USDA
Agricultural Research Service

Armillaria Root and Crown Rot, Phytophthora Root and Crown Rot, & Paradox Canker Disease

Overview considerations

Disease / pathogen	Relative degree of impact on incidence of disease				
	Site / soil factors, disease history	Rootstock	Preplant soil fumigation	Irrigation system & operation, other cultural management	Chemical control
Armillaria	**++++**	**+++**	**+ (temporary)**	**+++**	**-**
Phytophthora	**++++**	**++++**	**+ (temporary)**	**++++**	**+++**
Paradox canker (pathogen unk.)	**?**	**(?) (only Pdx?)**	**(?) (not likely)**	**?**	**-**

Armillaria root rot, symptoms & signs

Armillaria, background, biology

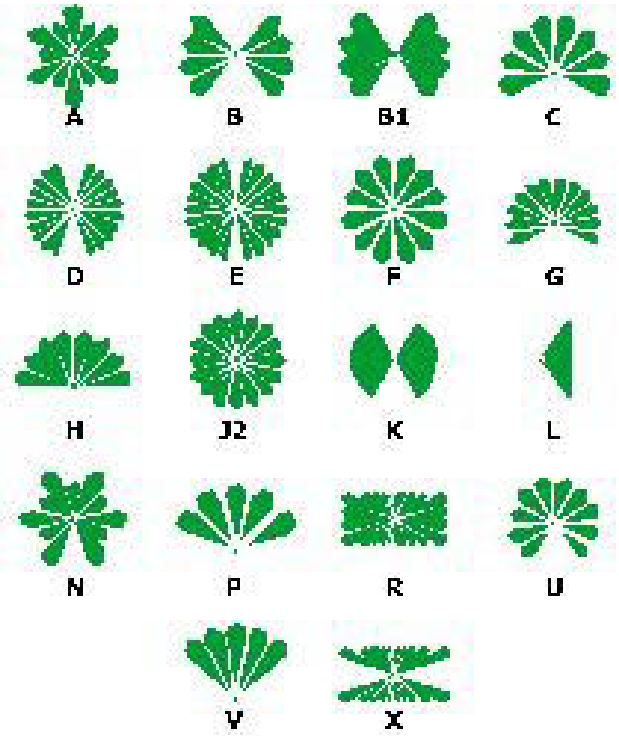
- *A. mellea* is the pathogen
- Found most often in riparian areas, former oak woodlands
- Wide host range, including all fruit and nut crops, many ornamentals
- Strains vary in aggressiveness
- Inoculum soilborne, persistant
- Spread tree to tree in soil, also by flooding, movement of infested soil and plants
- Likely that stress can predispose trees to Armillaria infection

Armillaria, management considerations

- Carefully consider and prepare orchard site, drainage included
- Well-drained soil less conducive to disease development and spread
- Eradication with preplant fumigation virtually impossible, but can reduce / delay incidence

Armillaria, management considerations

- Design and operate irrigation system to keep root crown and trunk dry while meeting crop ET; the dryness is less conducive to *Armillaria*



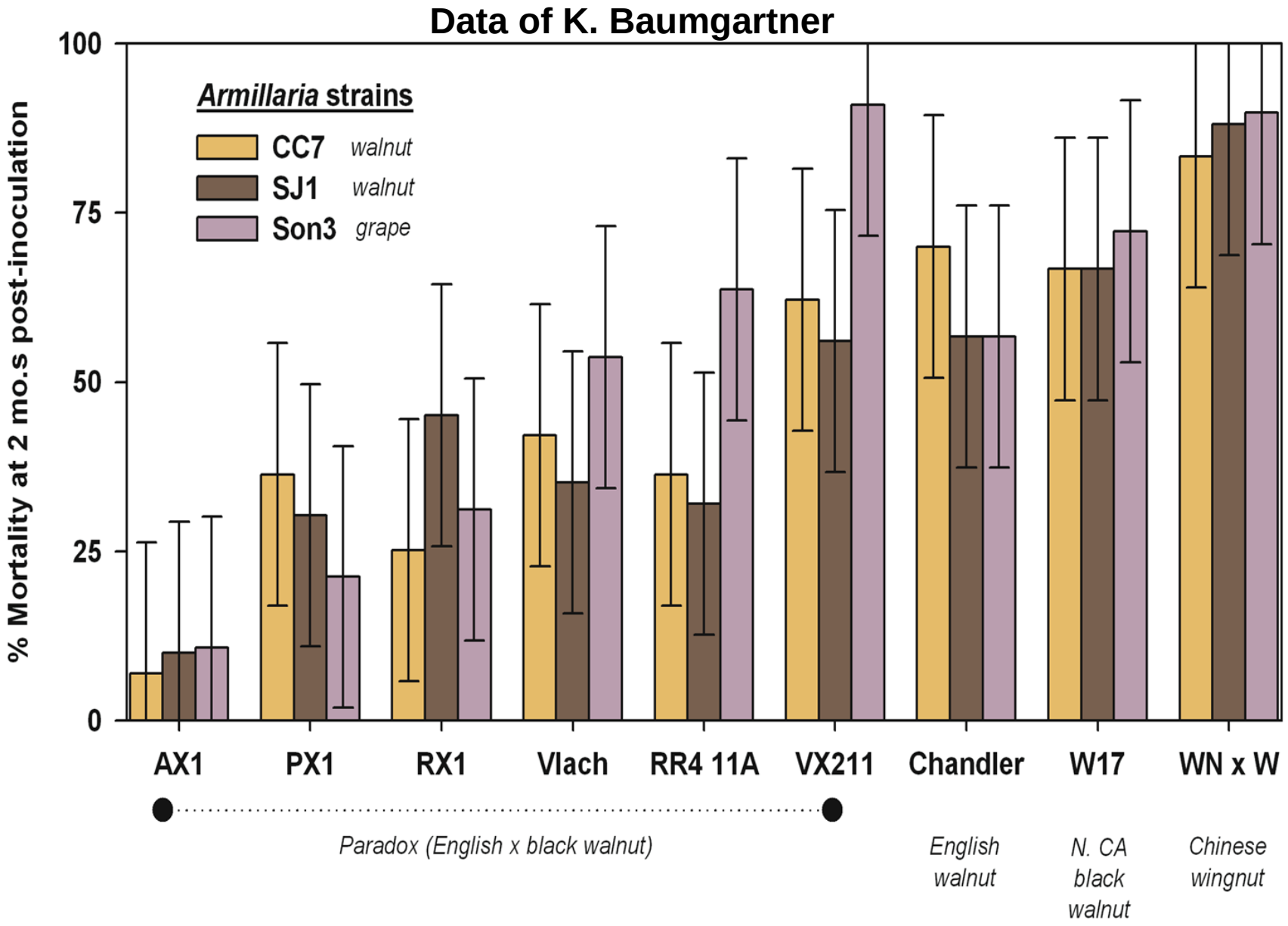
Armillaria, management considerations

- Among rootstocks, English walnut (*Juglans regia*) much more susceptible to *Amillaria* than Northern black (*J. hindsii*) or Paradox seedling (*J. hindsii x J. regia*)
- Mixed trial results on NCB vs. Paradox seedling
- Diverse Paradox hybrid clones evaluated for tolerance to *Armillaria* in tissue culture, confirmatory field trials needed

Armillaria **phenotyping assay: Inoculate walnut plants rooted in tissue culture medium with *Armillaria mellea***

