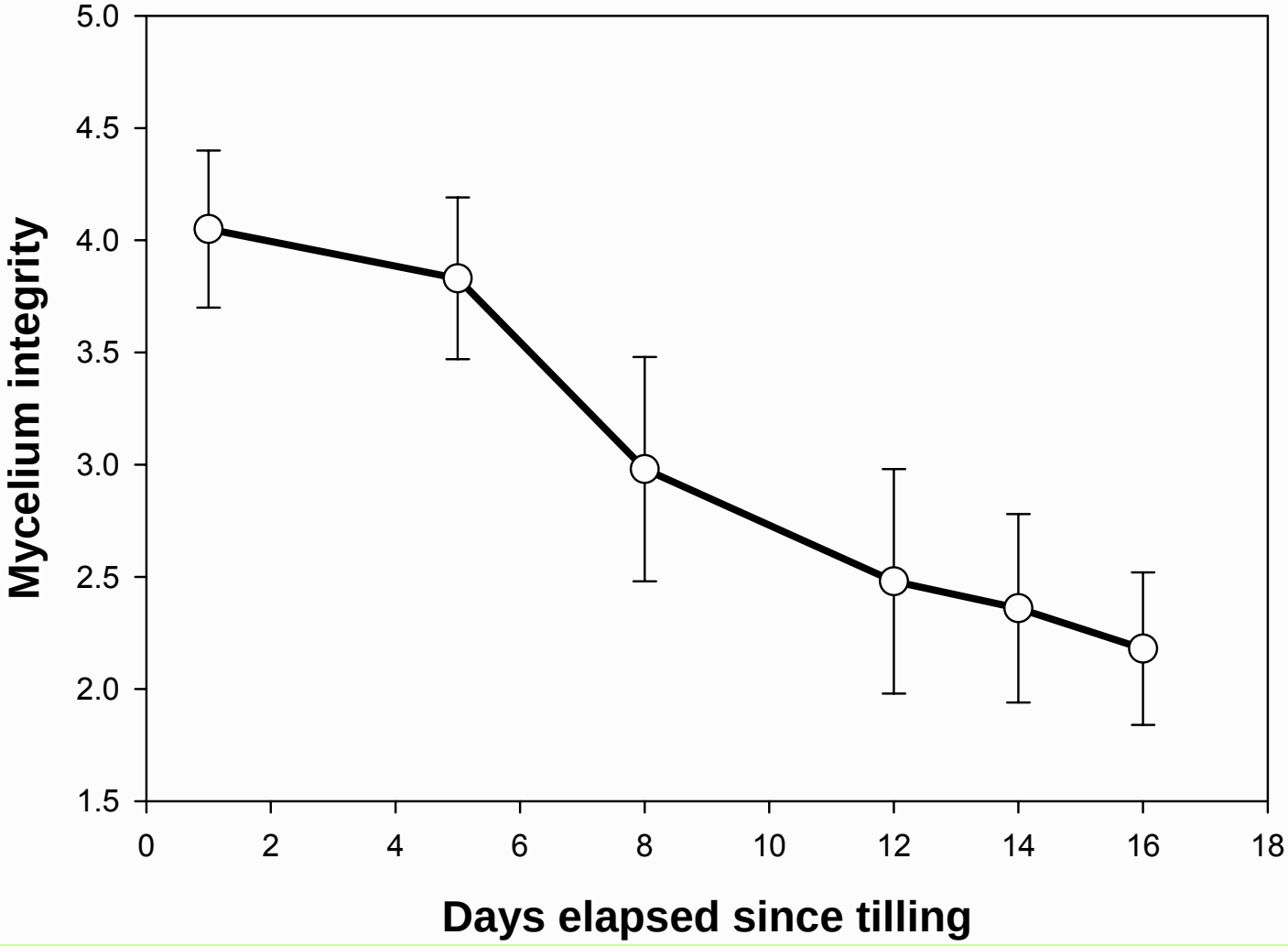


Mycelium integrity rating scale

