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.

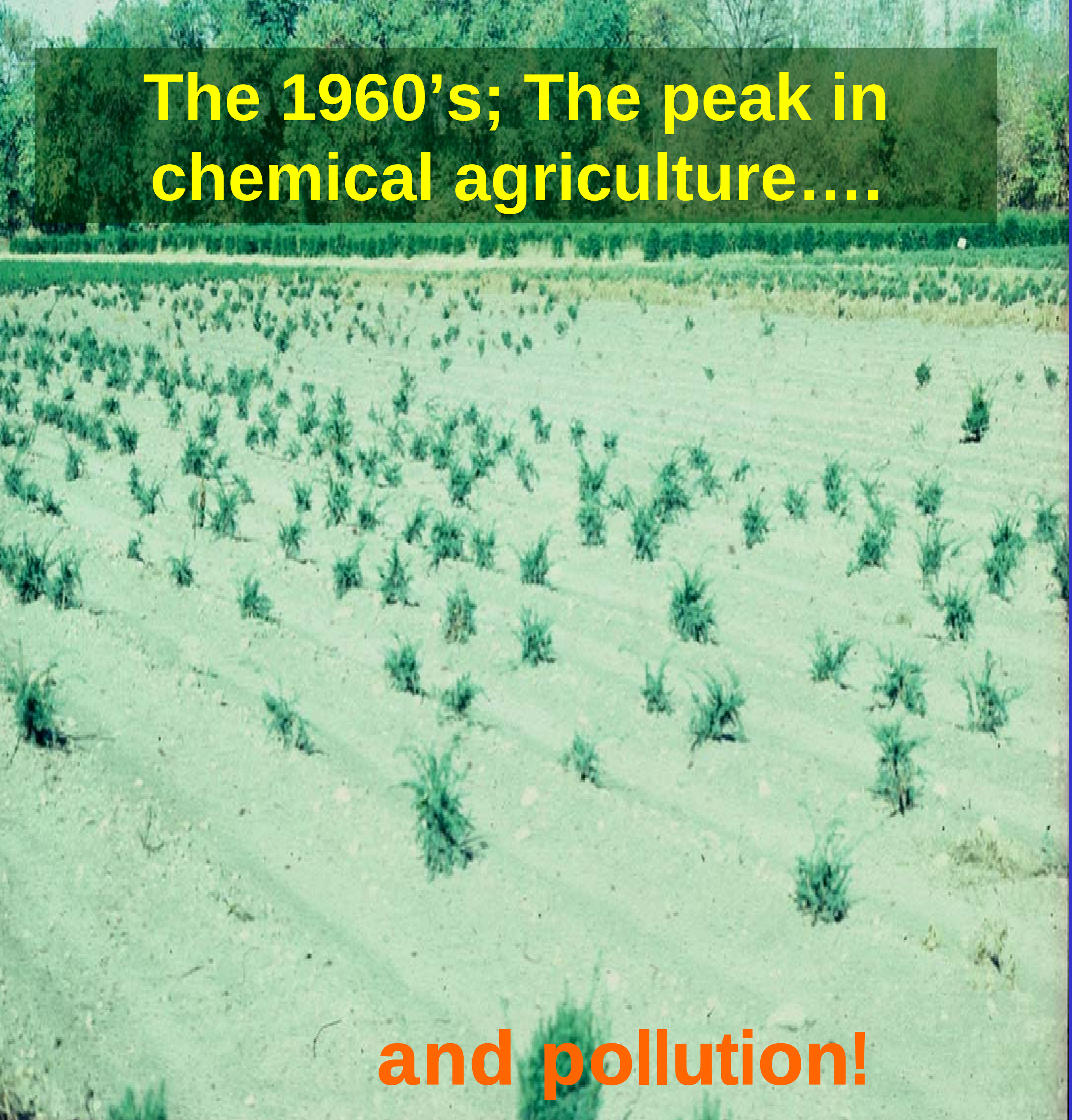
2002-

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

.