K. Baumgartner

Armillaria, resistance of rootstock clones in tissue culture

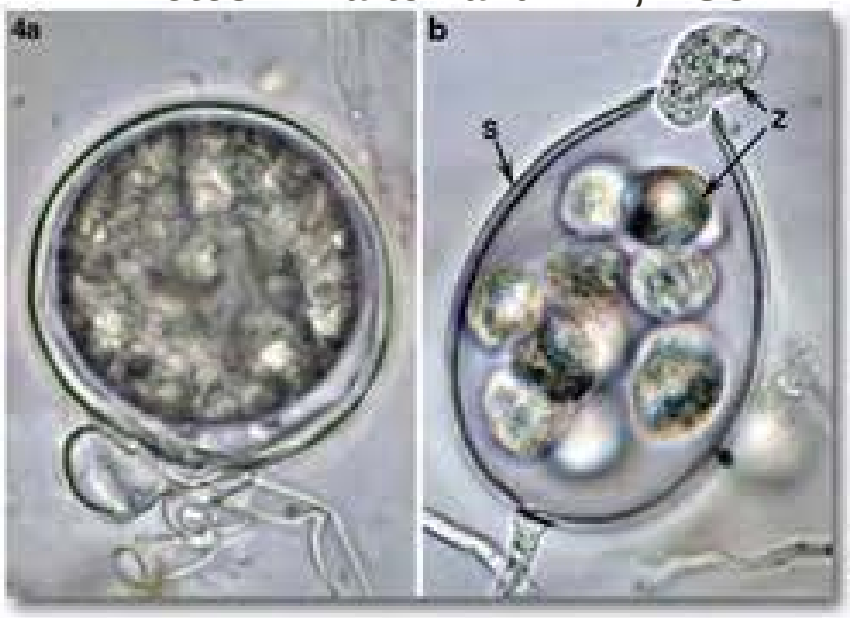


Phytophthora crown and root rots

Phytophthora- the pathogens

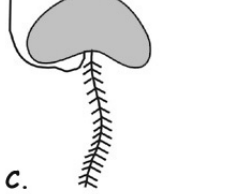
- More than 10 species of *Phytophthora* affect California walnuts
- *P. cinnamomi* and *P. citricola* are the most aggressive species
- Most species, incl. *P. cinnamomi* and *P. citricola* have wide host ranges
- Inoculum soilborne, persistant
- Spread by soil, surface water, infested planting material
- Soil water saturation favors infection

Photos: Wharton and Kirk, MSU

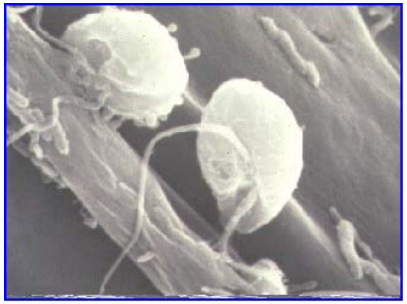


Oospore, note thick wall

Sporangium, note zoospores, (one swimming out)



Zoospore

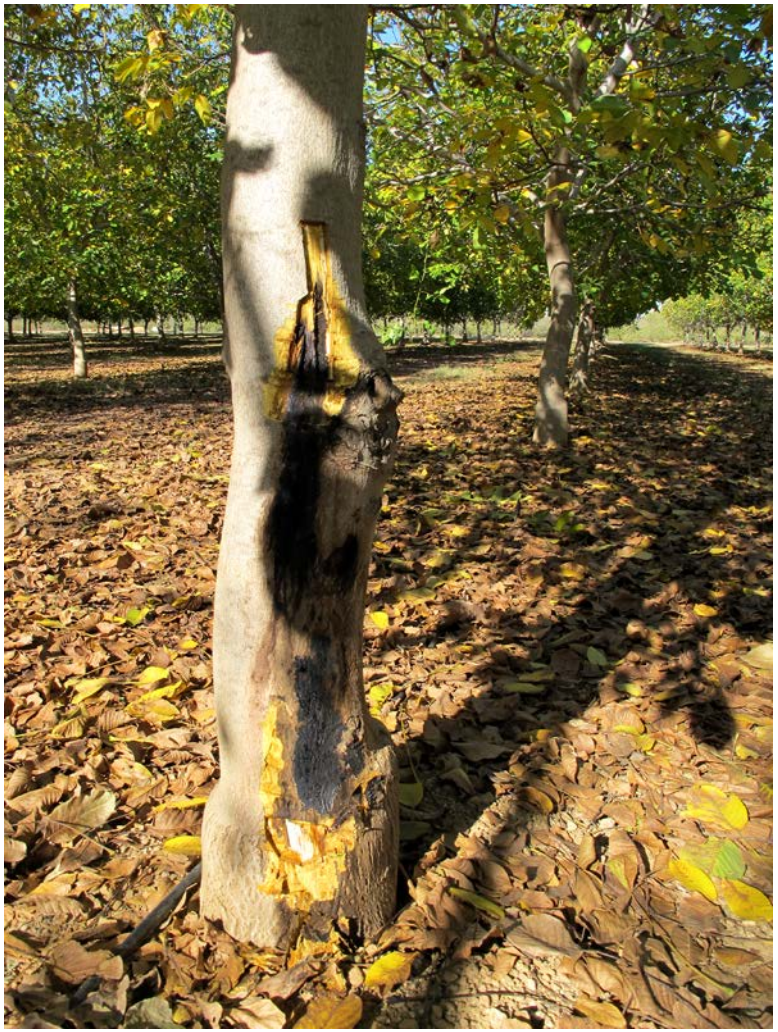


Zoospores on root
Photo: Sullivan, NC State

Phytophthora disease symptoms

Attack through roots, typical of *P. cinnamomi*…

Phytophthora disease symptoms

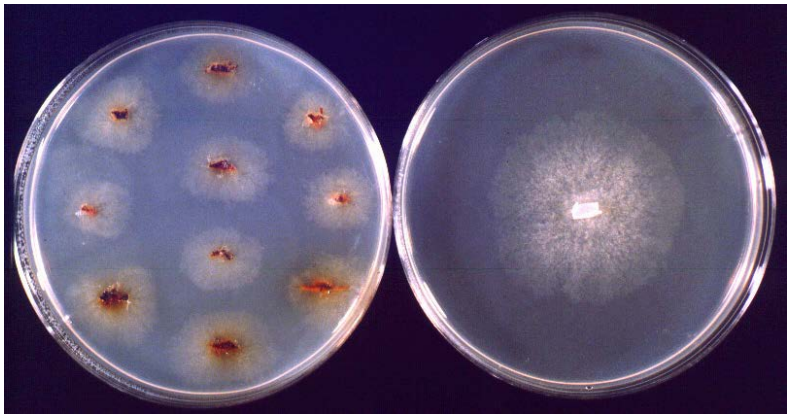


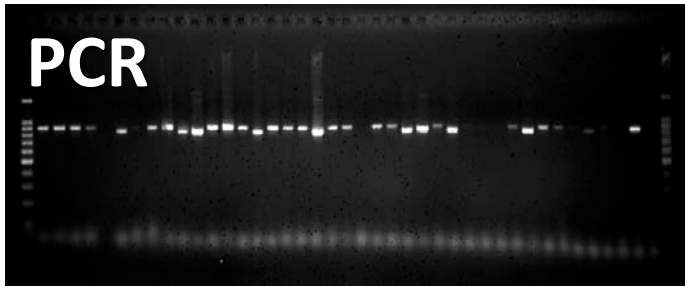
Attack of root crown, trunk; typical of *P. citricola*…