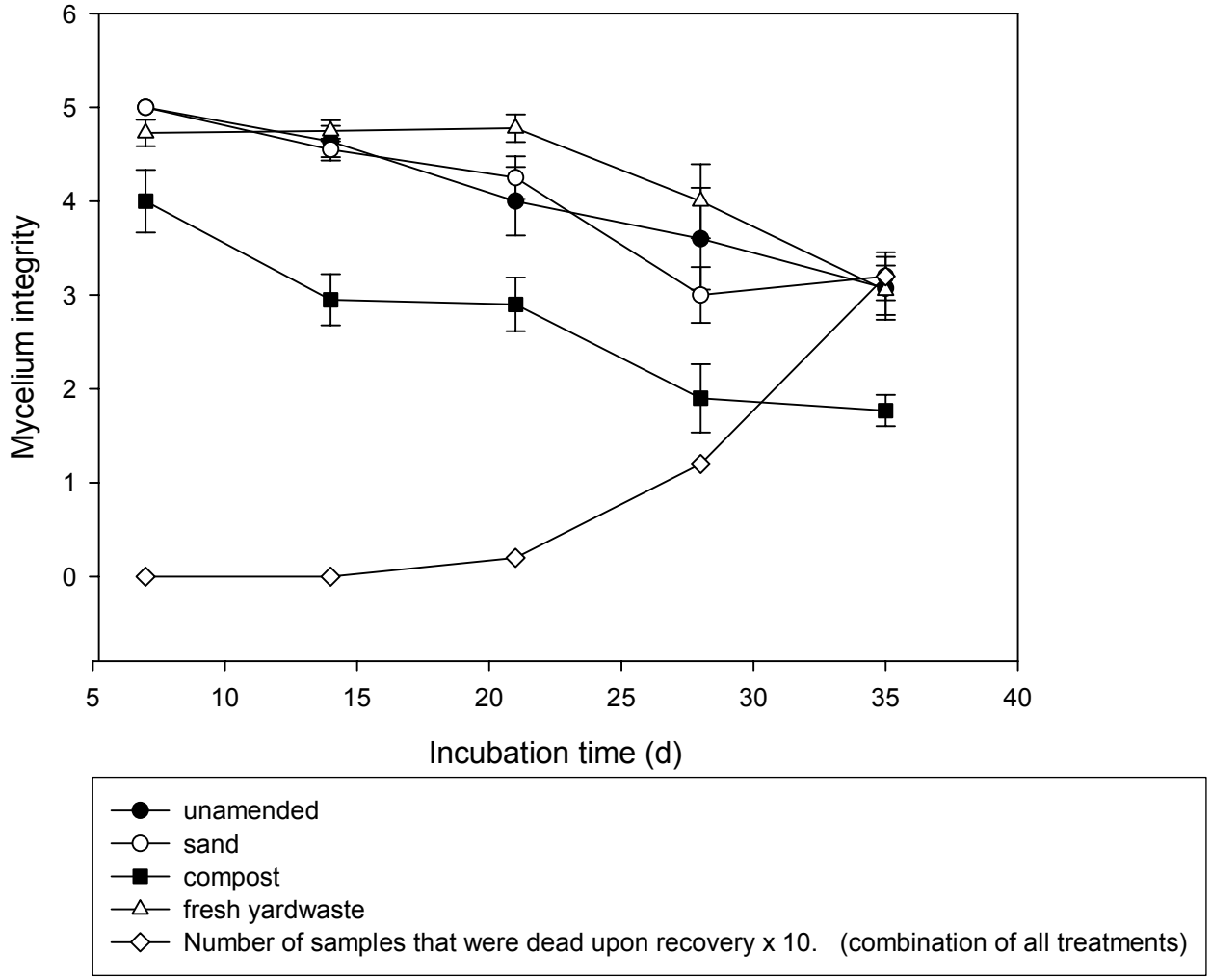
Degradation of *P. cinnamomi* in amended soils