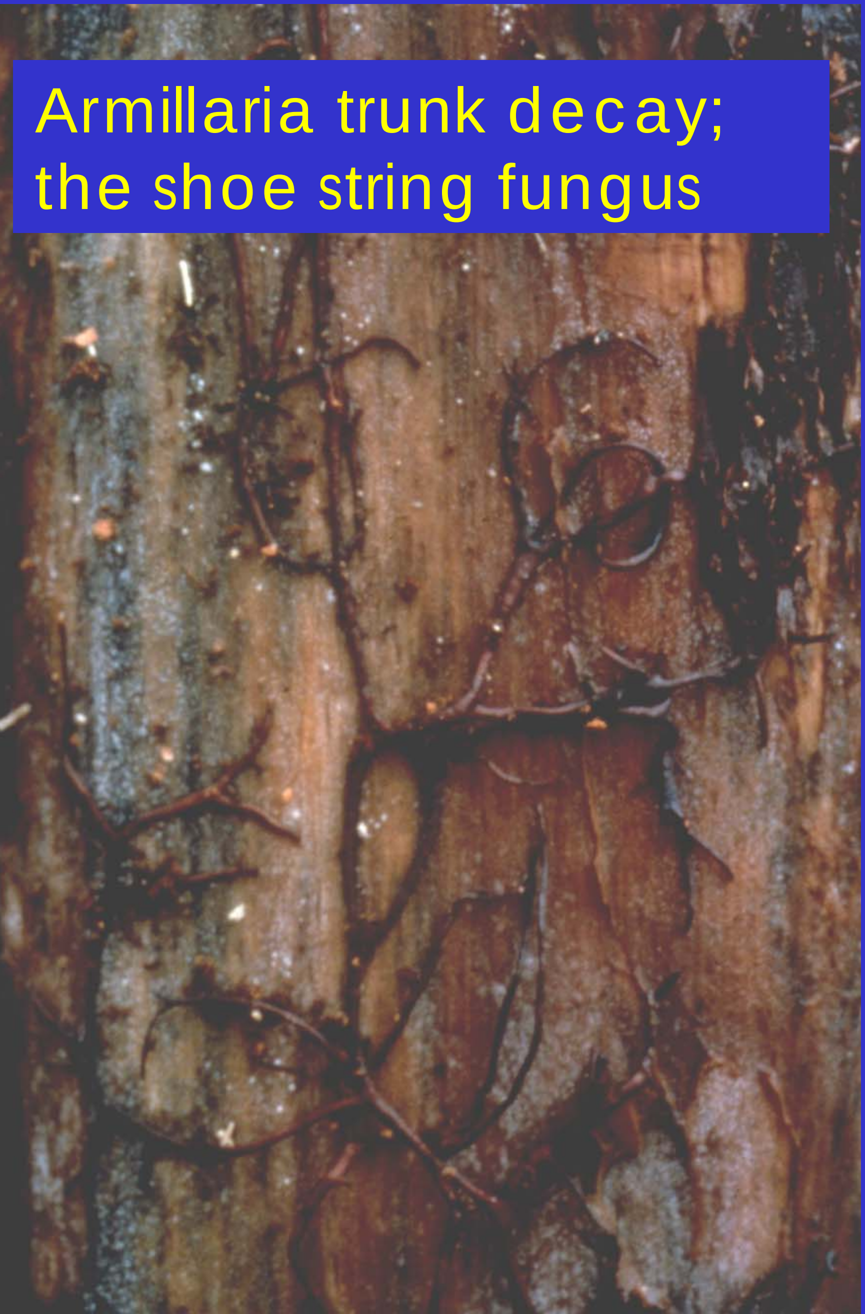
and pollution!