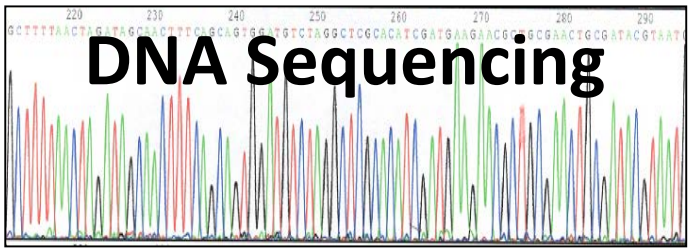
Phytophthora disease symptoms

Invasion of trunk under tree sleeves, *Phytophthora* sp.…

Phytophthora diagnostics





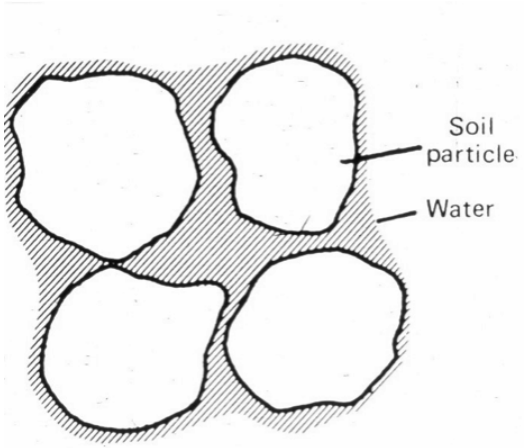


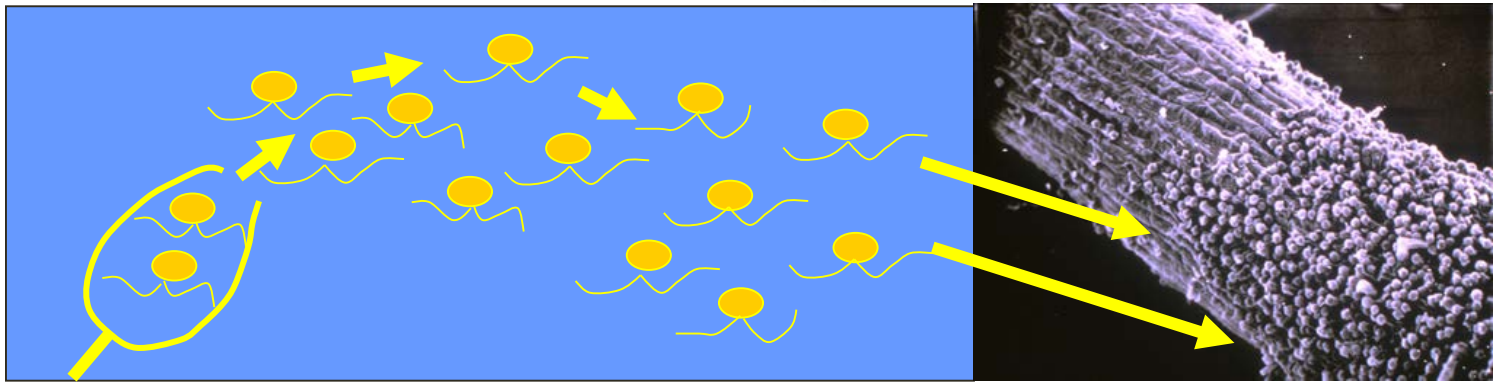
Species identification

Phytophthora and water, biology

Soil water saturation favors:

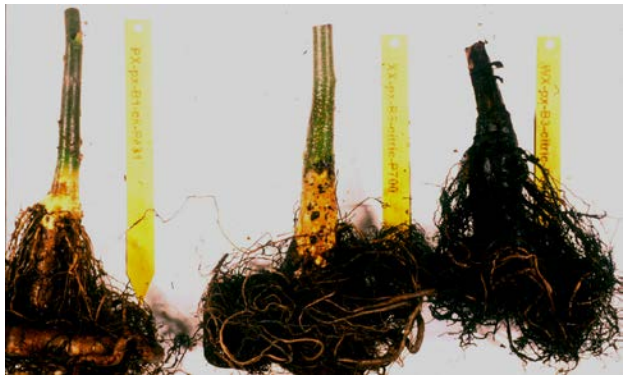
- **zoospore production**
- **zoospore dispersal**
- **zoospore attraction to roots**



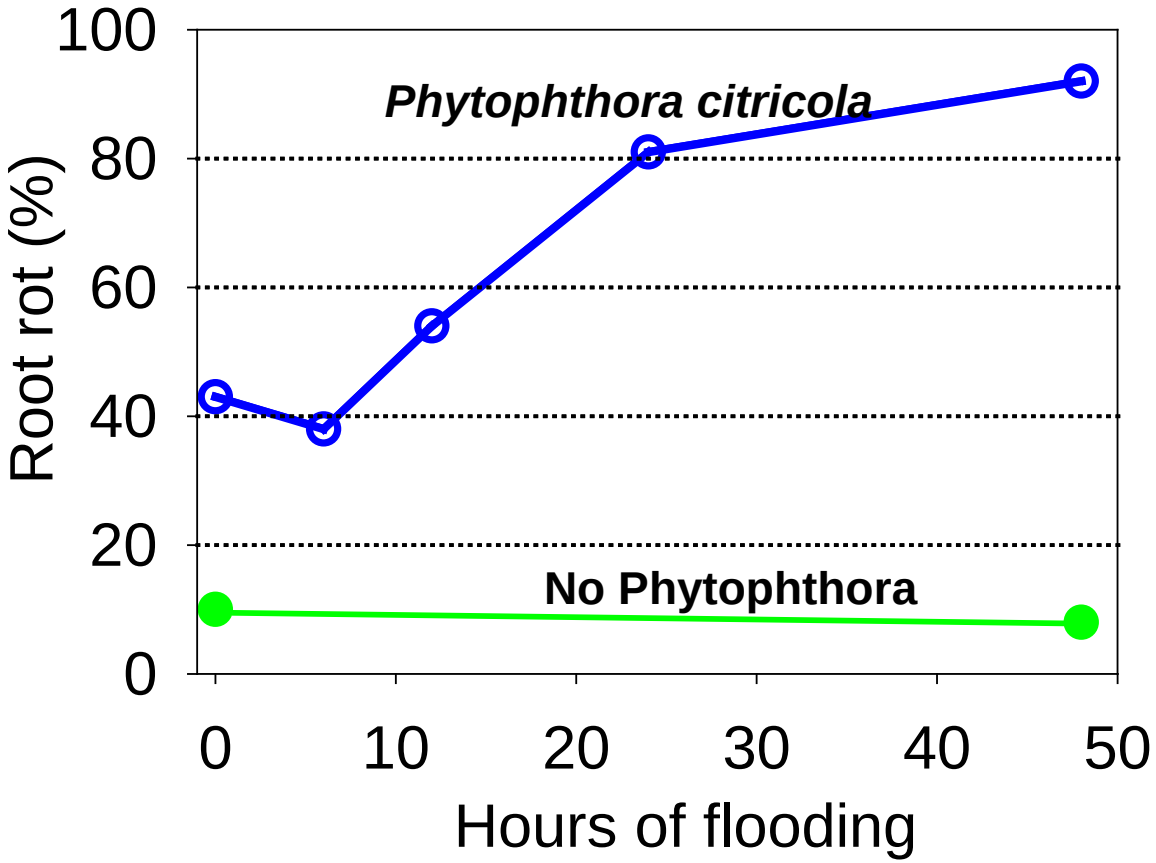


“Explosive potential…”