Degradation of *Phytophthora cinnamomi* mycelium associated with time after rototilling



Mycelial integrity of *P. cinnamomi* in various soil amendments over time

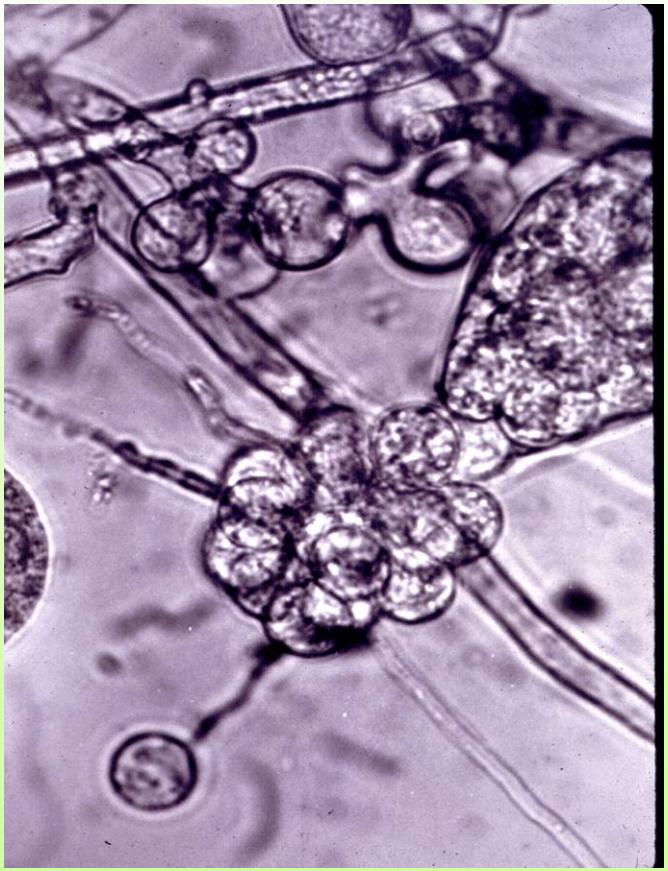


Mycelium integrity: 1= completly dissolved, no sign of mycelium left in envelope; 2 = Mycelium degraded into bits and pieces, you have to scrape it up to pick it up; 3=mycelium degraded on the edges, discolored, mushy; 4=minimaldegradation, discoloration, firm texture; 5= no evidence of degradation, mycelium not mushy, no discoloration, firm texture

Calcium control

- Calcium supplied as gypsum
- Applied to young trees at 15#/tree annually.
- Gypsum applied as a mulch and leached into the soil profile or over organic wood chip mulches.

Zoospore motility



Calcium at 1µM concentrations reduces the ability of the zoospores to swim uni-directionally. Disrupted swimming patterns prevent the spores from finding host roots.

Messenger et al., 1996 Plant Disease

Gypsum Mulches

Provide a slow release Ca^{++} source

Will not harm avocado roots

Will harm *Phytophthora* propagules.

Provides control equivalent to fungicides in some cases

Silicon

- A phytoalexin elicitor
  - *Fawe et al., 1998. Phytopathology 88:396-401*
- For root rot control (*Pythium*) seems to require either continuous or multiple applications as a preventative material
  - *Heine et al.,2007. J. Exp. Botany 58:569-577.*
- *Trees drenched with soluble Silicon before inoculation with P. cinnamomi had greater root dry weights*
  - *Bekker et al., 2005. So. African Avo. Yrbk 28:60-64.*
- *Suppression of disease better than with phosphonates*
  - *Bekker et al., 2007. Procs of VI World Avo Congress, Vista Del Mar, Chile*
- *Silicon amended potting soils led to the production of chitinase and glucanase defense proteins*
  - *Dan and Muir, 2002. Aus. Plant Path 31:9-13*

Phosphorus Acids

- Phosphorus acids are popular “fertilizers” that also control root rot in many cropping and ornamental plant growing areas
- Are they all alike?
- How do they compare to Aliette for root rot control?

