The Effect of *Phytophthora ramorum* on the Physiology and Xylem Function of Young Tanoak Trees

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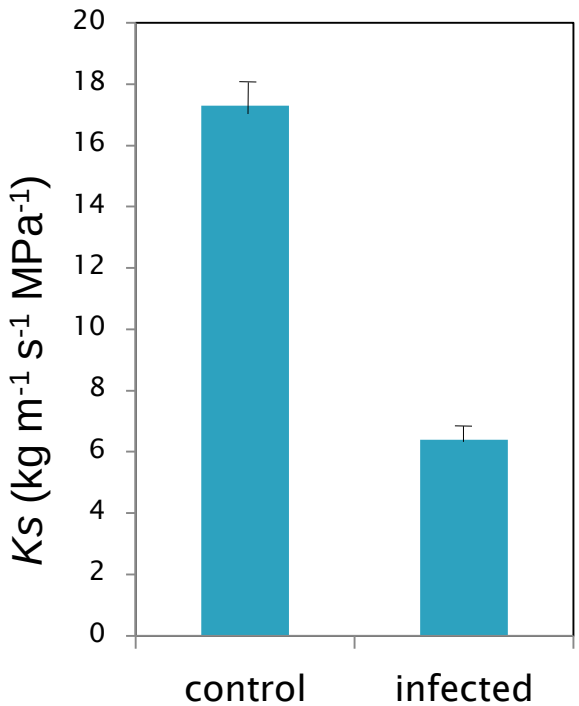
Proposed mechanisms of pathogenesis

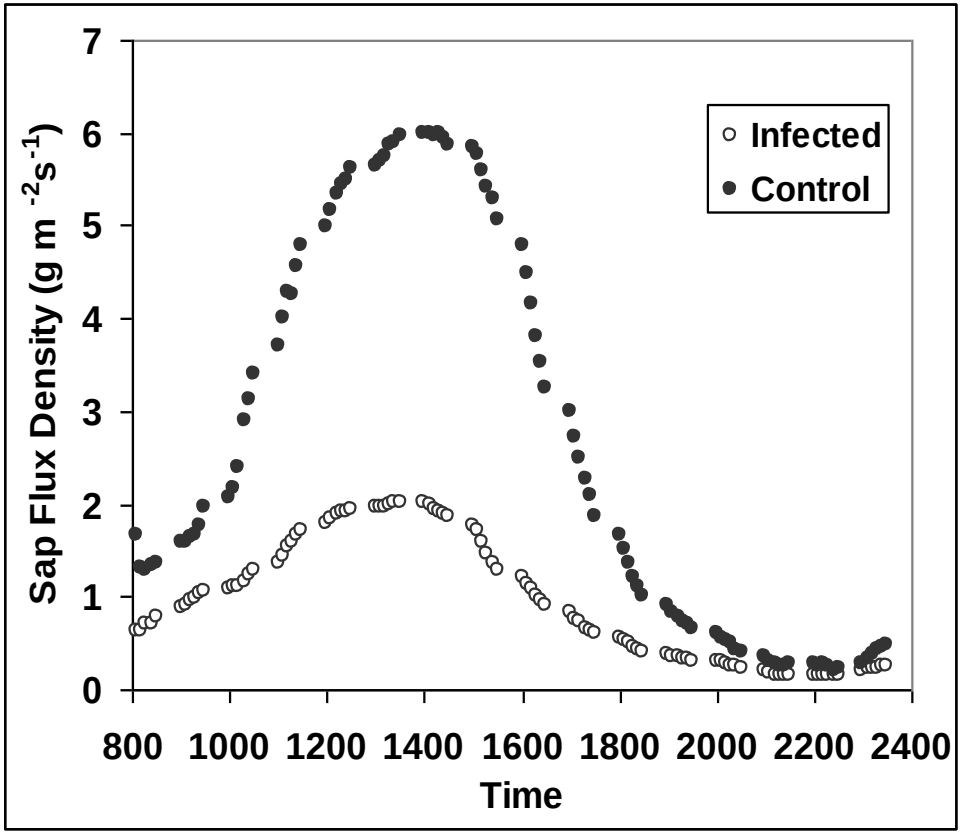
1. Phloem invasion, cambium death, stem cankers (“girdling”)
2. Xylem invasion leading to reduced hydraulic conductivity and drought stress
3. Elicitins act as toxins; interfere with photosynthesis

