

Another Chestnut Chat:

Phytophthora cinnamomi and American chestnut

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and

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Topics to Cover

- **Dr. Jeffers**

- background information on *Phytophthora* species
- overview of *Phytophthora* root rot on American chestnut
- initial screening efforts on resistance of hybrid chestnut seedlings to *Phytophthora cinnamomi*

- **Dr. McKeever**

- ongoing screening efforts at the Resistance Screening Center to determine resistance of hybrid chestnut seedlings to root rot caused by *P. cinnamomi*
- cooperation among USDA-FS, TACF, Clemson University



Phytophthora species as Plant Pathogens

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- Responsible for some of the most destructive diseases worldwide on an annual basis
 - late blight on potato & tomato



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photo: RPB

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 - sudden oak death on tanoak and oak species



Phytophthora species as Plant Pathogens

- 170+/- species identified & described
 - previously undescribed species are found each year
- Attack plants in all cropping systems
 - fruits, vegetables, field crops, ornamental plants
- Attack plants in forests & natural ecosystems
 - USA, Mexico, Argentina, Australia, Europe, etc.
- Active in most climatic regions of the world
 - tropical, temperate, alpine



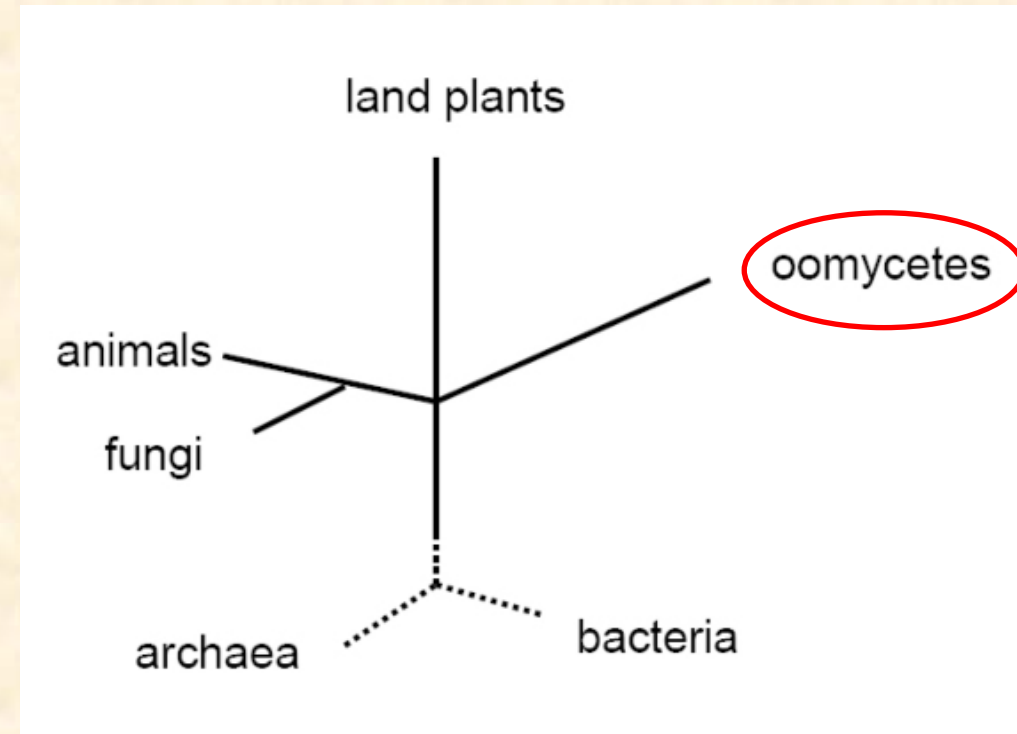
Phytophthora spp. as Plant Pathogens

- Some of the most economically important diseases on both herbaceous and perennial plants in USA and worldwide
- Cause problems annually in fields, farms, nurseries, greenhouses, landscapes, and forests
- Particularly serious in or following “wet” years, and
- Diseases often are associated with wet or saturated soils
 - because these pathogens produce swimming spores = zoospores



Species of *Phytophthora* Are Not Really Fungi!!