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 uM

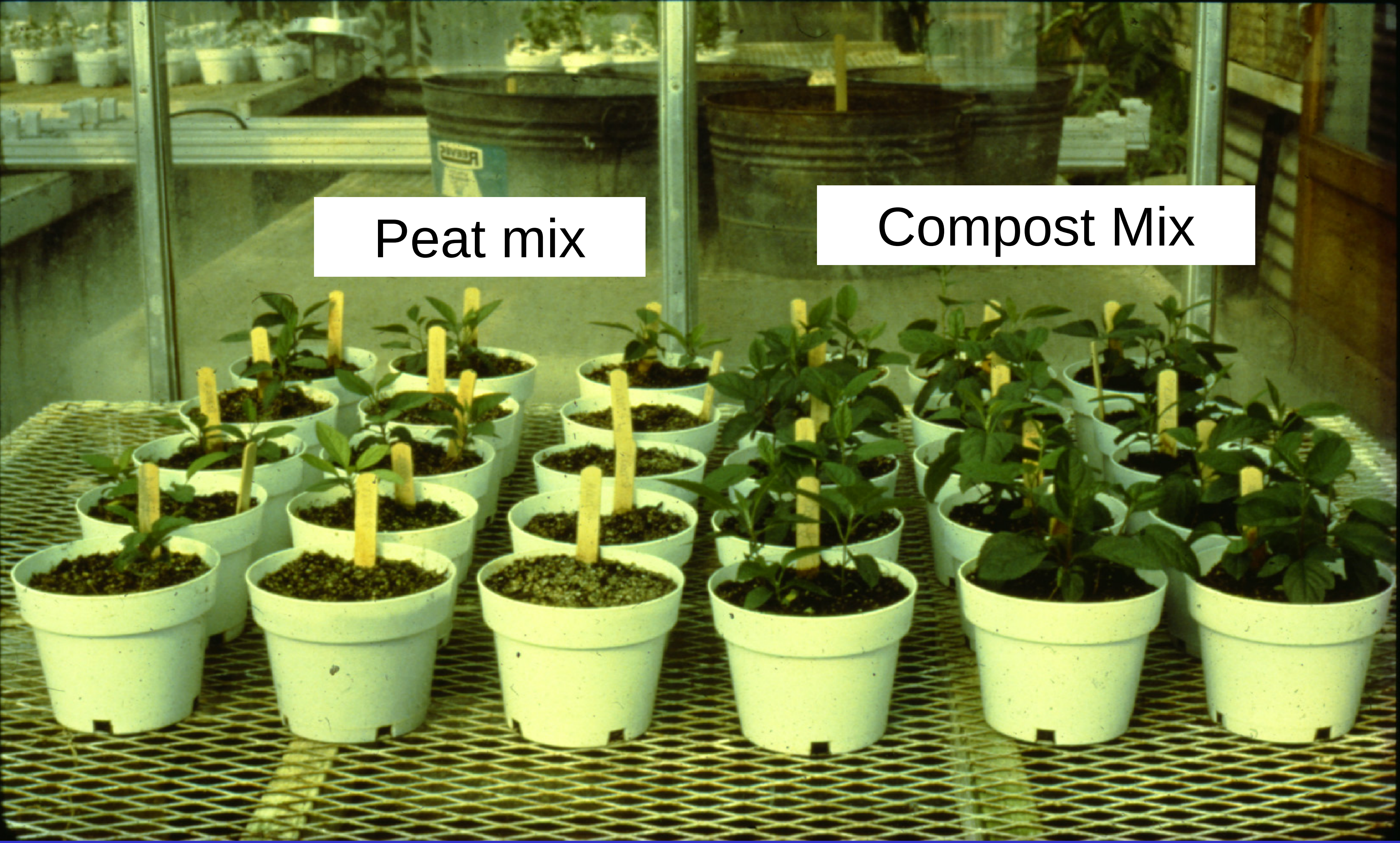