Evidence for hypothesis #2: plants die from drought stress

Reduced hydraulic conductivity, k_s



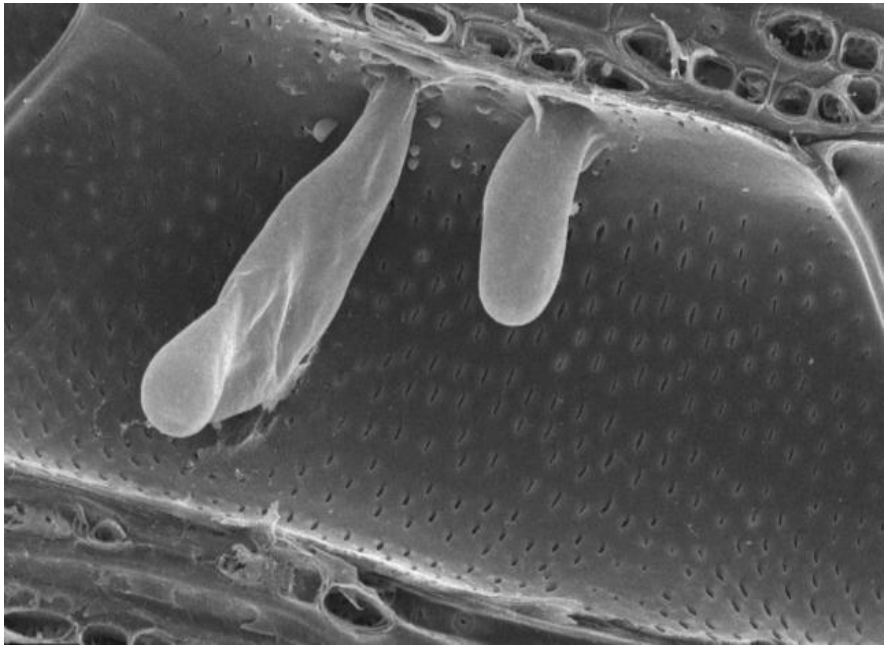
Reduced sap flux



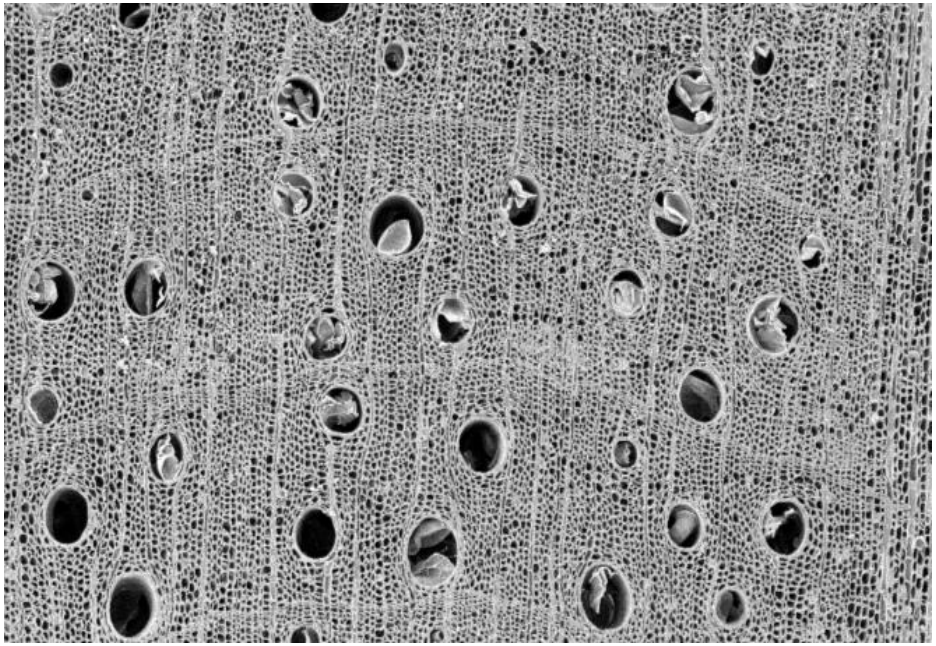
Parke *et al.* 2007

Increased tyloses

Tyloses in a tanoak vessel



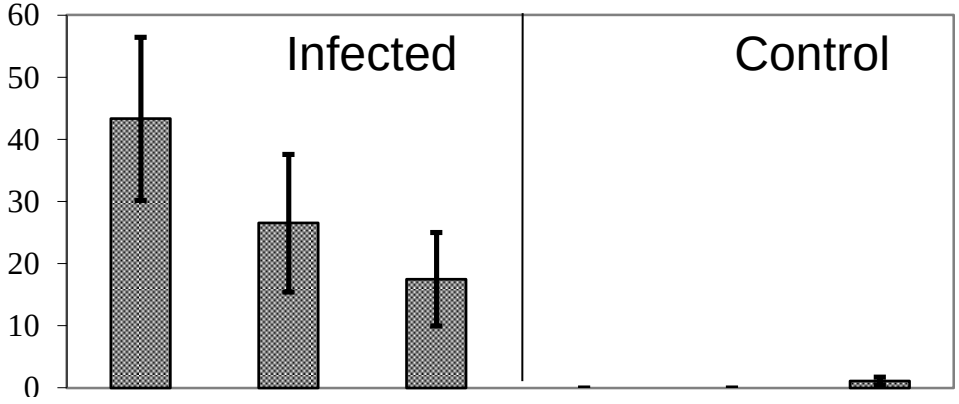
Tyloses occluding vessels in tanoak xylem



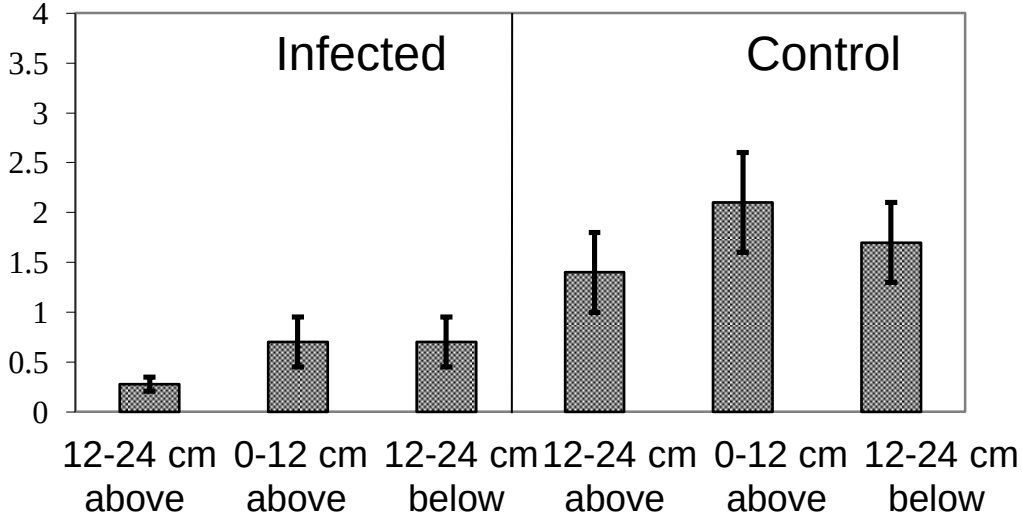
Parke et al. 2007

Tyloses and K_s from stem sections above and below the wound/inoculation site – 14 mo.

Tylosis occurrence (% of vessels occluded in xs)



K_s
(kg m^{-1} s^{-1} MPa^{-1})



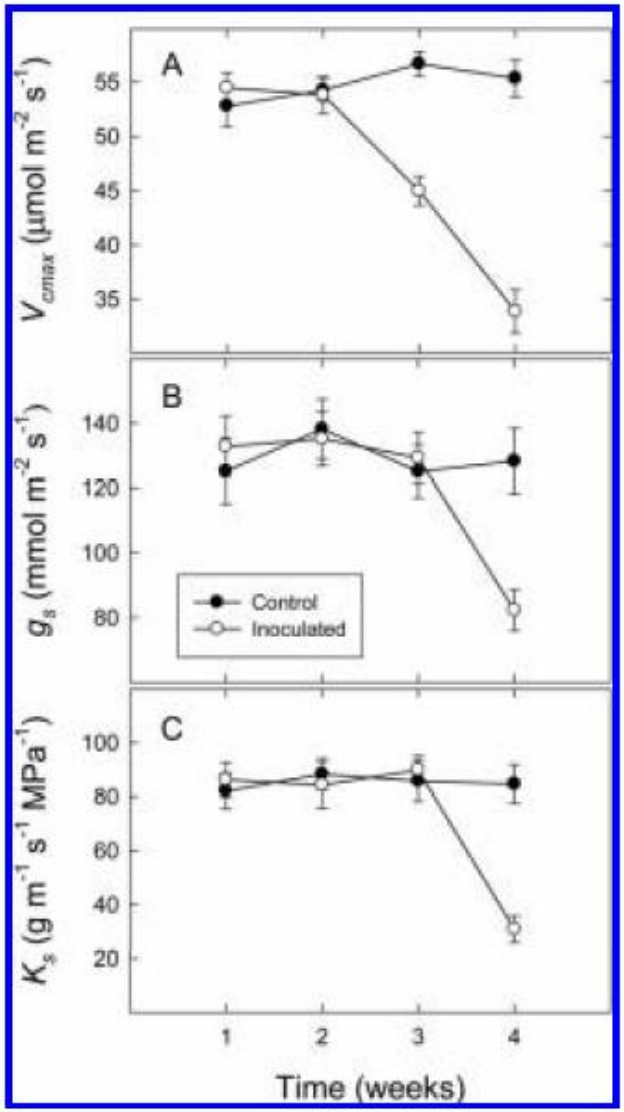
Collins *et al.* 2009

Pathogenesis

- Hypothesis #3: Elicitins act as toxins and cause disease symptoms.