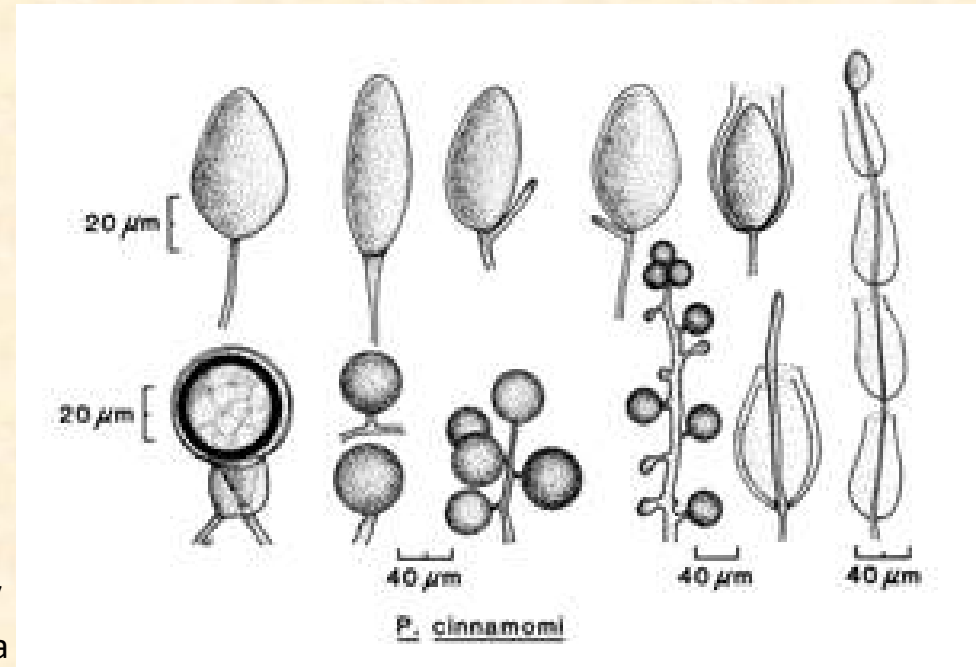
- Species of *Phytophthora* are not true fungi
 - used to be called “lower fungi”
 - or Phycomycetes
 - now called “fungus-like organisms”
- They are Oomycetes
 - more closely related to plants
 - related to several types of primitive algae:
 - golden & brown algae
 - cryptomonads – aquatic, unicellular organisms
 - diatoms – aquatic unicellular algae, phytoplankton



stick figure phylogenetic tree

Phytophthora Biology: Some Key Characters

- **Oospores:** very thick-walled spore
 - resting spore capable of long-term survival
- **Chlamydospores:** thick-walled resting spores
 - also capable of survival
 - but less “hardy” than oospores
- **Sporangia:** sac-like structures
 - produce zoospores or function can as a spore
- **Zoospores:** single-celled spores, self-contained
 - motile = swim in water films and free water



Sporangia Germinate to Release Swimming Zoospores = Infective Propagules

(when free water is available)



Phytophthora species: Survival

- Survival structures and locations
 - primarily oospores and chlamydospores in soil
 - also in infected plants & infested organic debris
- Survival: can persist for...
 - days in water as zoospores or sporangia
 - weeks or months in contaminated plant debris
 - years in soil as chlamydospores and oospores
 - indefinitely in infected living plants
- Once established in soil – nearly impossible to eradicate!!



Phytophthora Root Rot (PRR): The Other Disease Killing American Chestnut

- Long before chestnut blight was reported in North America
- Phytophthora root rot was killing chestnut trees in the SE USA
- Undocumented reports as early as 1825 in GA
- Widespread death of chestnuts and chinquapins in the Southeast since about 1850
- Reported in Europe in 1853 and claimed to be one of the most feared diseases – called ink disease
 - killing European chestnuts (*Castanea sativa*)

Phytophthora Root Rot on American Chestnut

- Pathogen: *Phytophthora cinnamomi*
 - introduced to USA in late 1700s or early 1800s
 - origin is SE Asia – first described on cinnamon trees in Sumatra in 1922
 - introduced through ones of the shipping ports in the southeastern USA
 - Charleston, Savannah, Mobile??
- Widespread death of trees at lower elevations
- Disease was first diagnosed and confirmed in 1930s
- Definitive research published in 1945
- Very little research after that – chestnut trees were gone!

Distribution of *Phytophthora* root rot and *P. cinnamomi* on American chestnut and chinquapin: 1945

Crandall, Gravatt, and Ryan. 1945.
Phytopathology 35: 162-180.