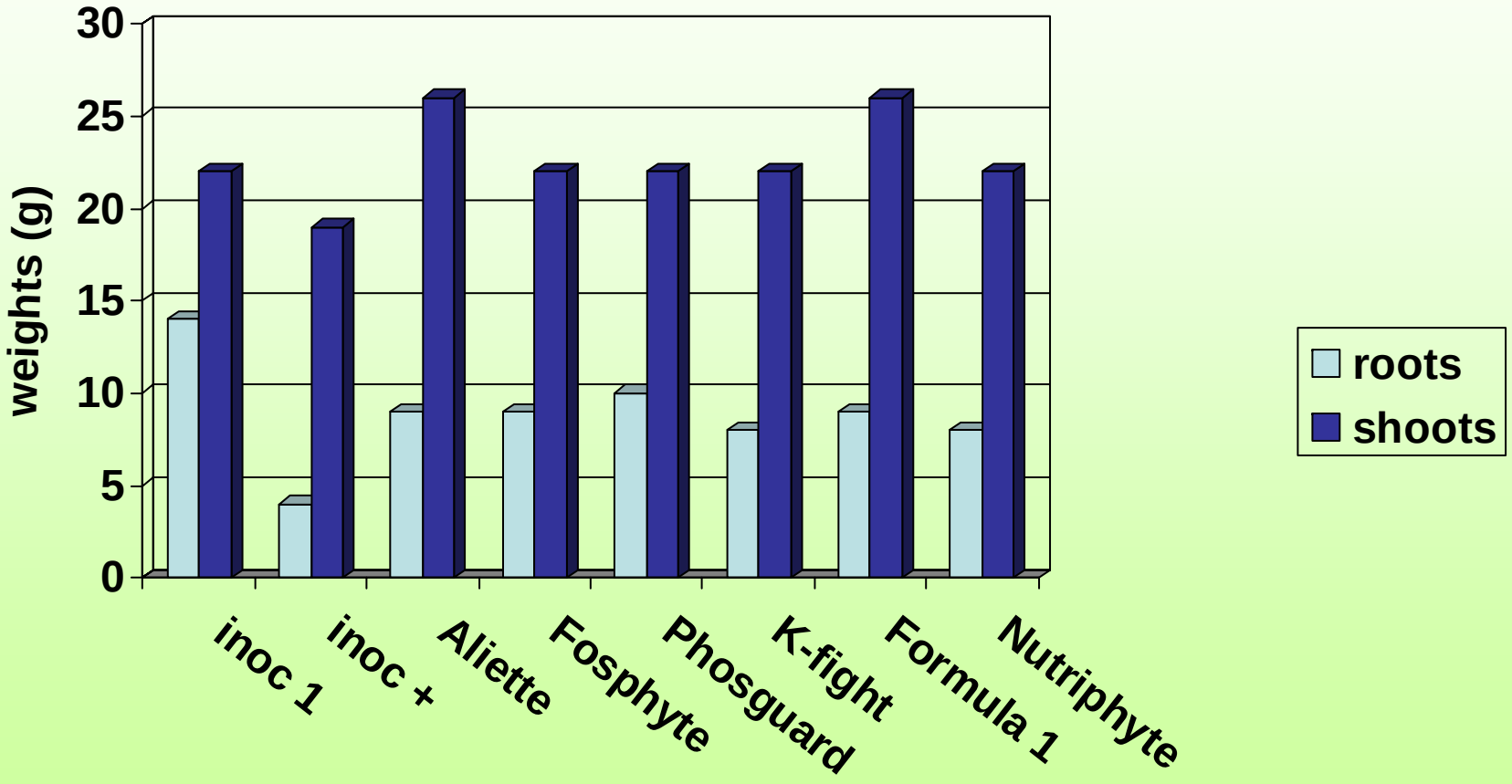
P. Cinnamomi control with phosphorus acids

Uninoculated control

Inoculated control

Fosfite™ drench

Effect of various phosphorus acids on root rot control.