Manter *et al.* 2007

(Rhododendron)



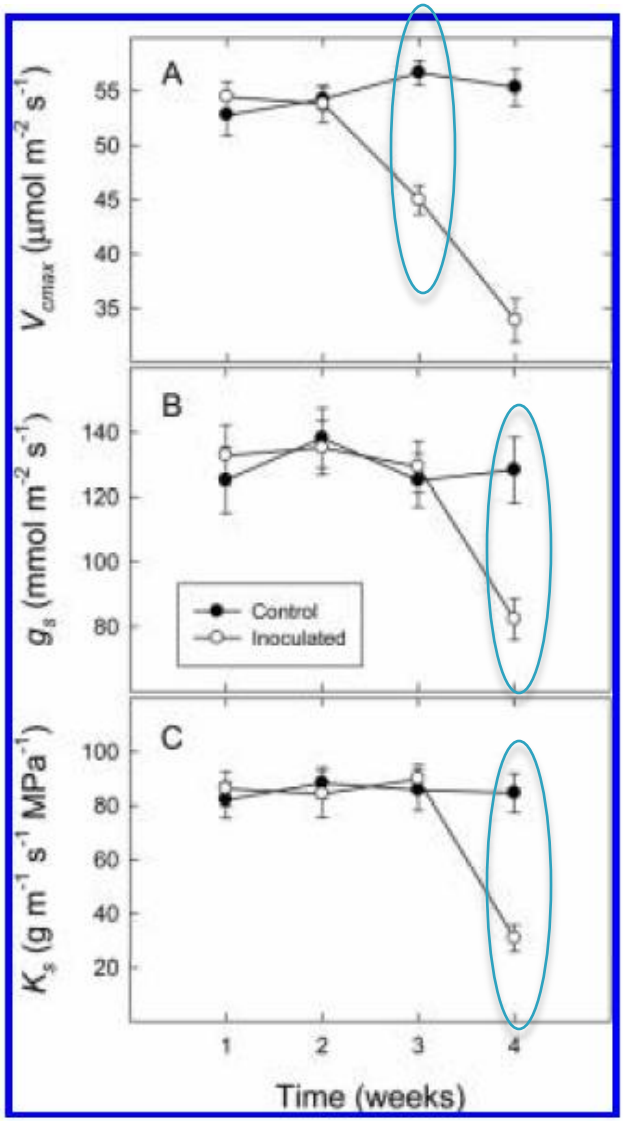
Max velocity of Rubisco

Stomatal conductance

Specific hydraulic conductivity

Pathogenesis

- Hypothesis #3: Elicitins act as toxins and cause disease symptoms.



Max velocity of Rubisco

Stomatal conductance

Specific hydraulic conductivity

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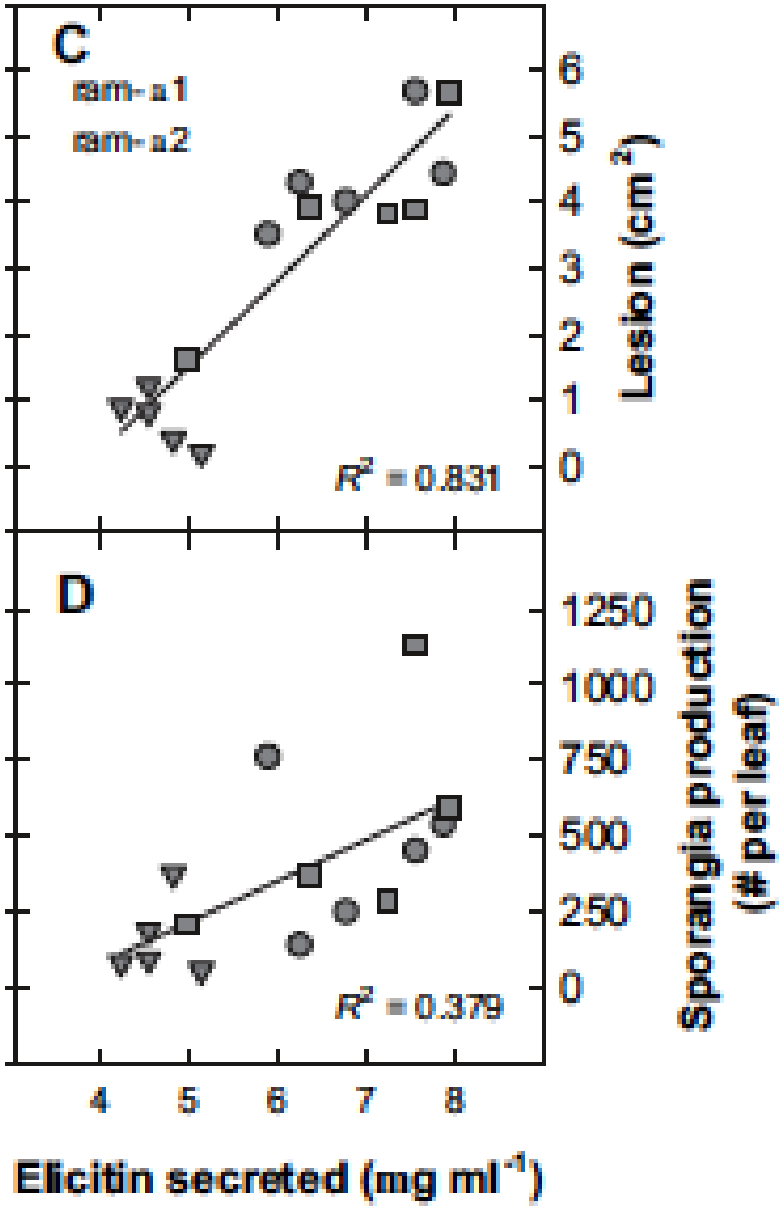


Manter, Parke, Hansen 2010

Research Questions

- How does *P. ramorum* infection impact physiological processes in tanoak? – what happens first?
- Does *P. ramorum* infection impact conductive properties of xylem tissue?
- Is elicitin secretion related to symptom severity?