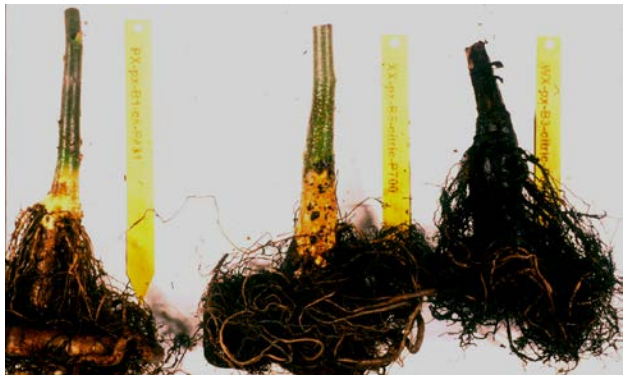
Phytophthora and water, biology



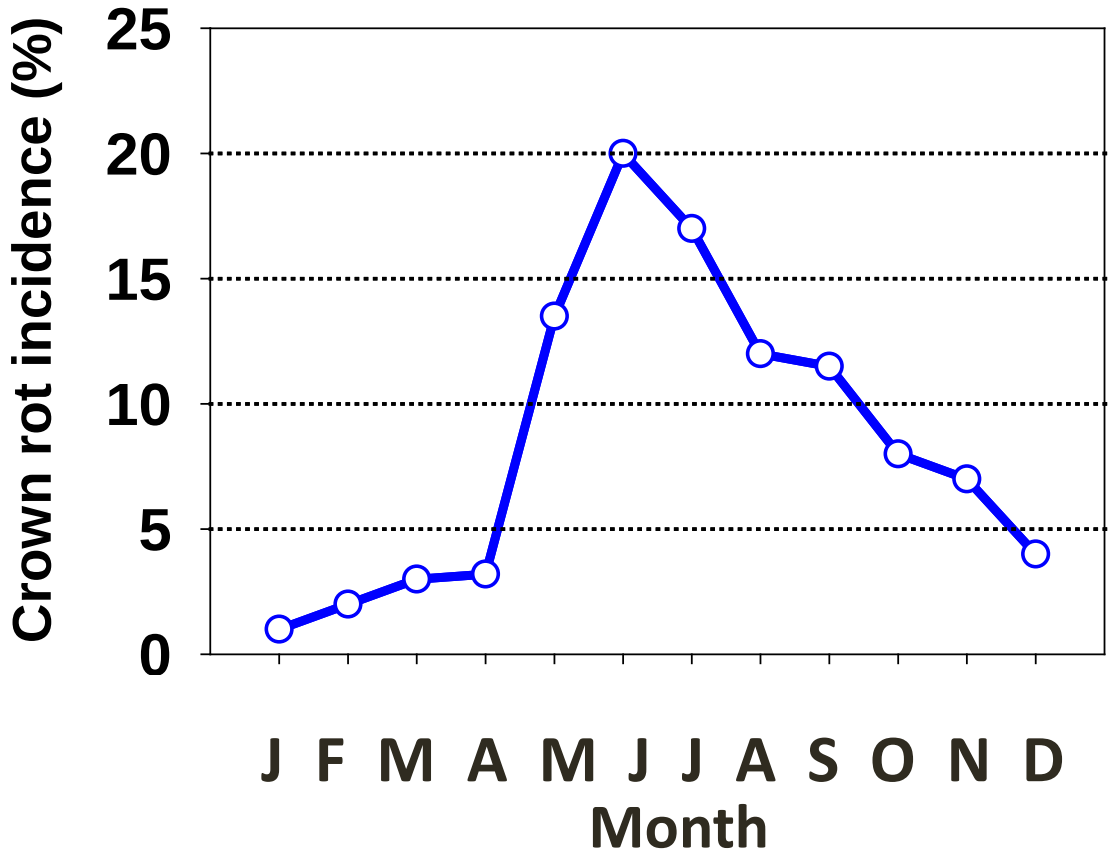
Interaction of *Phytophthora* with soil flooding



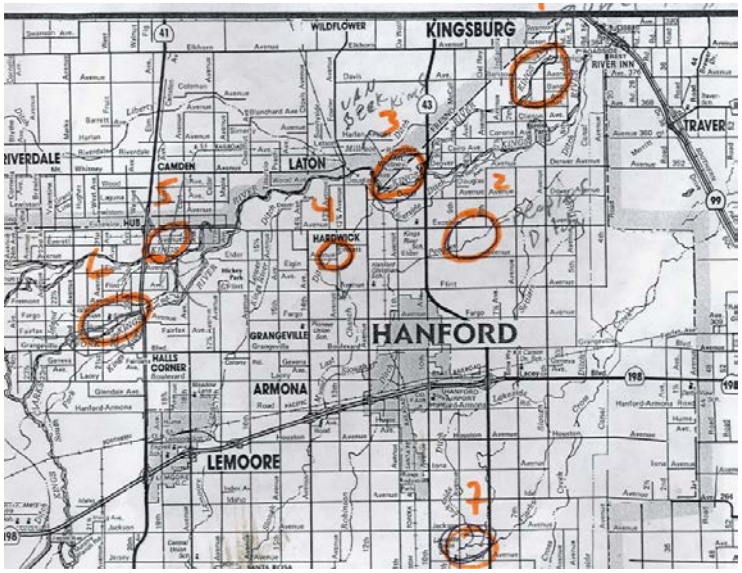
Phytophthora and water, biology



Seasonal modulation of susceptibility to *Phytophthora*



Phytophthora and water, biolgy



“Take-home message”: assume exposure, management matters…

Phytophthora and water, management

- Avoid introduction of *Phytophthora*
- Design and operate orchard & irrigation system to meet crop ET while avoiding prolonged soil water saturation
- Avoid >24 hr soil water saturation, especially when trees are active
- Berms, “splitters”, “cutout” patterns helpful

Managing *Phytophthora*- chemical approach

- Phosphonates (also known as phosphites), which contain HPO_3^{-2}, can suppress *Phytophthora* if applied properly-- trial at UCD

Managing *Phytophthora*- chemical

- Treatments:
  1 foliar spray
  and/or
  3 chemigations
  applied (Sept)

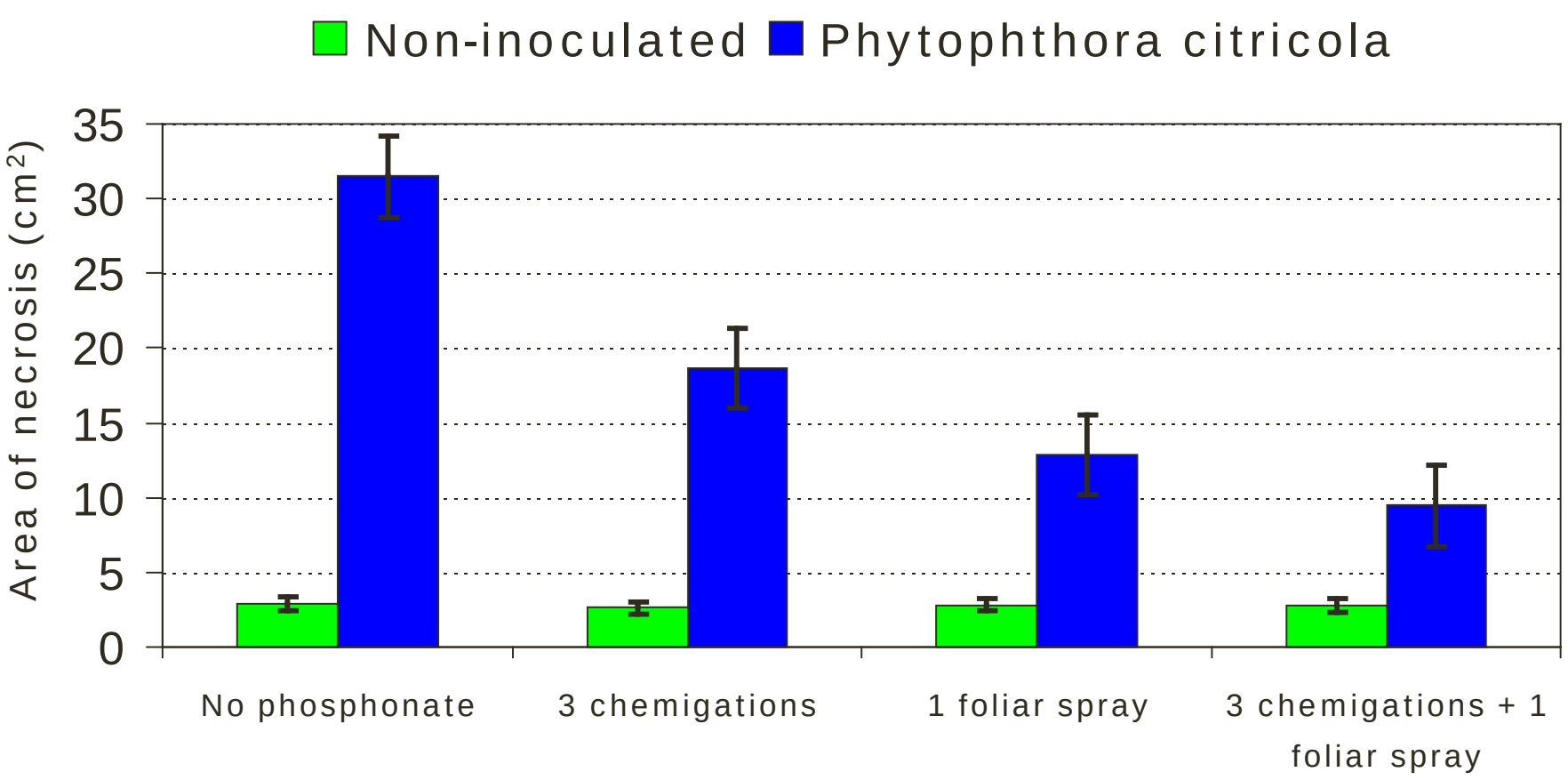
- Test inoculations following Oct-Dec and Apr-Aug

Results, UCD phosphonate trial

Efficacy of phosphonate treatments (3 qts./A),

-Trees inoculated 1 month after phosphonate treatments completed

-Cankers measured 3 months after inoculation



Phosphonates continued

- Need to stay abreast of updates on crop residue tolerances for phosphonates in EU
- California phosphonate advisory information available through Carl Eidsath, Technical Support Director: carl@walnuts.org
- When evaluating phosphonates, pay attention to PO_3 (phosphorous acid) content, the a.i.