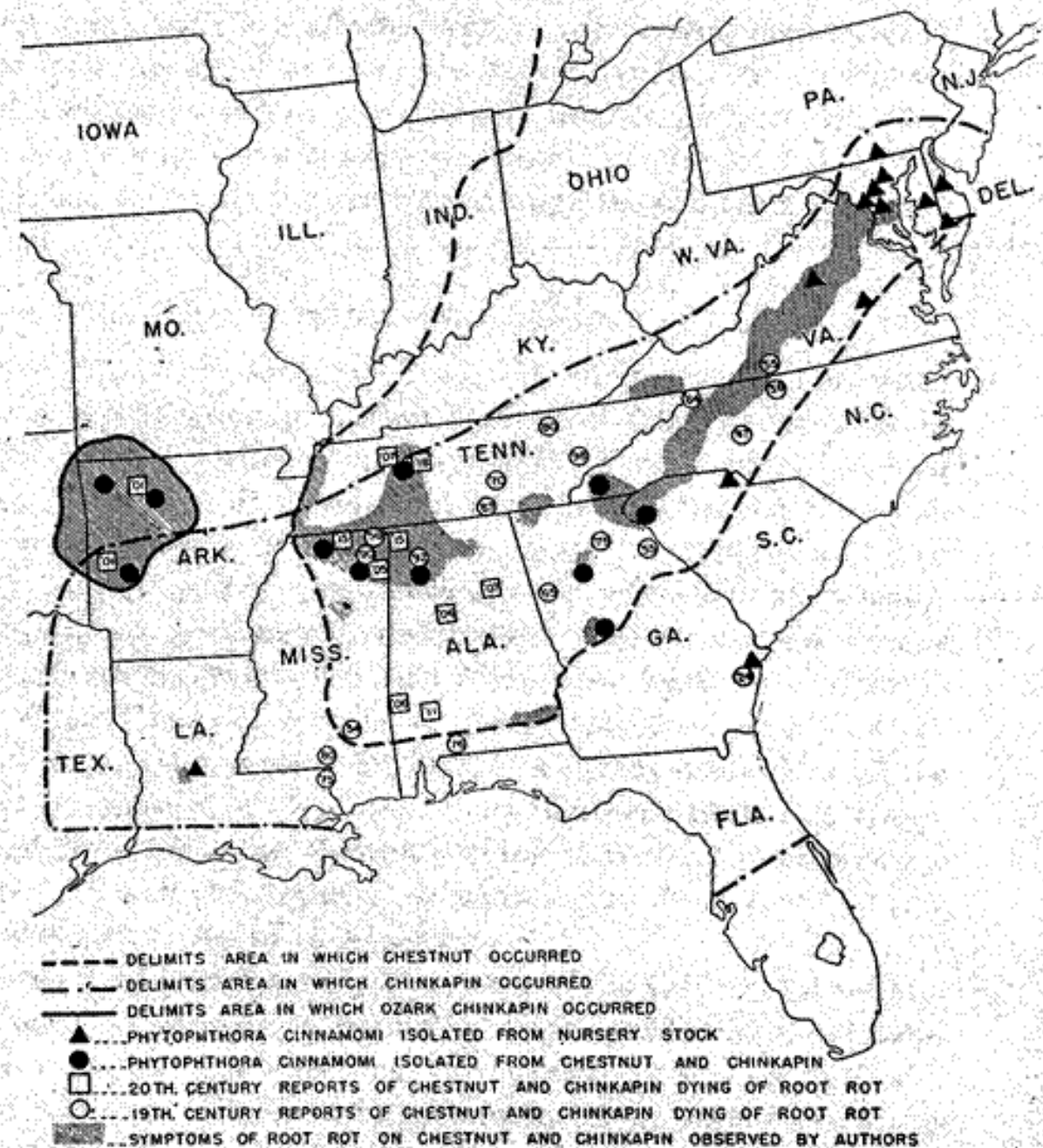


FIG. 2. Observed range of root rot caused by *Phytophthora cinnamomi*.

Phytophthora Root Rot Re-Discovered in 2003

- For years, blight diverted everyone's attention away from PRR due to its widespread nature in all eastern forests
- Until root rot killed a high percentage of hybrid seedlings planted in several locations in the Southeast
- *P. cinnamomi* confirmed as the pathogen in 2003 at Chestnut Return Farm in SC
 - start of my collaboration with Dr. Joe James and TACF...