Materials and Methods: Growth chamber experiments

- Tanoak saplings
  - Photosynthesis/stomatal conductance
  - Water usage
  - Stem specific hydraulic conductivity
  - Tylosis frequency
- Tanoak seedlings (repeated)
  - Photosynthesis/stomatal conductance
  - Water usage
  - Stem specific hydraulic conductivity

Materials and Methods– tanoak saplings

- Two-year-old tanoaks inoculated with:

Treatment	Lineage	Elicitin production (µg/ml)
PR-07-058 High Elicitin	NA2	7.23 a
4353 Low Elicitin	NA1	4.52 b
Wounded control	-	-

n = 20/treatment

Materials and Methods– tanoak saplings

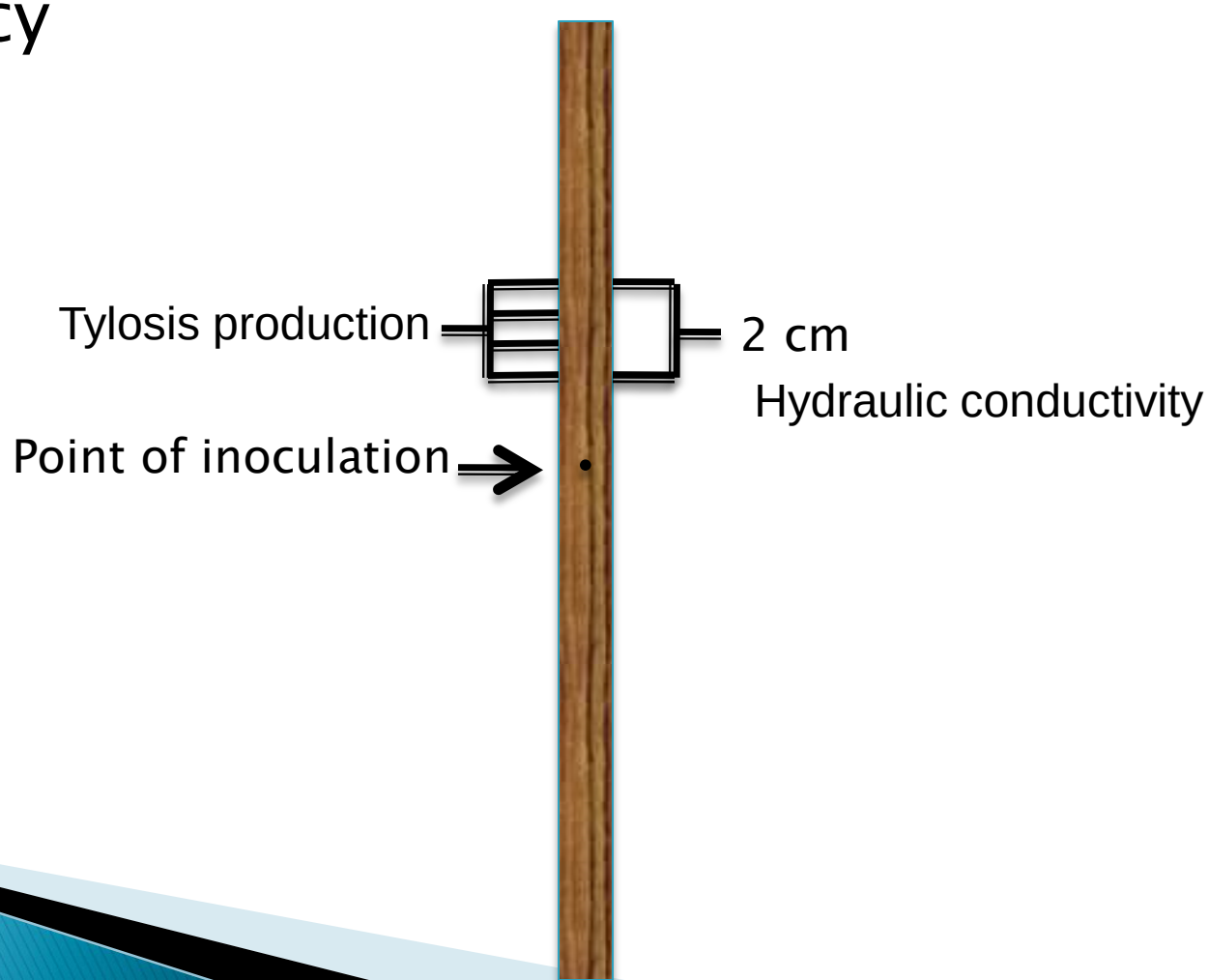
- Photosynthesis/stomatal conductance : Average of three top leaves

Materials and Methods– tanoak saplings

- Water usage

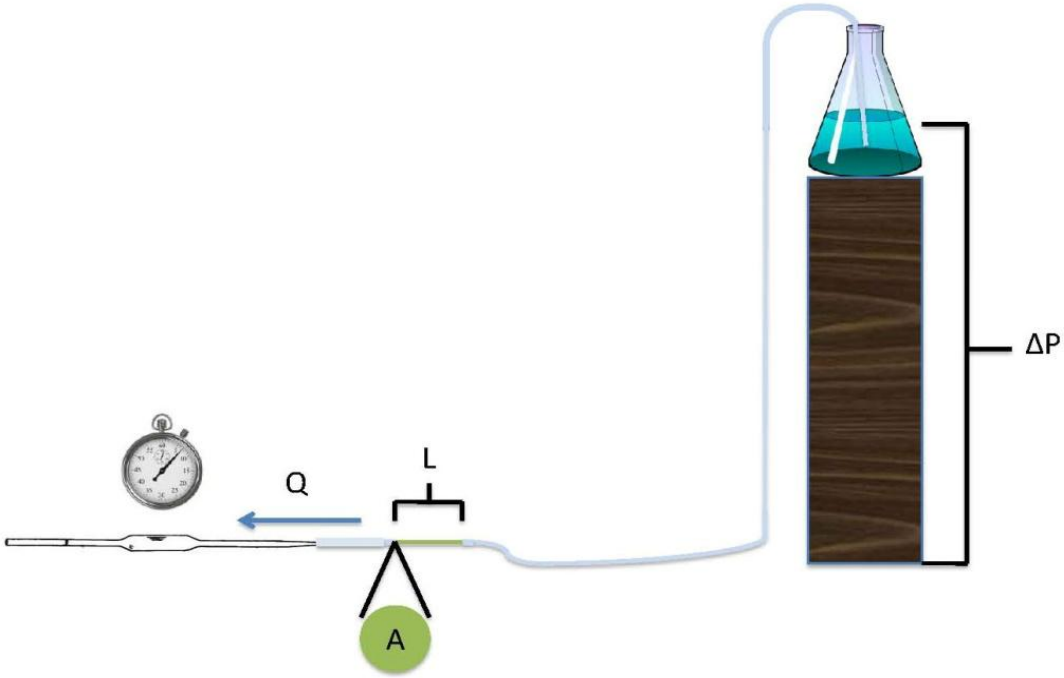
Materials and Methods– tanoak saplings

- Stem specific hydraulic conductivity/tylosis frequency



Materials and Methods– tanoak saplings

- Stem specific hydraulic conductivity



Darcy's Law:

$$Ks = (Ql)/(A\Delta P)$$

Q = volume flow rate

L = length of sample

A = cross-sectional area of conductive tissue

ΔP = pressure difference = height of liquid supply

K_s = specific conductivity

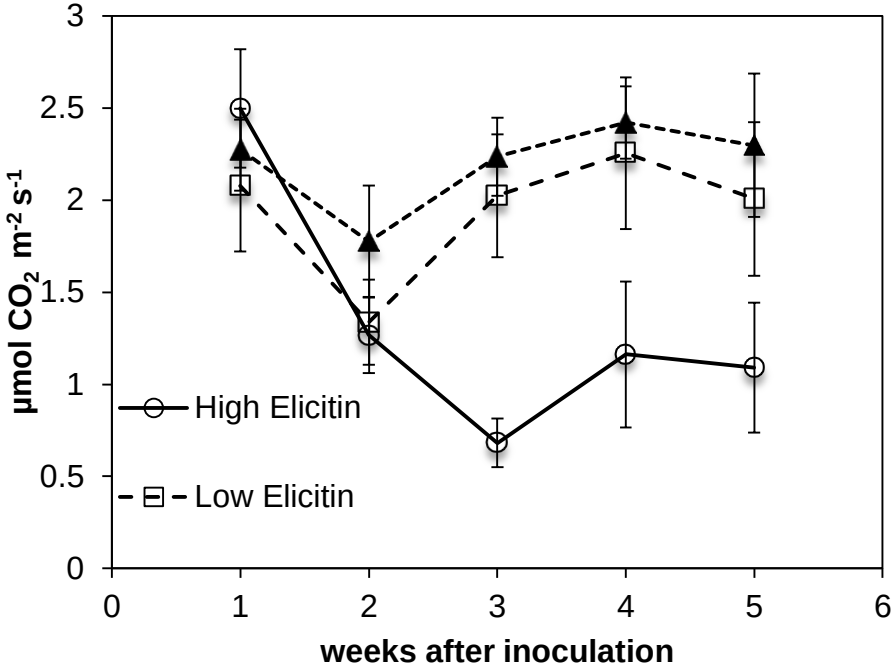
Results – tanoak saplings

Infected tanoak stem