Searching for rootstock resistance to *Phytophthora*

In diverse species and hybrids of Juglans from the NCGR and WIP…

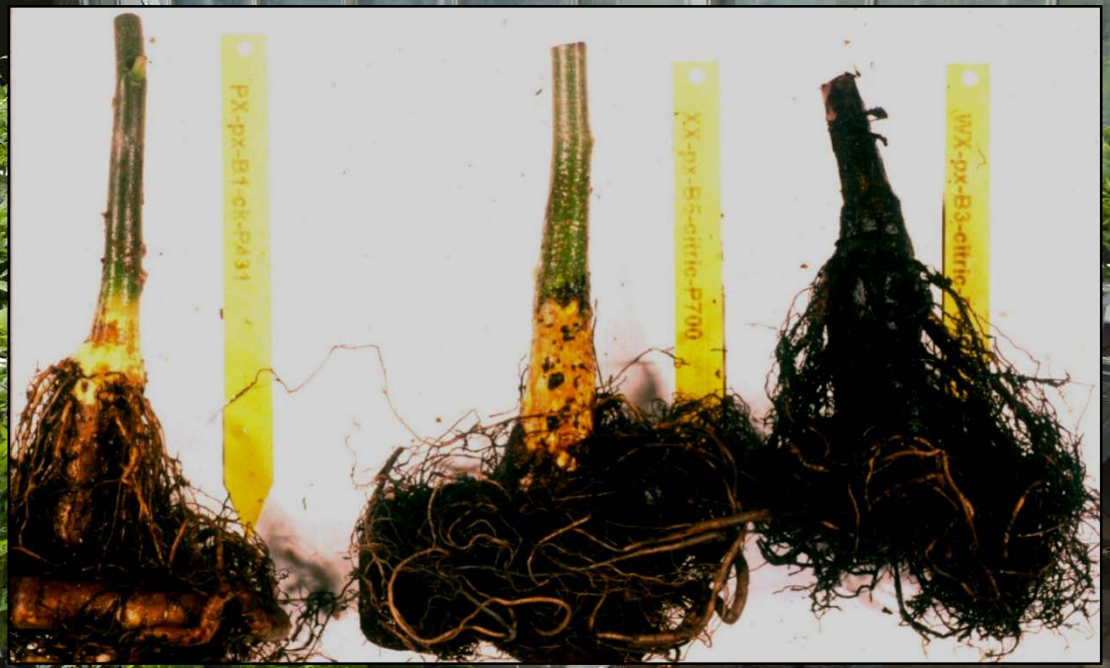
Assessing resistance to *Phytophthora*

2 to 3-month exposure to *P. cinnamomi*, *P. citricola*, Control

Assessing resistance to *Phytophthora*

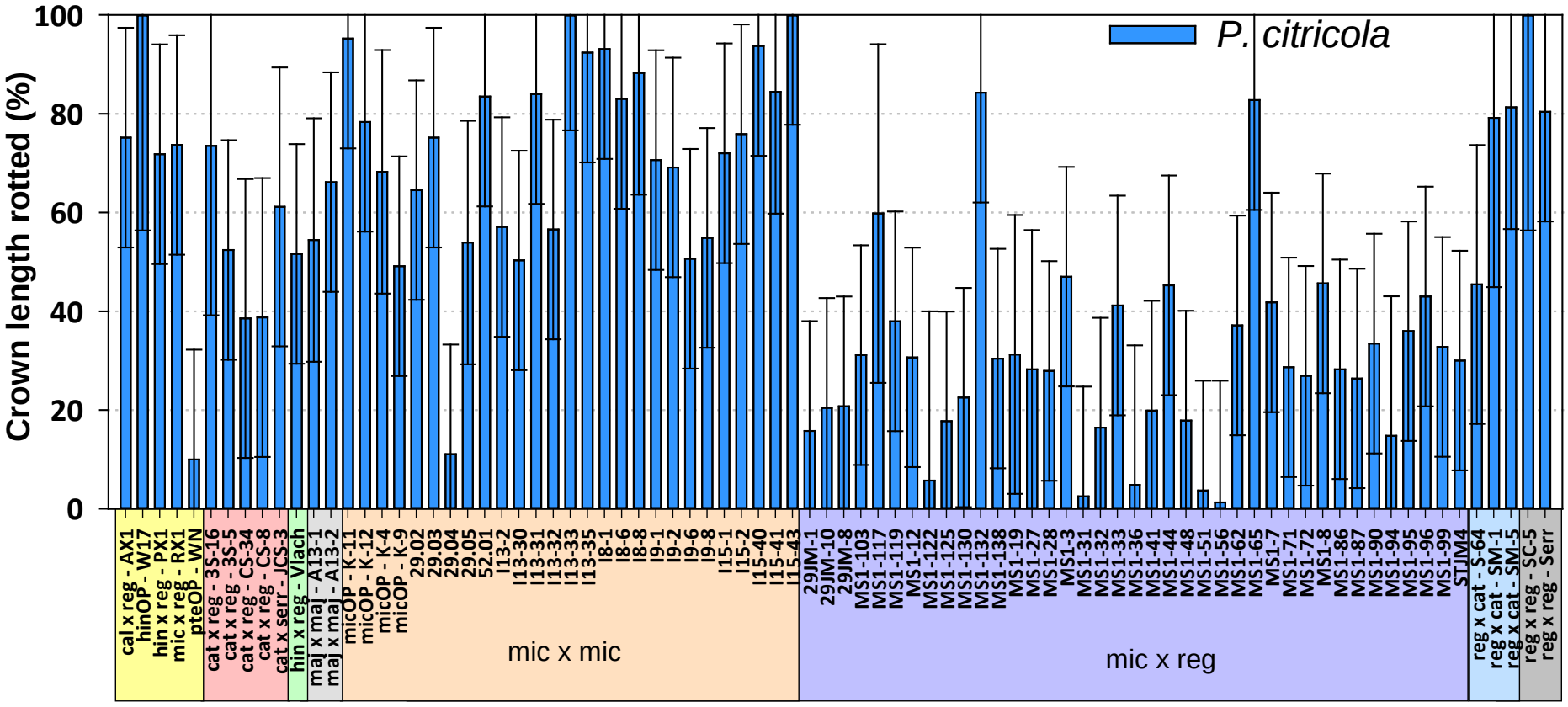
Resistance assessed according to:

- Survival duration; ratings, 0 to 5 scale)
- Crown length rotted (%) (measured)
- Root length rotted (%) (visual)