AM Mycorrhizal Effects

That mycorrhizae selectively enrich for bacterial associates from the background soil that contribute to plant growth and health

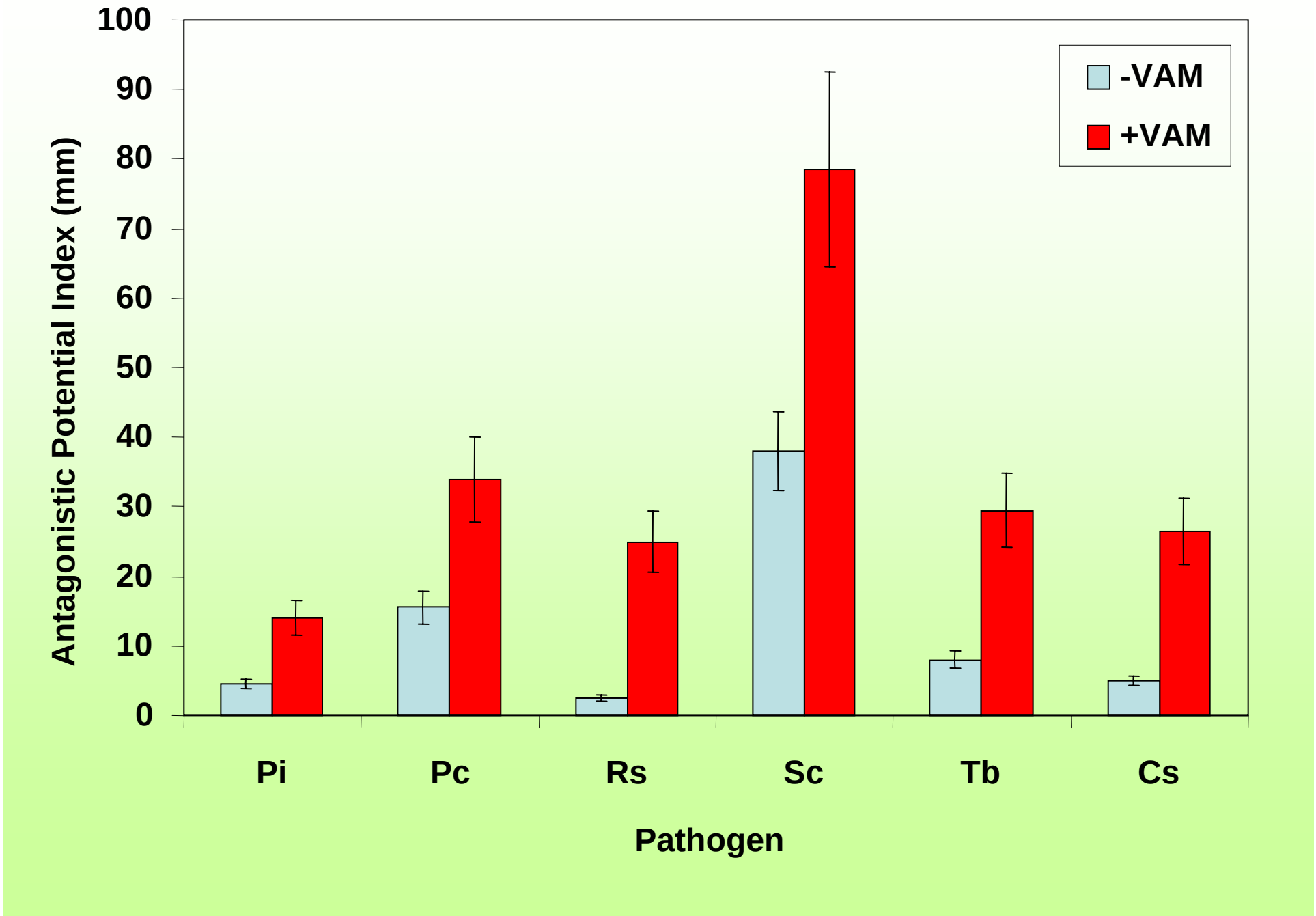
(antagonistic bacterial associates)

Slides in this sequence courtesy of Bob Linderman USDA/ARS, OR. From the Soil Fungus Conference, 2007, Santa Paula.