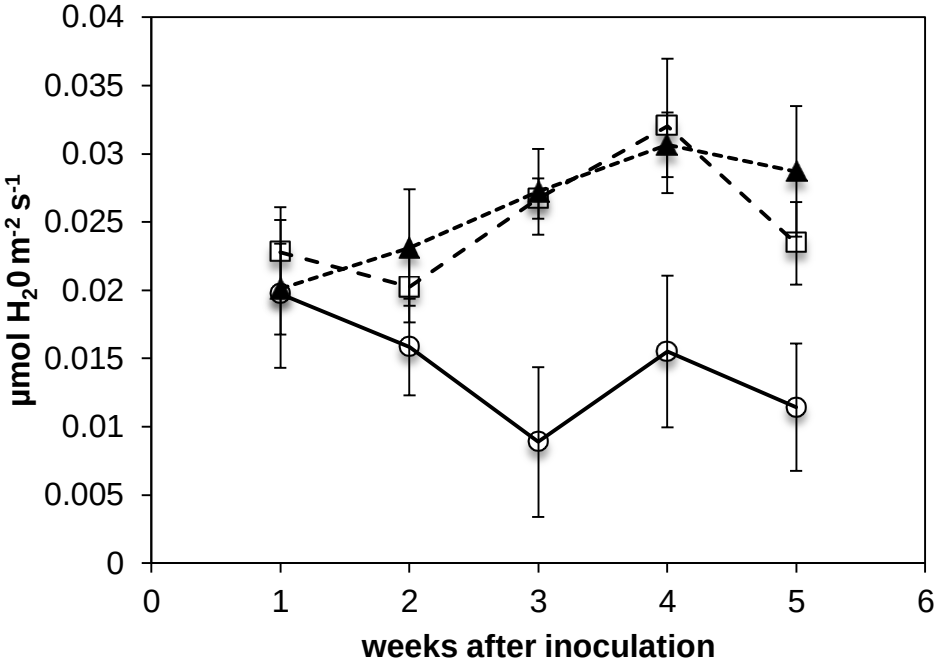
Necrotic xylem tissue

Results – tanoak saplings

Photosynthesis

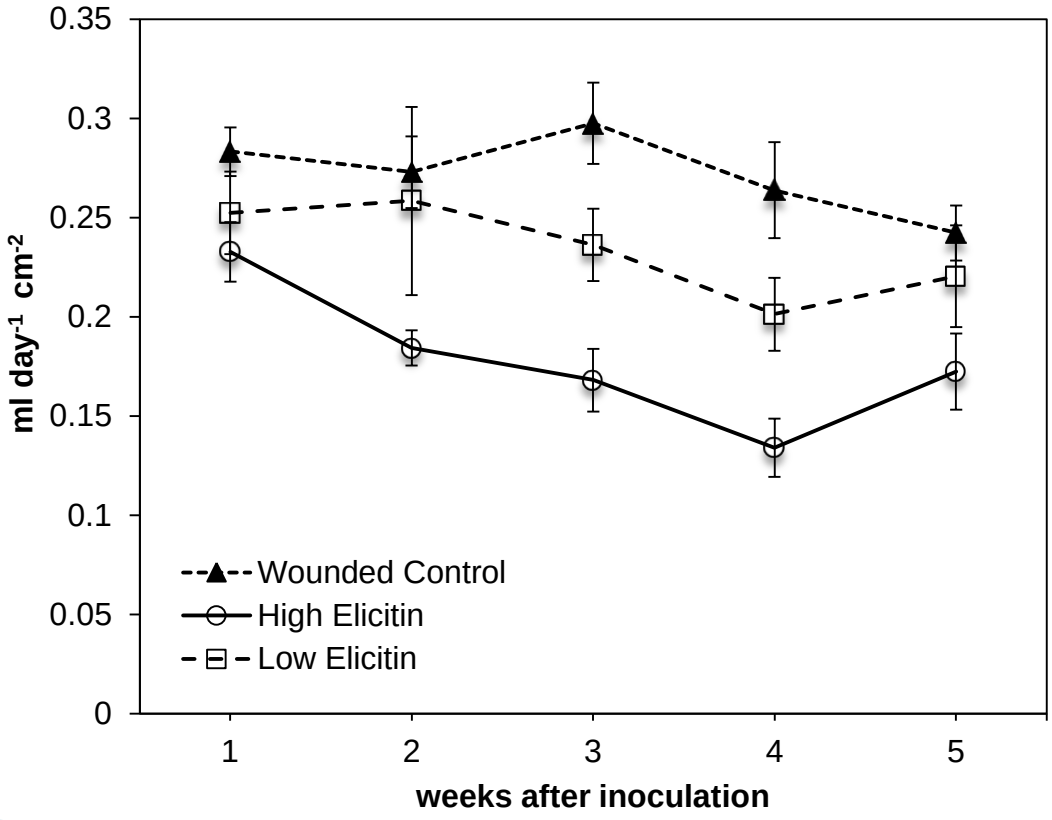


Stomatal conductance



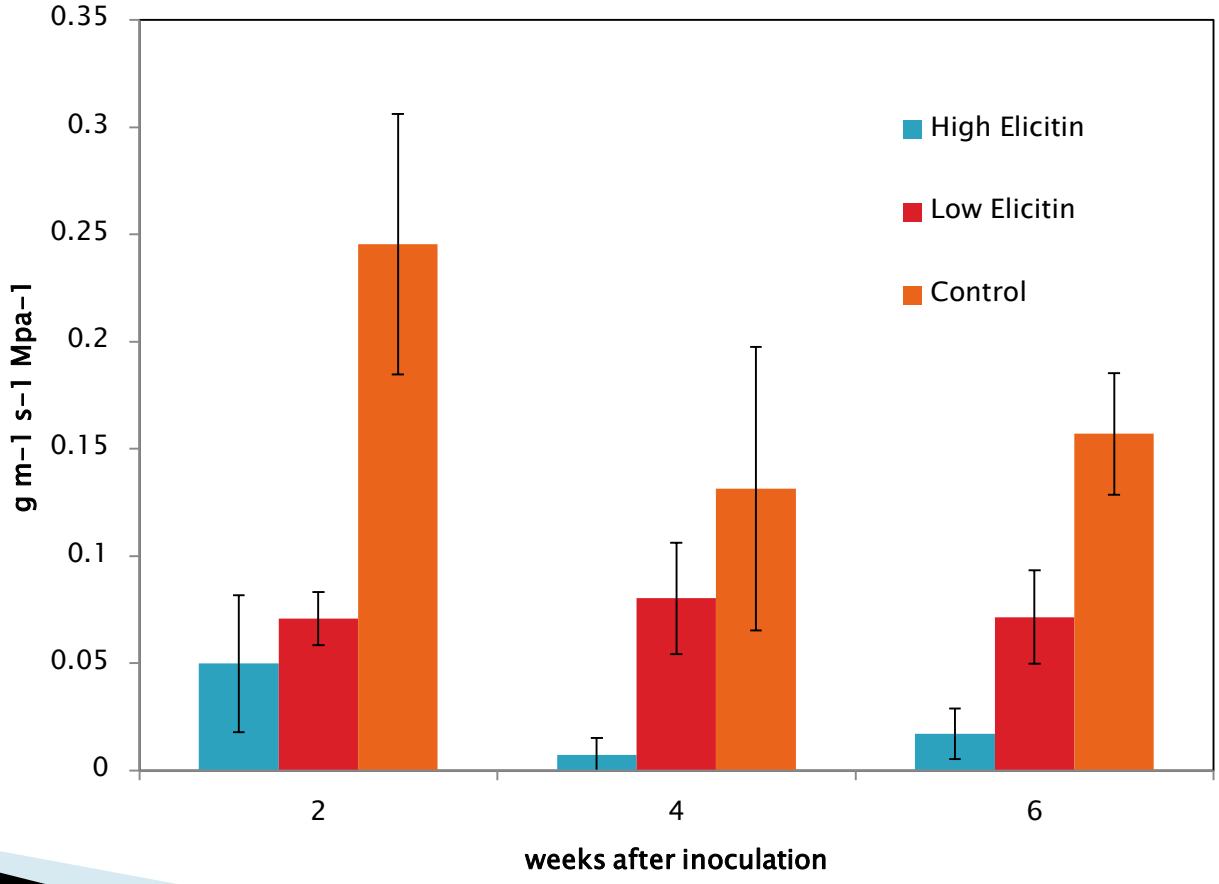
Results – tanoak saplings

- Water usage



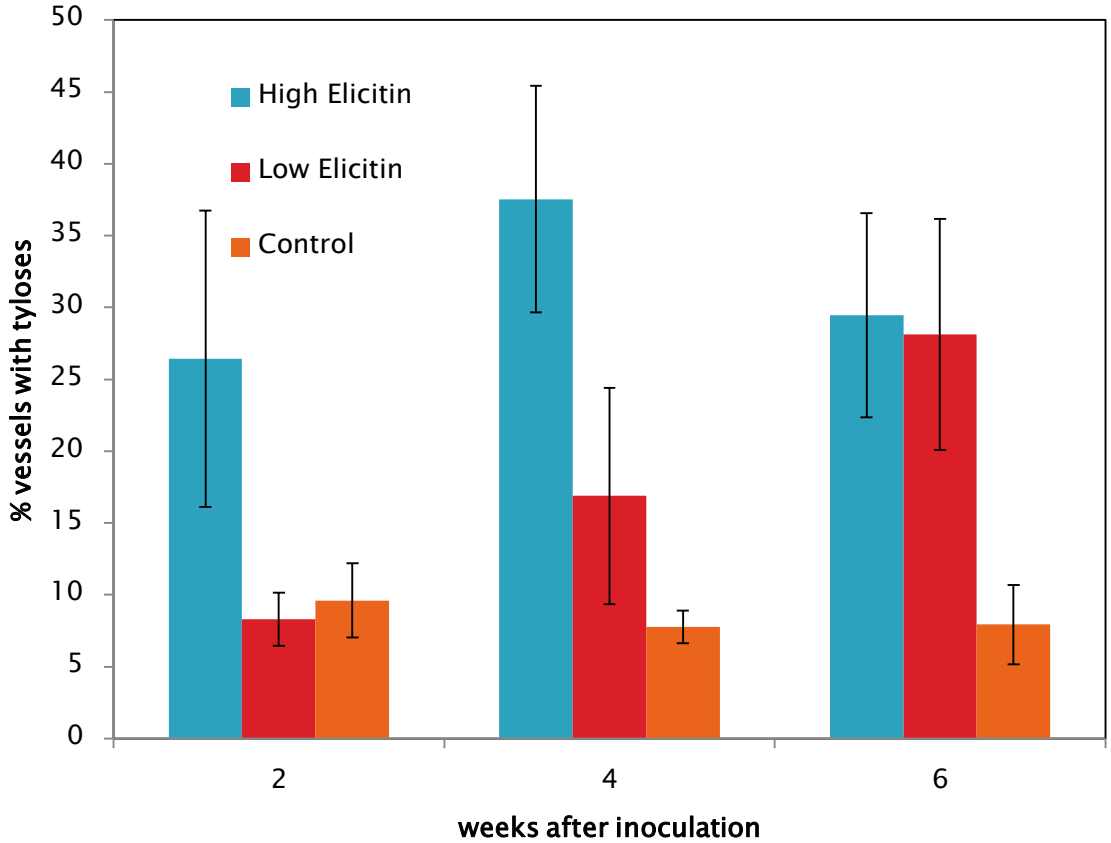