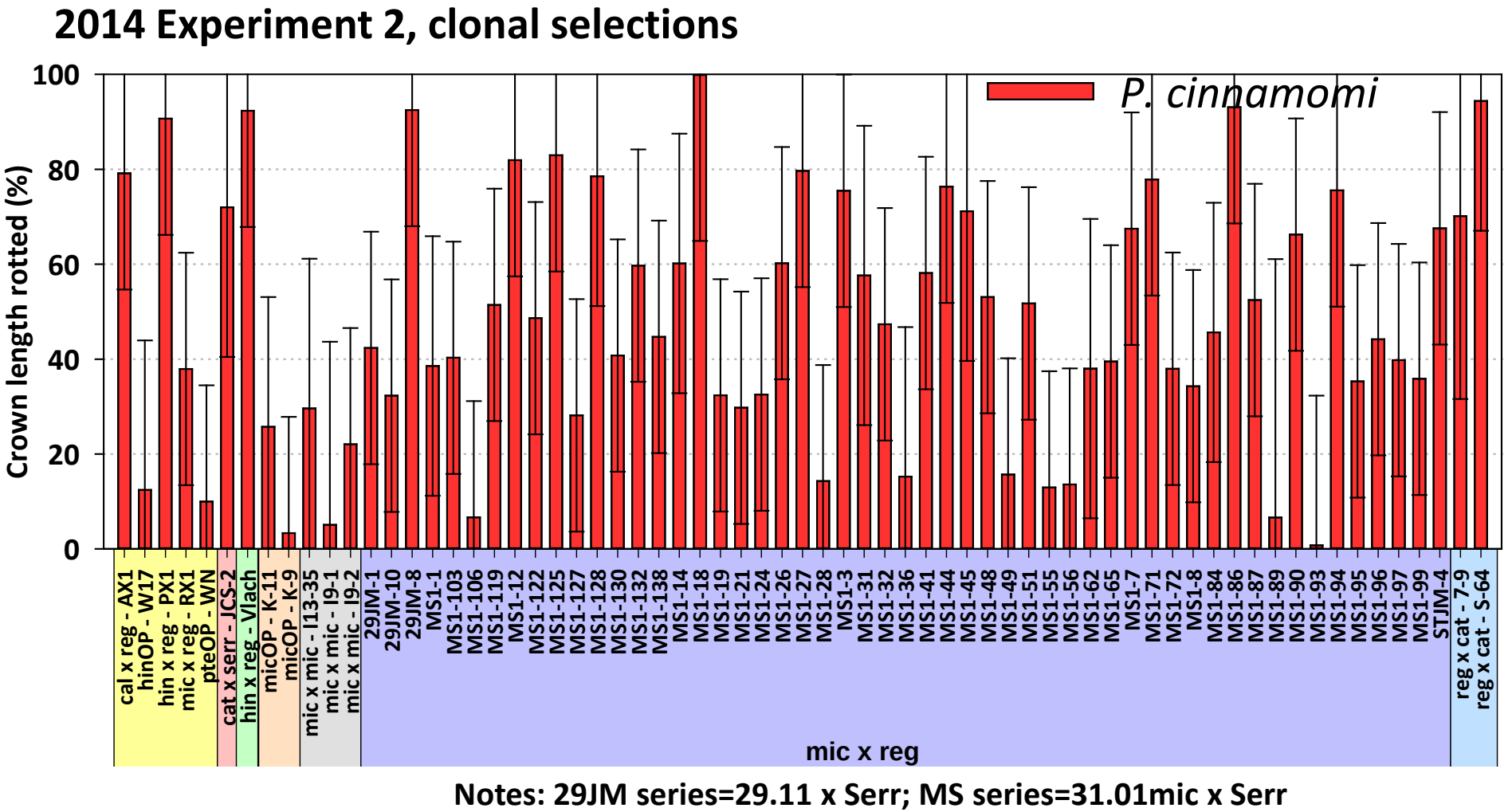
Assessing resistance to *Phytophthora*

2014 Experiment 1, clonal selections



Notes: MS=31.01mic x Serr

Assessing resistance to *Phytophthora*

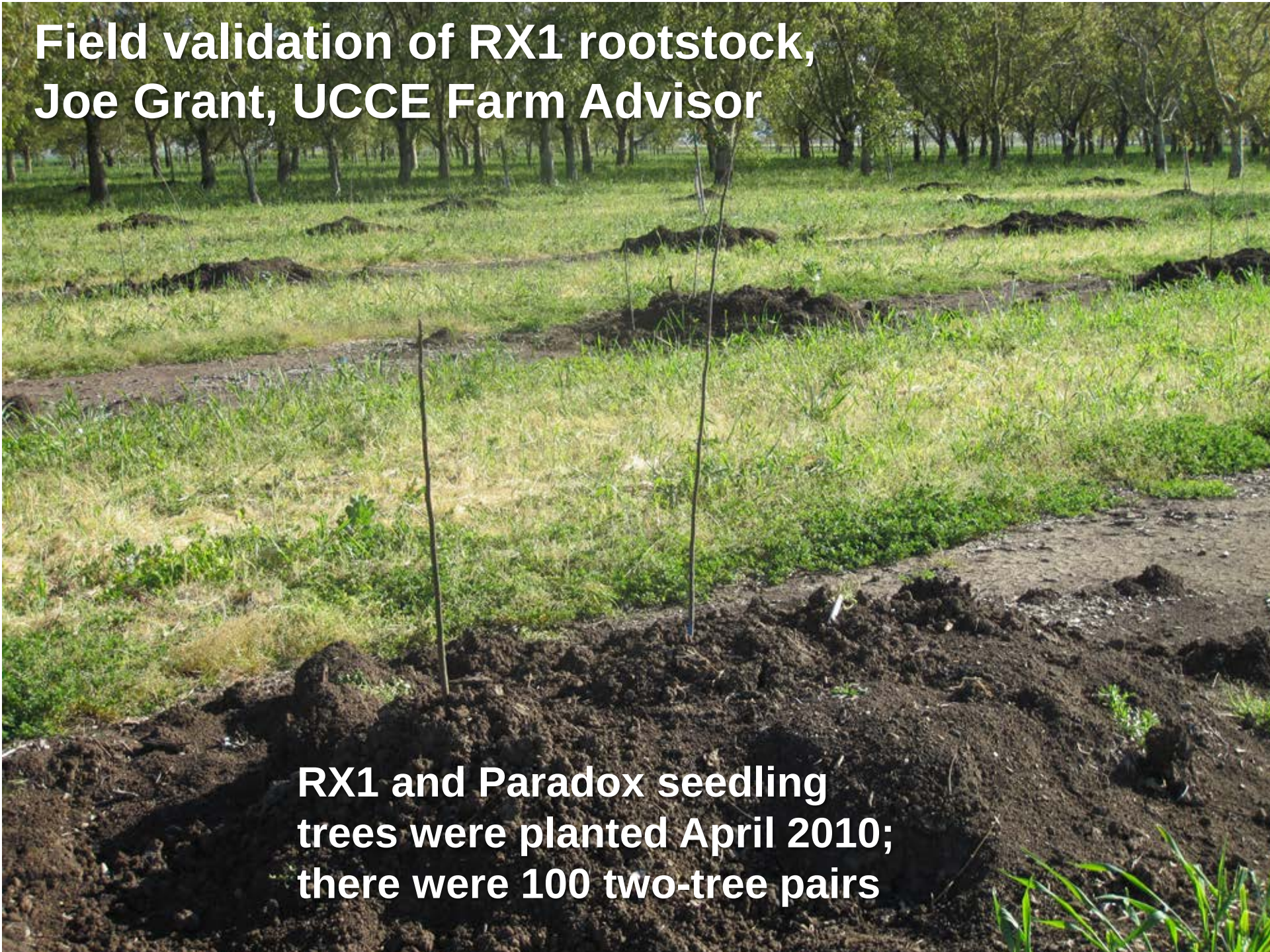


Notes: 29JM series=29.11 x Serr; MS series=31.01mic x Serr

Field testing of RX1 rootstock with Joe Grant, UCCE Farm Advisor

7-15-2003 **9-16-2011**

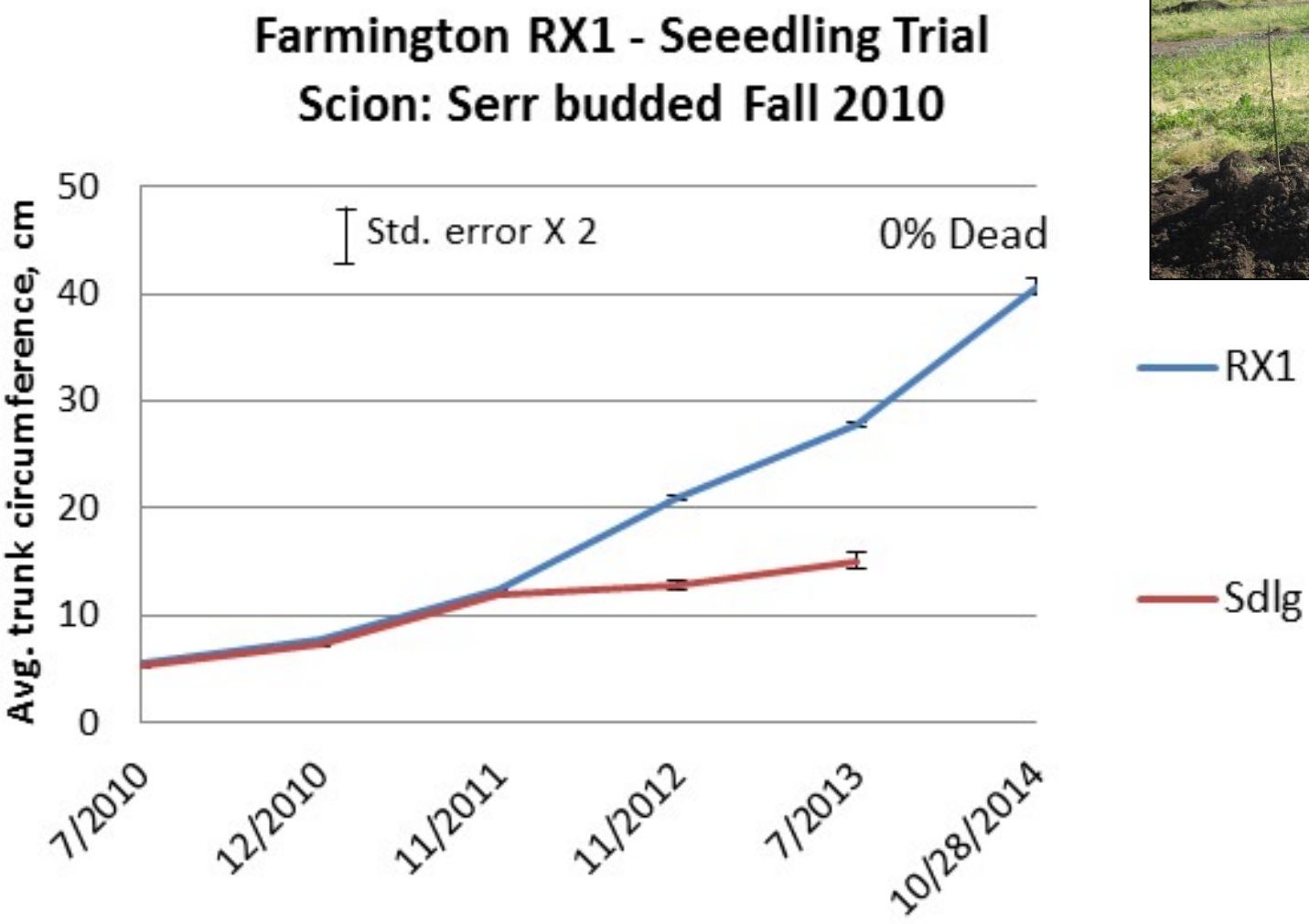
Orchard area infested with *P. cinnamomi*


Field validation of RX1 rootstock,
Joe Grant, UCCE Farm Advisor