Antagonistic potential

- **Capacity of all the bacteria in bulk, rhizosphere or mycorrhizosphere soil to inhibit a specific pathogen**

- **Antagonistic Potential Index (API) is the sum of all the zones of inhibition (mm) by the bacteria tested *in vitro* to inhibit growth of a specific pathogen.**


Antagonistic Potential Index (mm)
100
90
80
70
60
50
40
30
20
10
0
-VAM
+VAM
Pi
Pc
Rs
Sc
Tb
Cs
Pathogen

Compost or compost tea effects on diseases: Interpretation

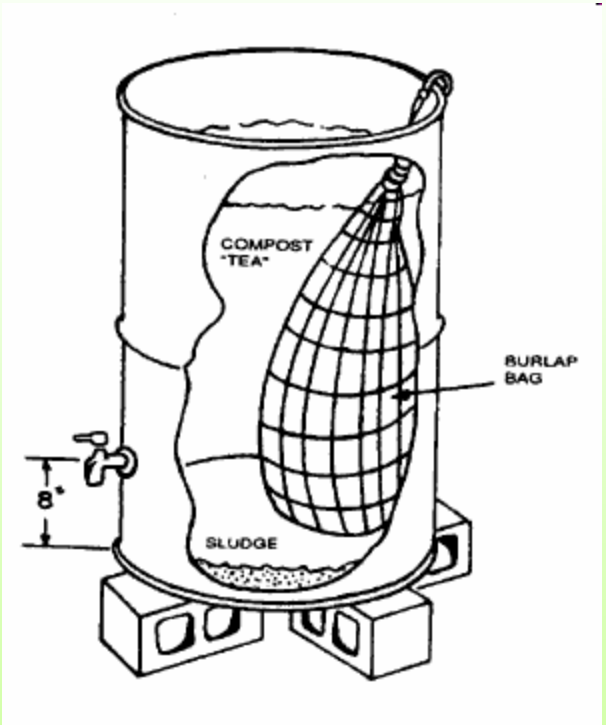
- Adding antagonists that suppress disease
- Stimulating antagonists already present in soil or potting mix
- Adding anti-pathogen chemicals produced during composting (including microbial metabolites)
- Poor correlation between active CFU's and disease reduction.

- For a review on compost teas see:

Scheuerell and Mahaffee, 2004. Phytopathology 94:1156-1163

Compost Tea

- Advocated for disease suppression
- Many systems and plant types
- Putative foliar and root disease controls



Compost Tea

Summary

(*Linderman, 2007*)

The Mycorrhizosphere Paradigm-a microbial hierarchy

Plant roots attract

Mycorrhizal fungi attract

Bacterial associates

Result: a “team” system that has worked to support plant growth and health for some 460 million years!!

Integrated Control

- Use all the methods discussed today
  - Mulching
  - Fungicides
  - Cultural controls
  - Resistance