Results – tanoak saplings

- Stem specific hydraulic conductivity



Results – tanoak saplings

- Percentage of vessels with tyloses



Results – tanoak saplings

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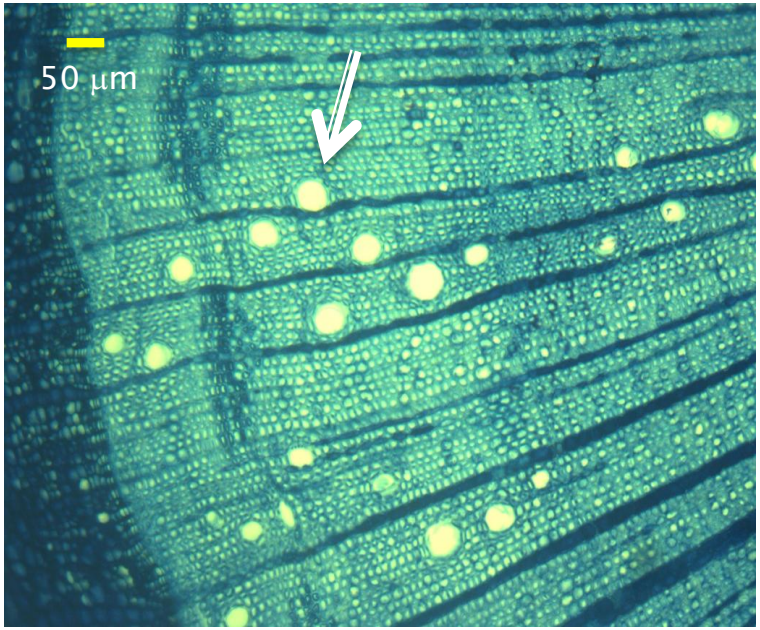
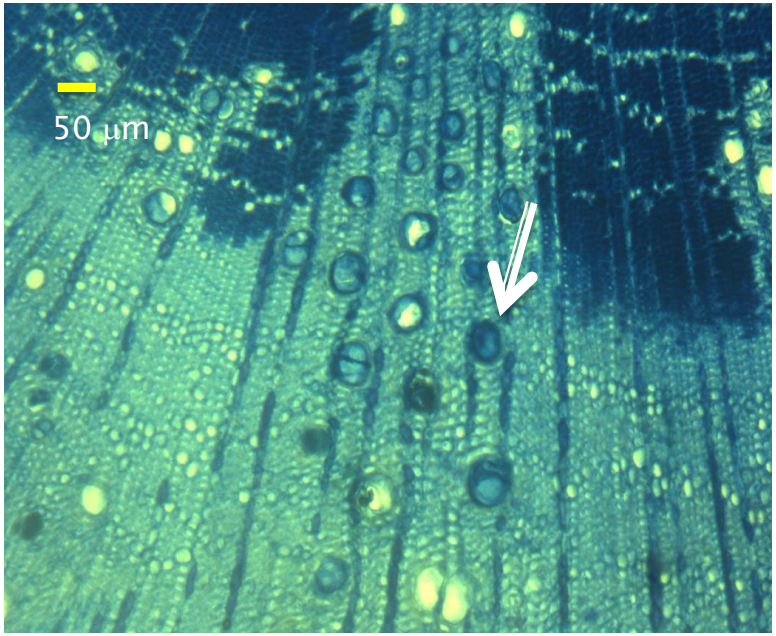