RX1 and Paradox seedling
trees were planted April 2010;
there were 100 two-tree pairs

Field testing RX1
(trees planted 2010 Joe Grant)

Yr	Rootstock	Mortality (%)
2010	Pdx sdg.	0
	RX1	0
2011	Pdx. sdg.	17 (+6)
	RX1	0
2012	Pdx. Sdg.	31 (+17)
	RX1	0

****P. cinnamomi* isolated from 54% of dead trees and 21% of poorly growing trees (2012).**



Data of Joseph Grant

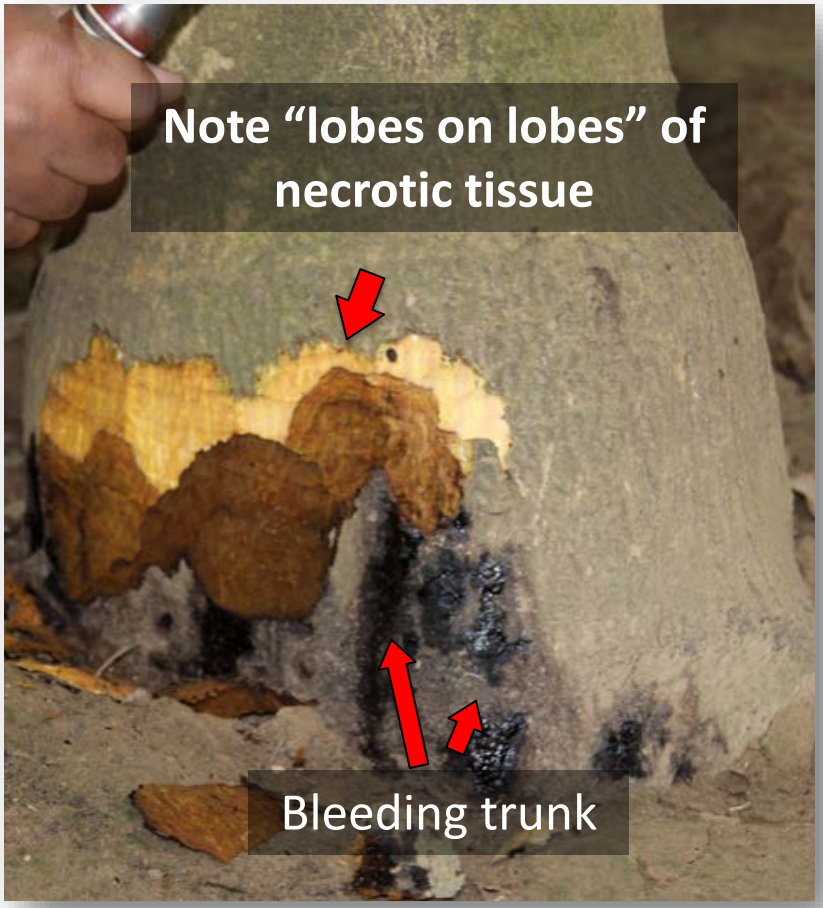
Not Phytophthora!

Photos by Bob Beede

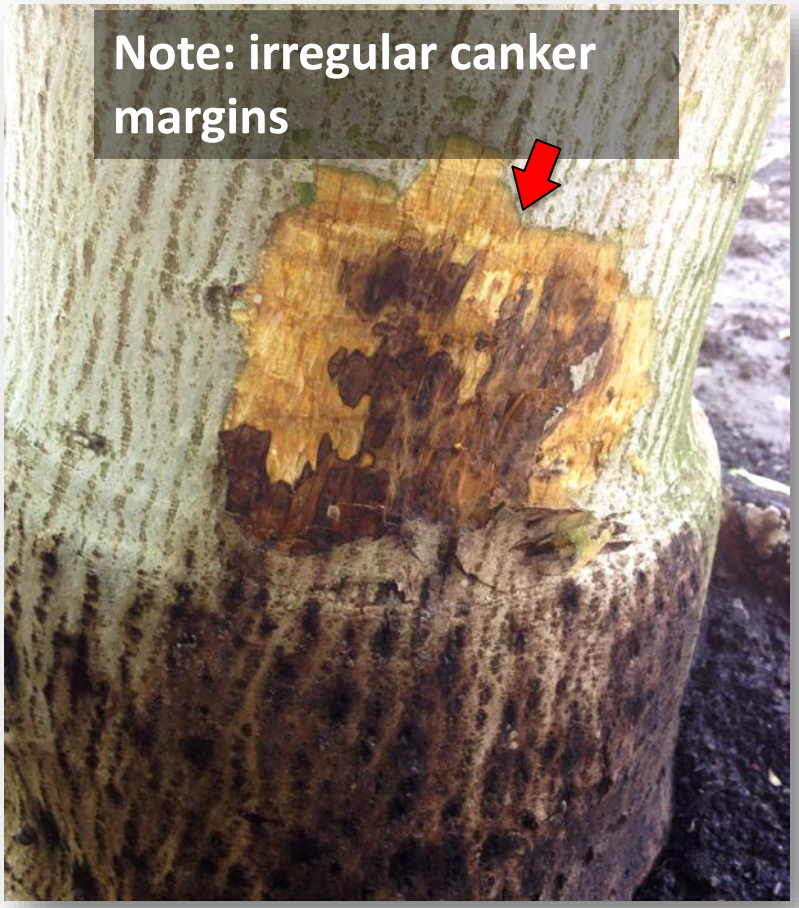
Paradox canker, aka. “Lethal paradox canker” (LPC)