Disease predisposing factors & cultural controls

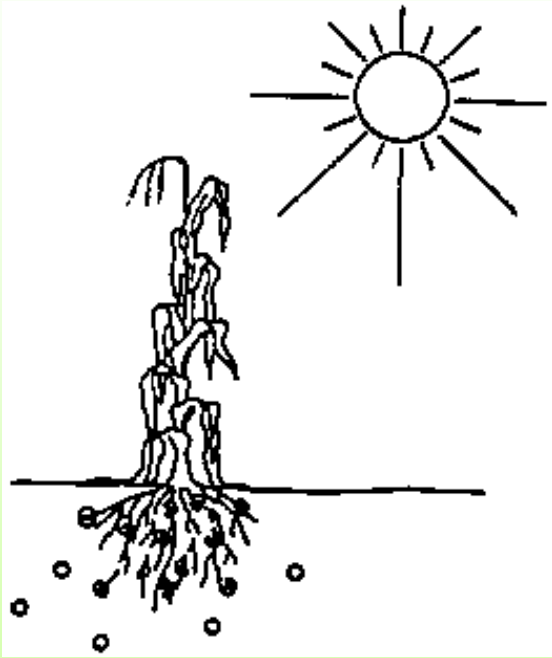
- Excess moisture→ drainage
- Planting too deep
  - Backfill over the crown→ correct planting depths
- Salinity→ leaching
- Compaction →aeration

Flooding is deadly if *Phytophthora* is present in the soil

Planting Too Deep

- Almost always leads to problems/death of the plant
- Associated with *Phytophthora* collar rots
- “Kiss of death” for native plants

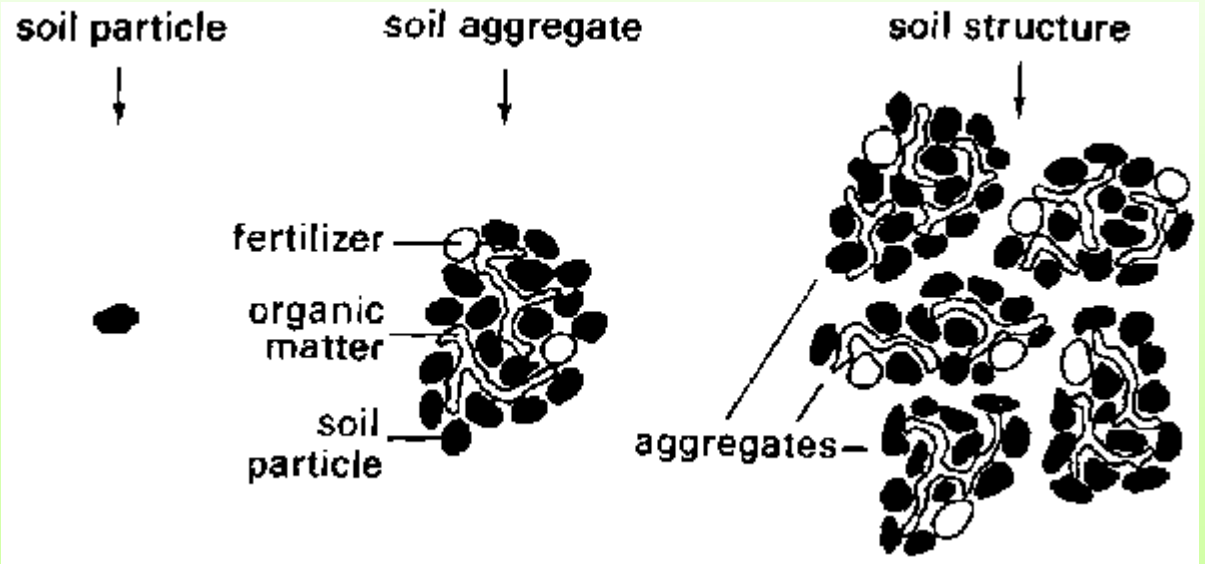
Soil Salinity



Jim MacDonald, UC Davis, effects studied on Chrysanthemum

Soil Structure

- Soil particles combine to form aggregates



Earth transport + compaction

Cultural Controls

Without attention to cultural control all other control methods will fail and the disease will worsen

Conclusions

- Organic mulches probably have varied roles in the suppression of diseases in soil Parasitism, enzymes and soil modification.
- Disturbance (tillage) probably plays a significant role in raising microbial activity of soils and thus the level of antagonists.
- Phosphorus acids are effective but alike
- Calcium ion can be used as therapy
- Mycorrhizae play a role as they increase antagonistic potential of the soil.