PRR on Hybrid Chestnut Seedlings



Phytophthora Root Rot Symptoms



More Symptoms on Chestnut Seedlings



PRR on Hybrid American Chestnut Seedling



Screening Hybrid Chestnuts for Resistance

- Develop a system to evaluate chestnut seedlings for resistance to *P. cinnamomi* – want to mimic what happens in the field
 - Goal: create a resistant population of trees for continued breeding efforts
- Research was a collaboration
 - Dr. Joe James at Chestnut Return Farms – the research site
 - Dr. Paul Sisco at TACF and many others...
- Seed families provided by TACF: backcross hybrids – F_1 to BC_4
 - American = susceptible control & Chinese = resistant control

P. cinnamomi Screening at Chestnut Return Farm: Planting



P. cinnamomi Screening: Inoculation



PRR: 16 days after Inoculation



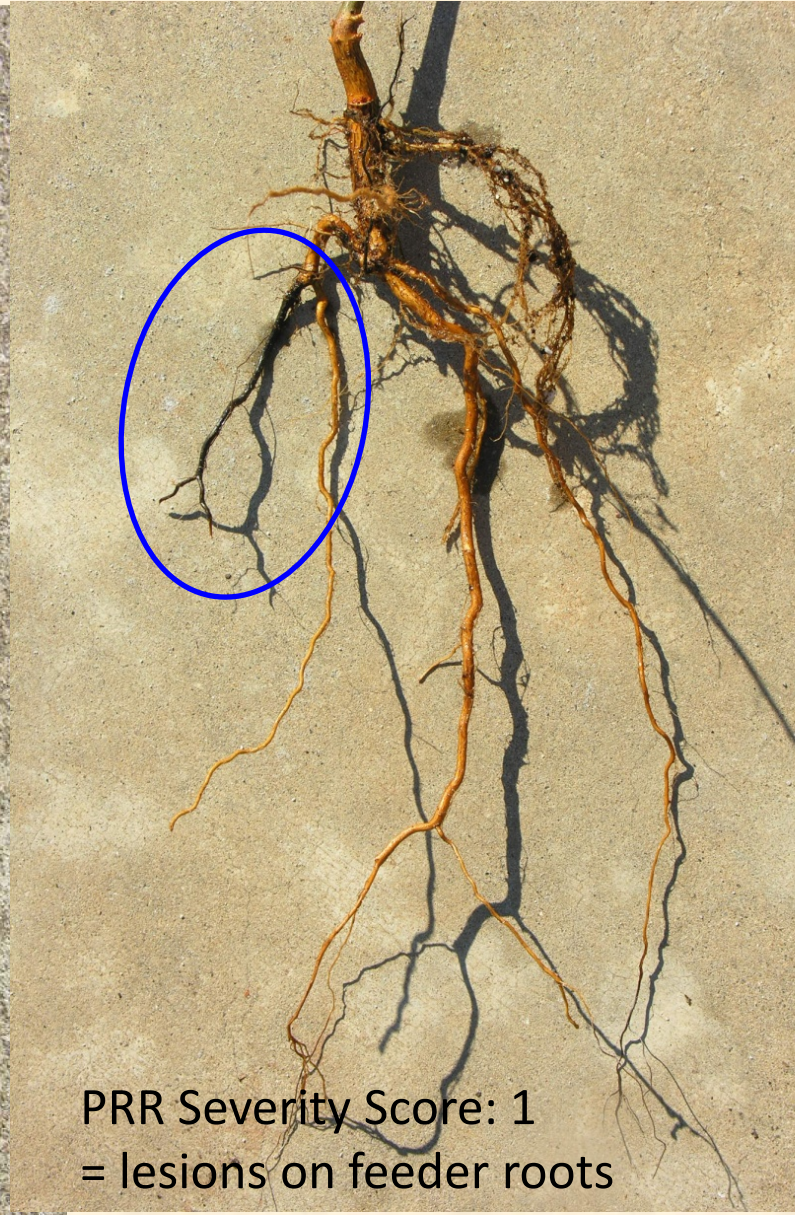
Evaluating Hybrid Seedlings in Nov-Dec



P. cinnamomi Screening: Evaluation



PRR Severity Score: 0
= healthy roots



PRR Severity Score: 1
= lesions on feeder roots



PRR Severity Score: 2
= lesions on tap root

P. cinnamomi Screening: Evaluation



PRR Severity Score: 3
= plants dead

Results After 14 Years of Screening: 2004-2017

- 18,525 seedlings tested
- 505 hybrid families evaluated – some in multiple years
- Resistance detected in hybrid families each year
 - therefore, genes for resistance to *P. cinnamomi* are present in hybrid chestnut families originally selected for resistance to *C. parasitica*
- Genetic analysis confirmed presence of resistance in certain TACF hybrid families – specific sources of resistance are being identified
- Focused breeding efforts now under way at TACF to develop hybrid chestnut families resistant to *P. cinnamomi*
 - project continues in Asheville, NC at the Bent Creek Experimental Forest