Armillaria trunk decay; the shoe string fungus

Conclusion: 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

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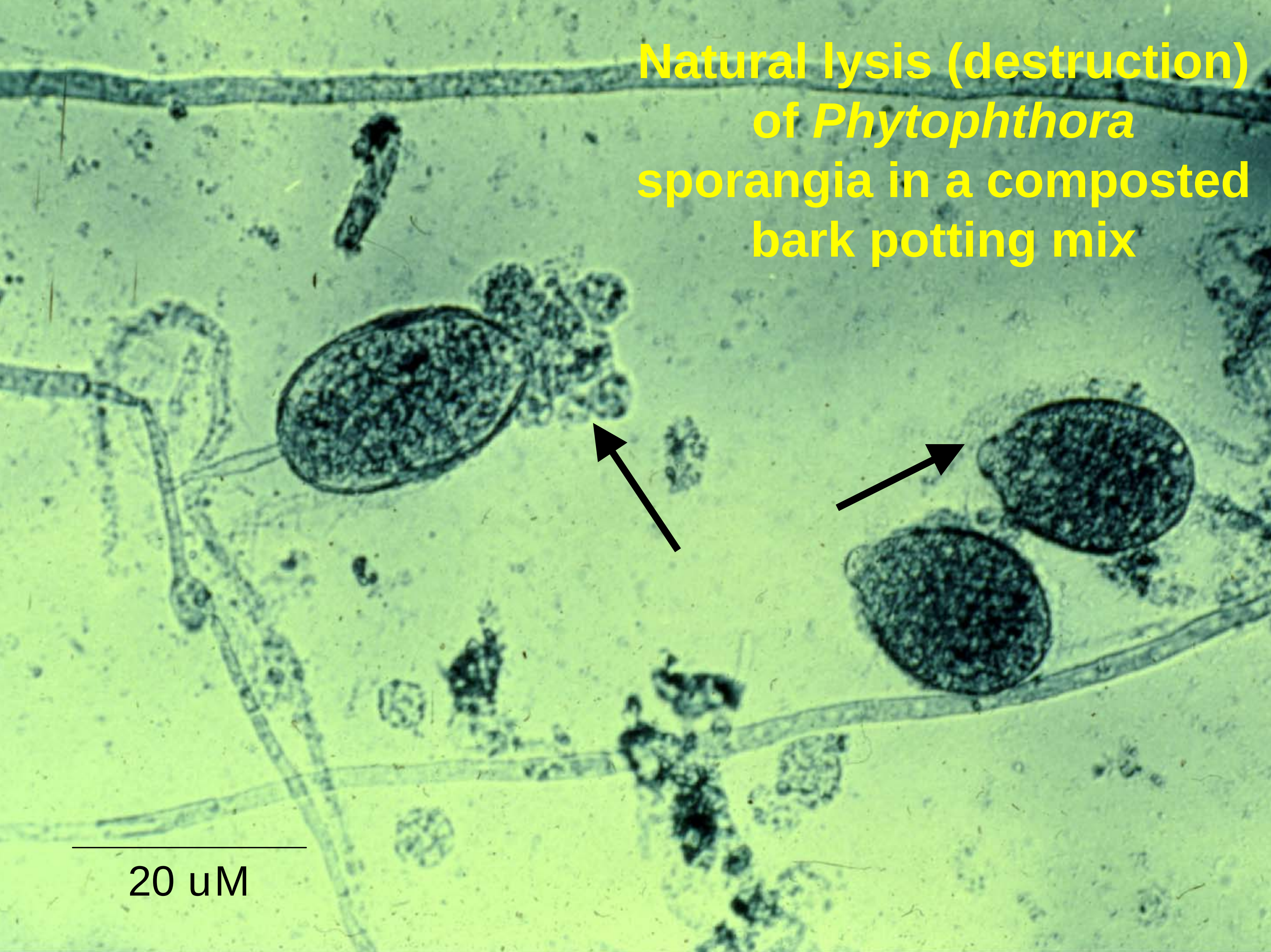
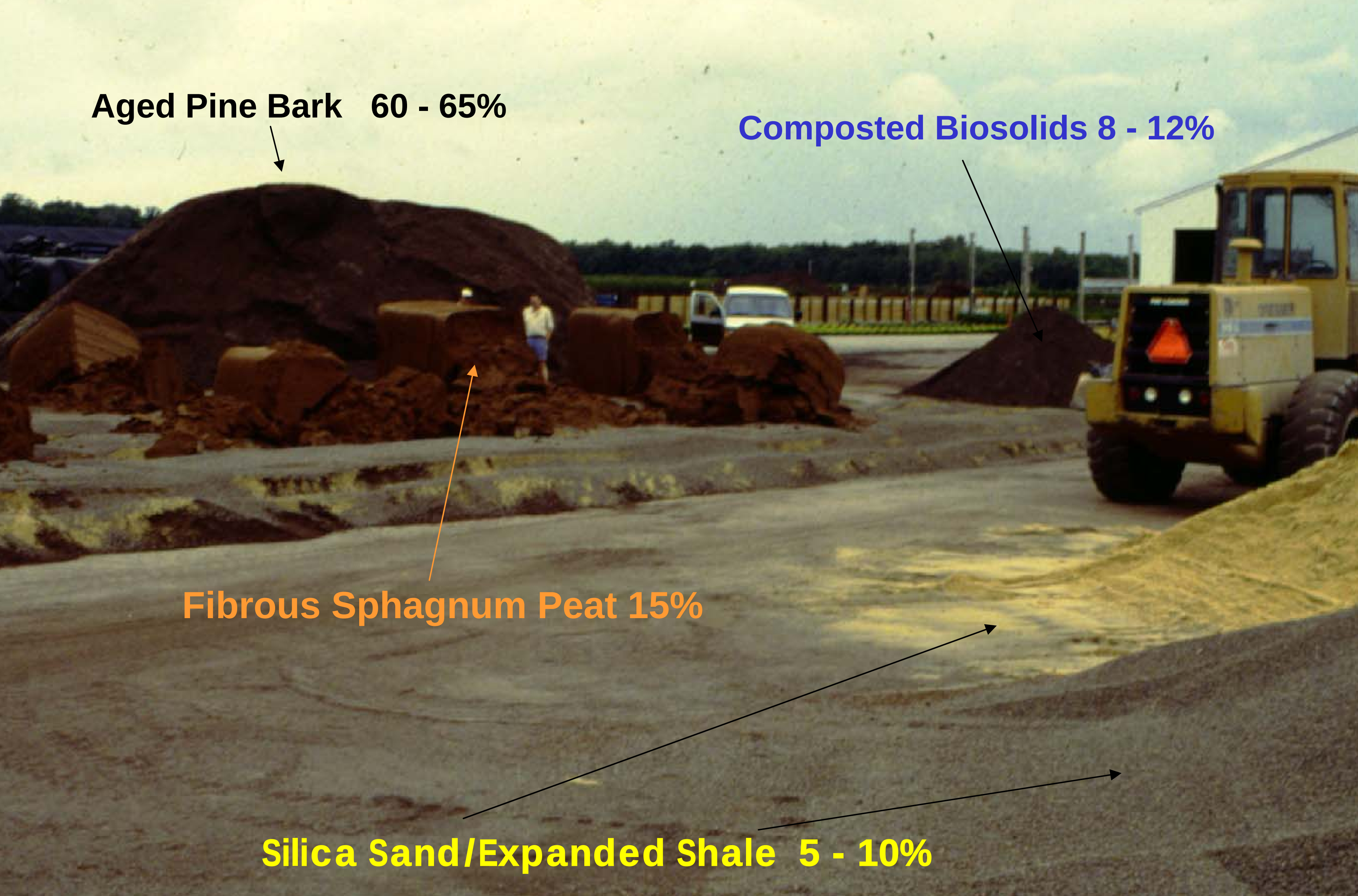