Photos by E. Fichtner

Discriminating between LPC and Phytophthora cankers



Lethal Paradox canker



Phytophthora canker

Symptoms of other canker diseases in walnut

Phytophthora trunk canker

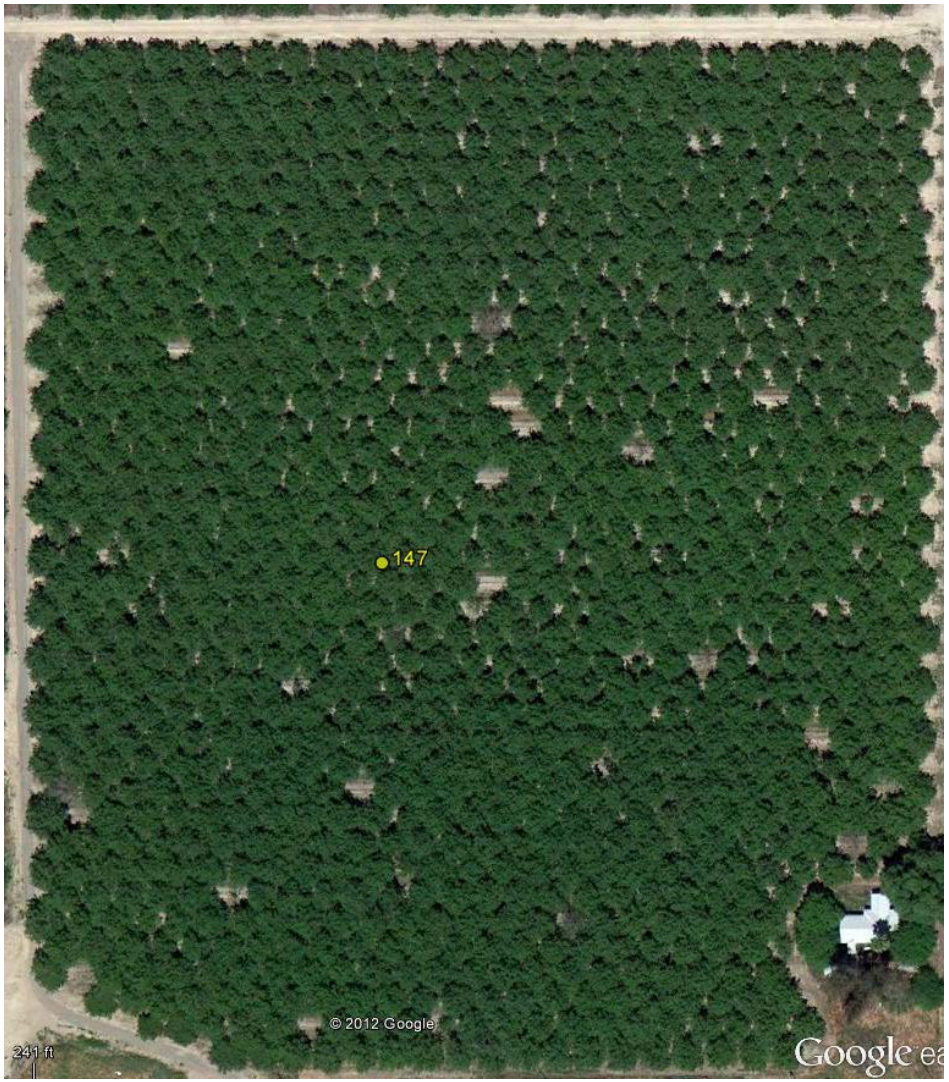
Deep/shallow bark canker

Blackline (CLRV) canker on Pdx

Thousand cankers disease

Paradox canker- “An emerging problem”

Near Tehama

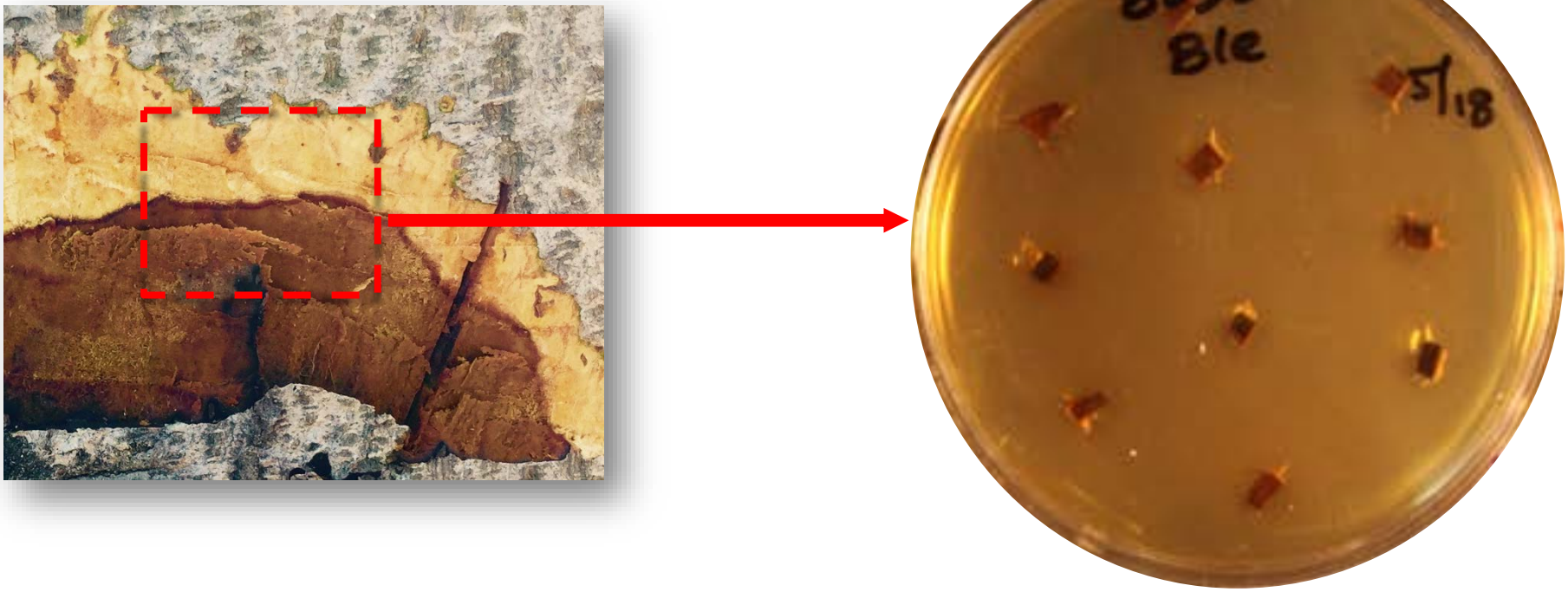


Near Hanford

Distribution of LPC in California

- Fresno
- Tulare
- Kings
- Yolo
- Colusa
- Sutter
- Yuba
- Tehama

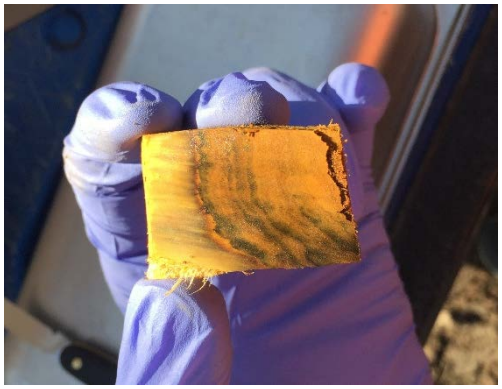
Determining the unknown cause of LPC



To date no culturable organism has consistently been associated with LPC

Culture-independent approach to LPC etiology:

Metagenomic Next Generation Sequencing of DNA and RNA



H. Gouran

Nucleic acid extraction (DNA/RNA)

Concluding management considerations

Armillaria and Phytophthora:

- **Site selection, history, sanitation** are the foundation, avoid spread
- **Fumigation** benefit temporary
- **Rootstock selection** critical, resistance available- know your soilborne pathogen(s), keep abreast of rootstock improvements
- **Orchard and irrigation system design**, **operation:** meet crop ET, avoid prolonged soil water saturation, keep root crown region dry

Phytophthora only:

- **Phosphonates** suppress *Phytophthora*, but be aware of EU-based crop residue advisories

Paradox canker:

- **We need to determine cause,** experimenting with various Paradox clones as replacements for lost trees may offer insights


Thank You!