Natural lysis (destruction) of *Phytophthora* sporangia in a composted bark potting mix
20 uM

I. NATURAL SUPPRESSION
An example of how it is used in nurseries



Media Naturally Suppressive to Pythium and Phytophthora Root Rots

Aged Pine Bark	60 - 65%
Fibrous Sphagnum Peat	15%
Composted Biosolids	8 - 12%
Silica Sand/Expanded Shale	5 - 10%

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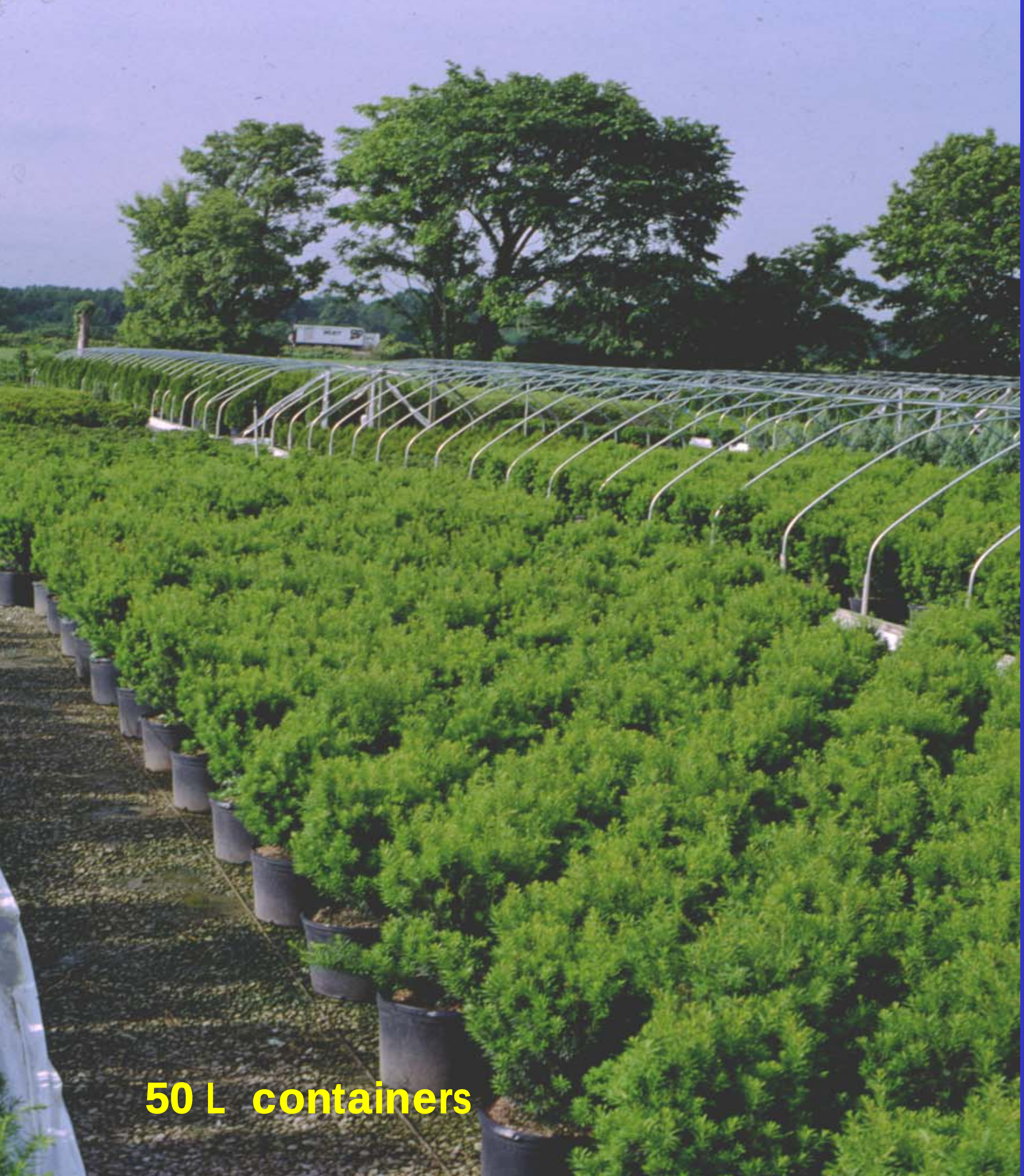
Early days of natural root rot suppression.

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 susceptibilty to Phytophthora root rot!

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Natural Suppression formulation requirements:

COMPOST

- Fresh materials aggravate whereas composts suppress root rots; Stability must be < 0.5 mg CO_2 g OM^{-1} h^{-1}
- NH_4 content < 100 ppm
- Salinity < 8-10 mmhos cm^{-1}

POTTING MIX

- Incorporate compost at a rate that meets fertility and physical property requirements of potting mixes
- Moisture content > 50% (w/w) to enhance colonization by bacterial and fungal biocontrol agents so as to induce natural suppression

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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

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Present Status: Compost-induced Plant Disease Suppression

I. General (Natural) Suppression
(>90% of mature composts)

- Phytophthora root rots
- Pythium root rots

II. Specific suppresssion
(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

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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

Stone et al, 2001 Soil Sci. Soc. Am.J. 65: 761-770.

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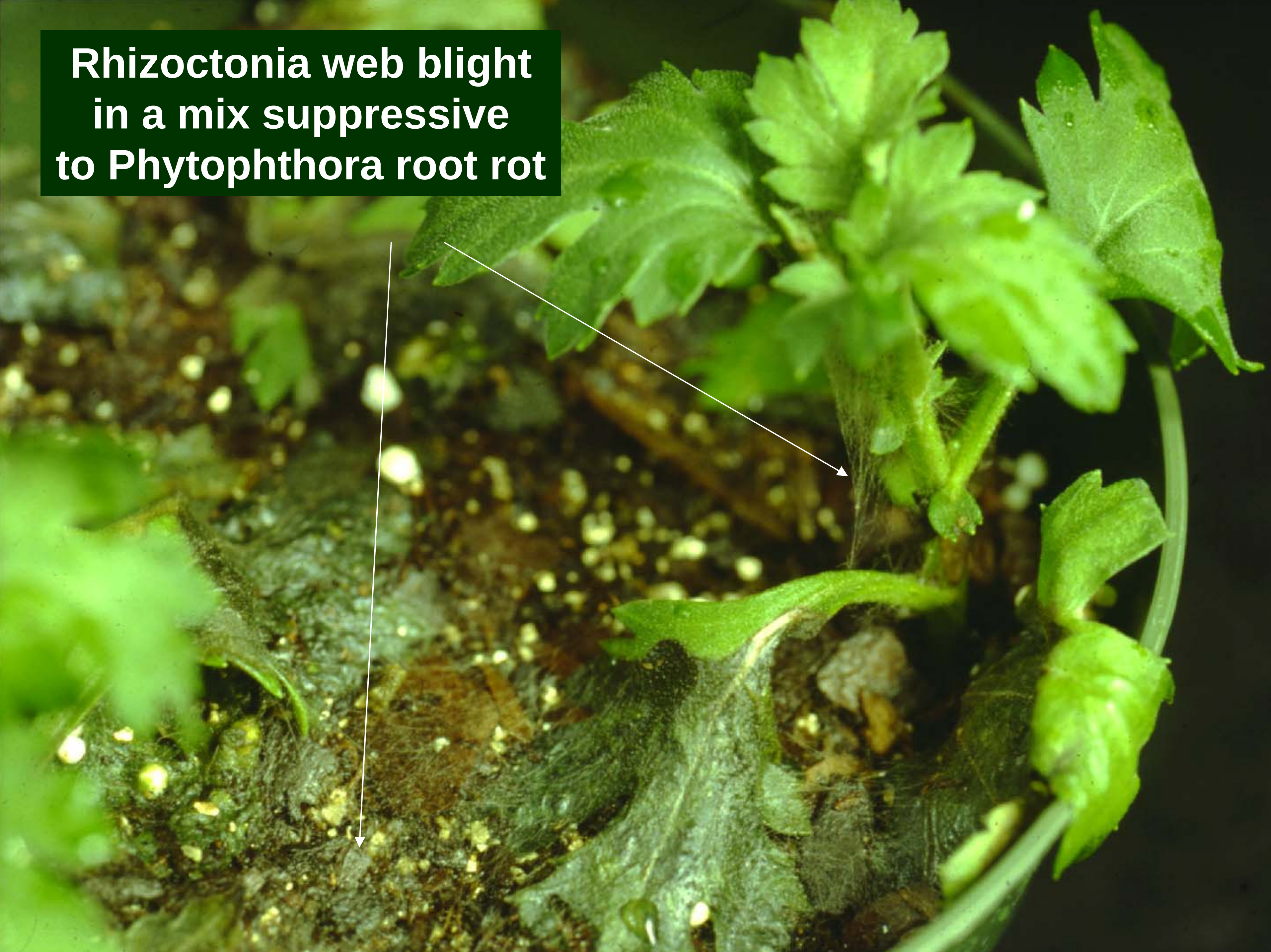
Rhizoctonia web blight
in a mix suppressive
to Phytophthora root rot

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.

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Earthgro (CSB)
✓
Au R
R
R + T382
+F299

Compost Microflora

- 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 suppressoion..

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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.**

Krause et al, 2003, Phytopathology 93:1292-1300.

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).

Potting Mix	Control Treatment	Disease Severity (AUDPC)	Salabilit y
peat	control	1137.3a	4.0a
peat	Chlorothalonil	451.6b	3.8a
peat	T382	285.6b	3.2b
SD compost (5%)	T382	160.4b	2.4c

Horst et al., 2003, Phytopath: 93: S37.

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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.**

•Pharand et al, 2002, Phytopathol. 92:424-438
•Khan et al, 2004, Plant Disease 88: 280 -286.

Can ISR be scaled up commercially?

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

Hoitink et al, 2002 OARDC Ornamentals Annual Report.

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T382
Control
T382
Phytophthora Blight of Rhododendron

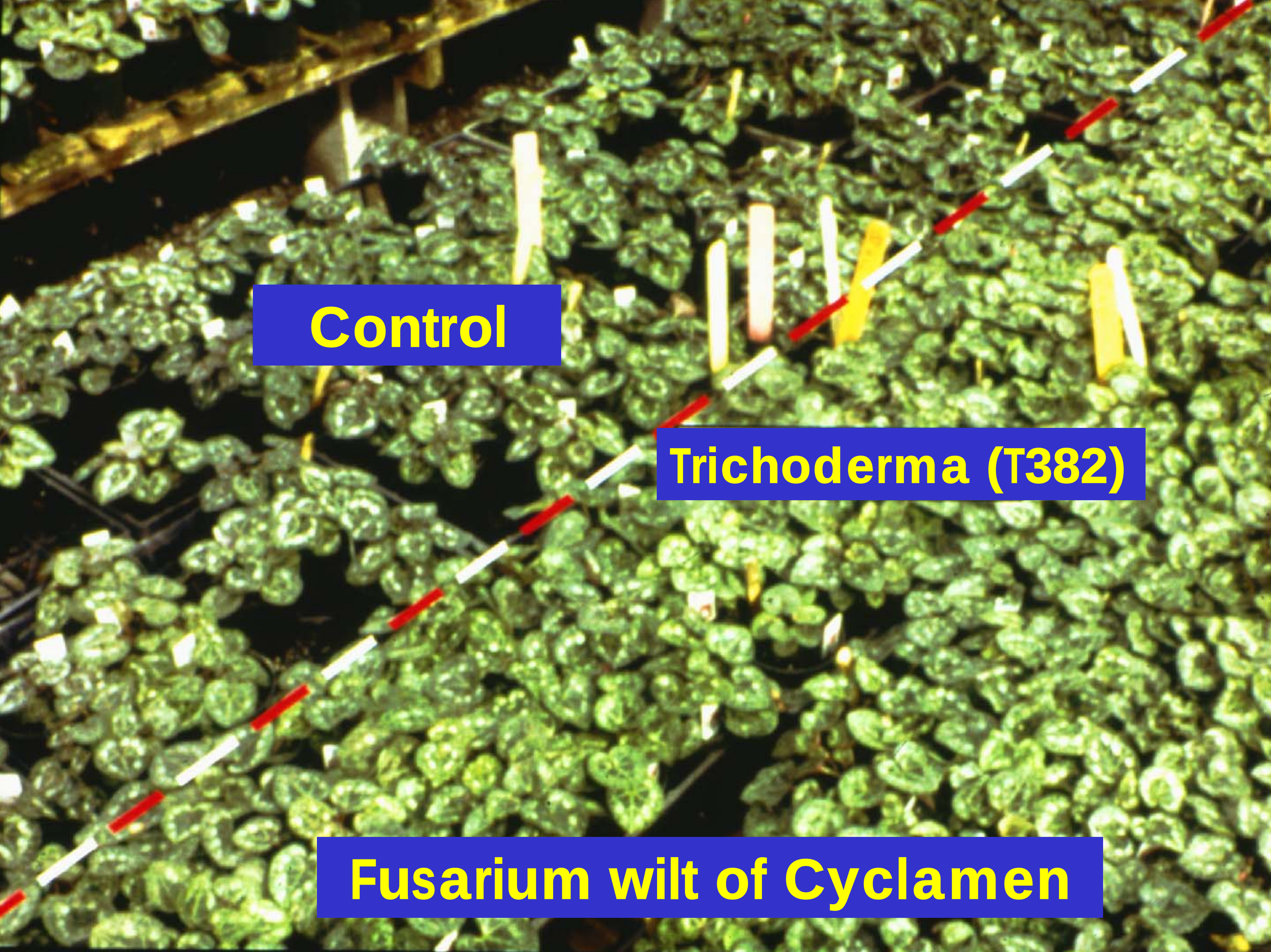

Control
T382


T382
Natural Mix
(Control)

Suppression of Phytophthora Dieback on Rhododendron cv English Roseum induced by *Trichoderma hamatum* 382

	Disease Severity [a]			
	Dieback (%)		Plants Killed (%)	
Treatment	Mean	Std.Dev.	Mean	Std.Dev.
Control	16.9	11.8	4.2	4.4
T382 [b]	6.3	5.1	1.1	1.3
	p= 0.05		p=0.002	

Hoitink et al, 2006 Phytopathol. 96: 186-189.


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 <u>must be</u> 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.

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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