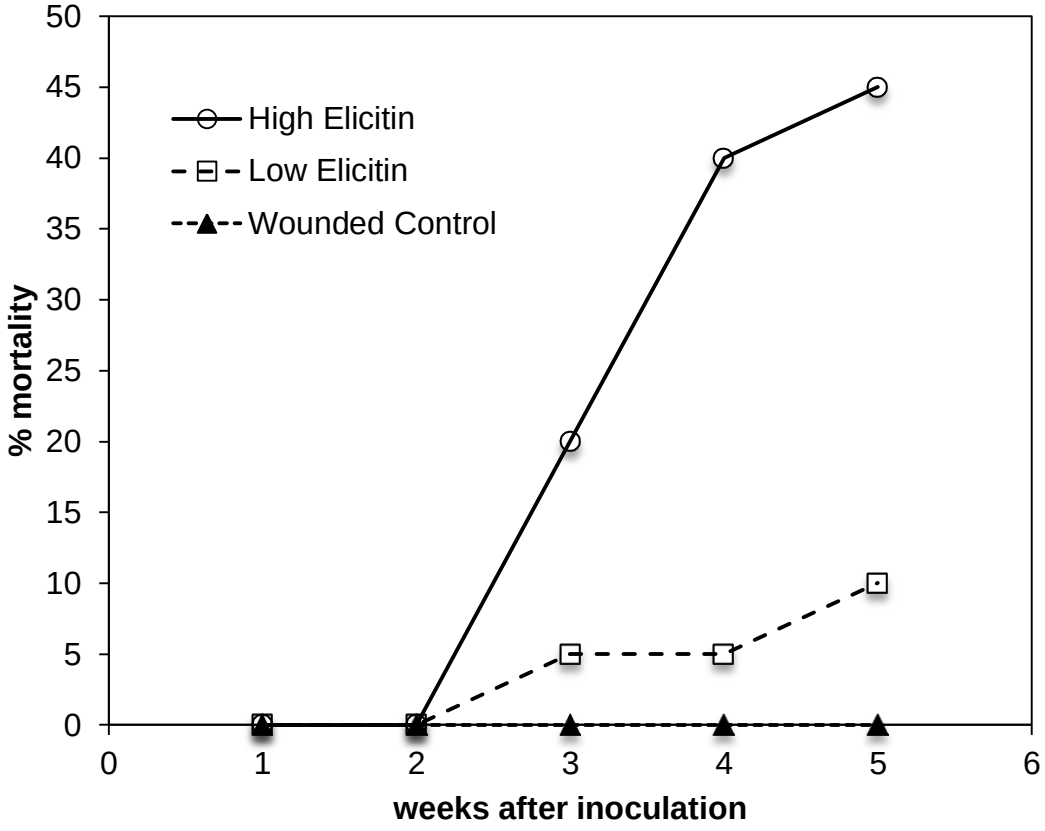
Uninfected tanoak stem x-section



Infected tanoak stem x-section

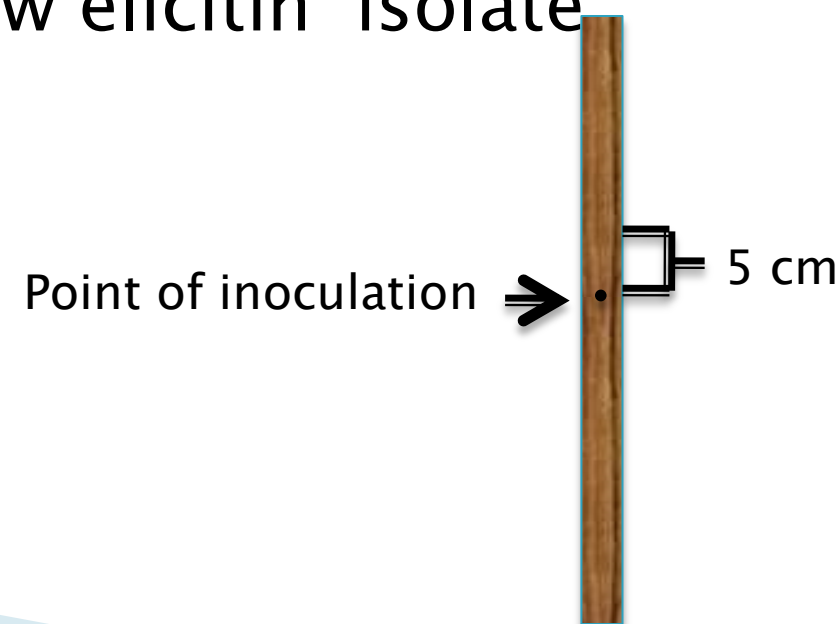
Results – tanoak saplings

- Mortality



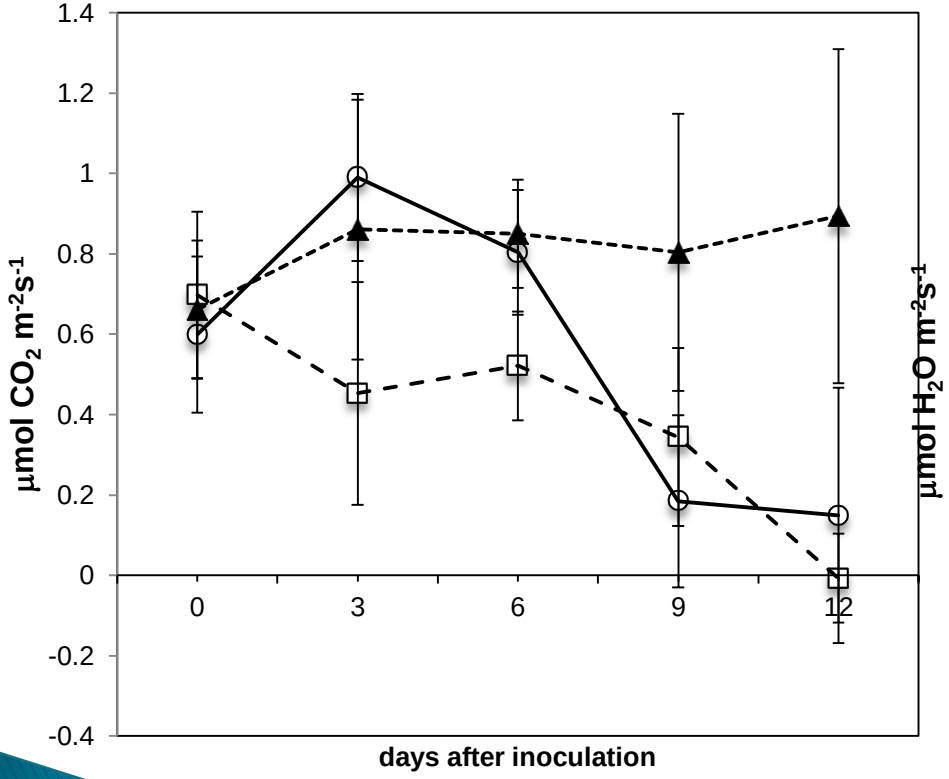
Materials and Methods – tanoak seedlings

- Photosynthesis, stomatal conductance, and water usage were measured as previously described.
- Stem specific hydraulic conductivity
- Measurements taken 2x/week for 2 weeks
- Substituted a different 'low elicitin' isolate

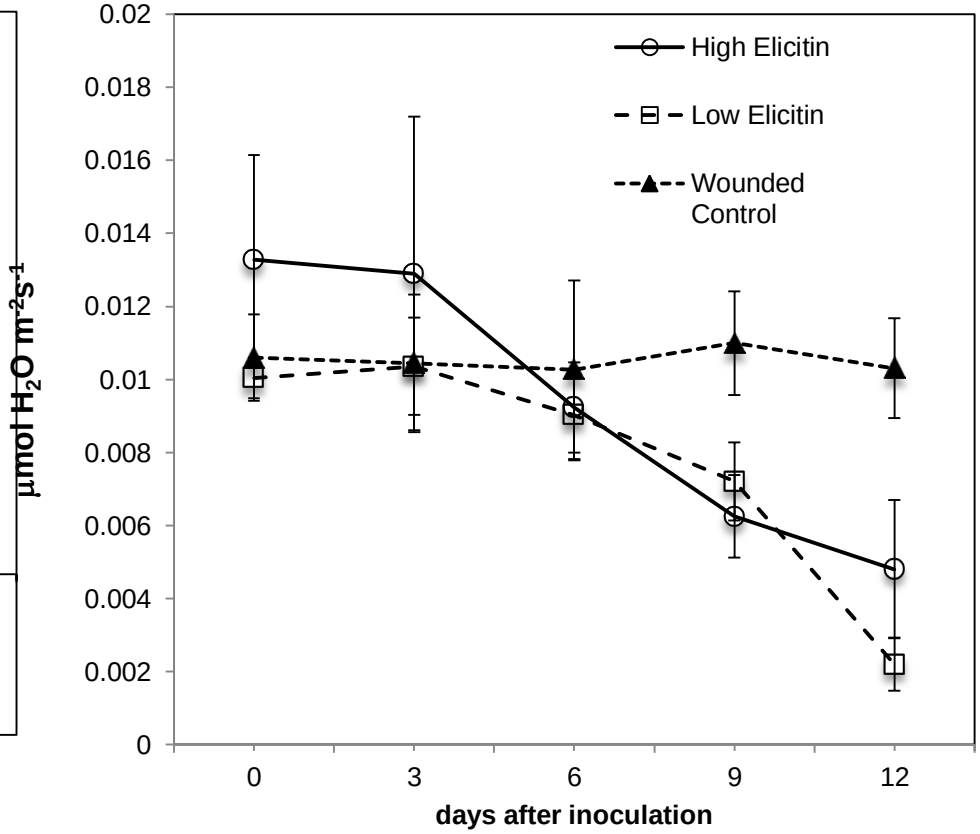


Results – tanoak seedlings

Photosynthesis

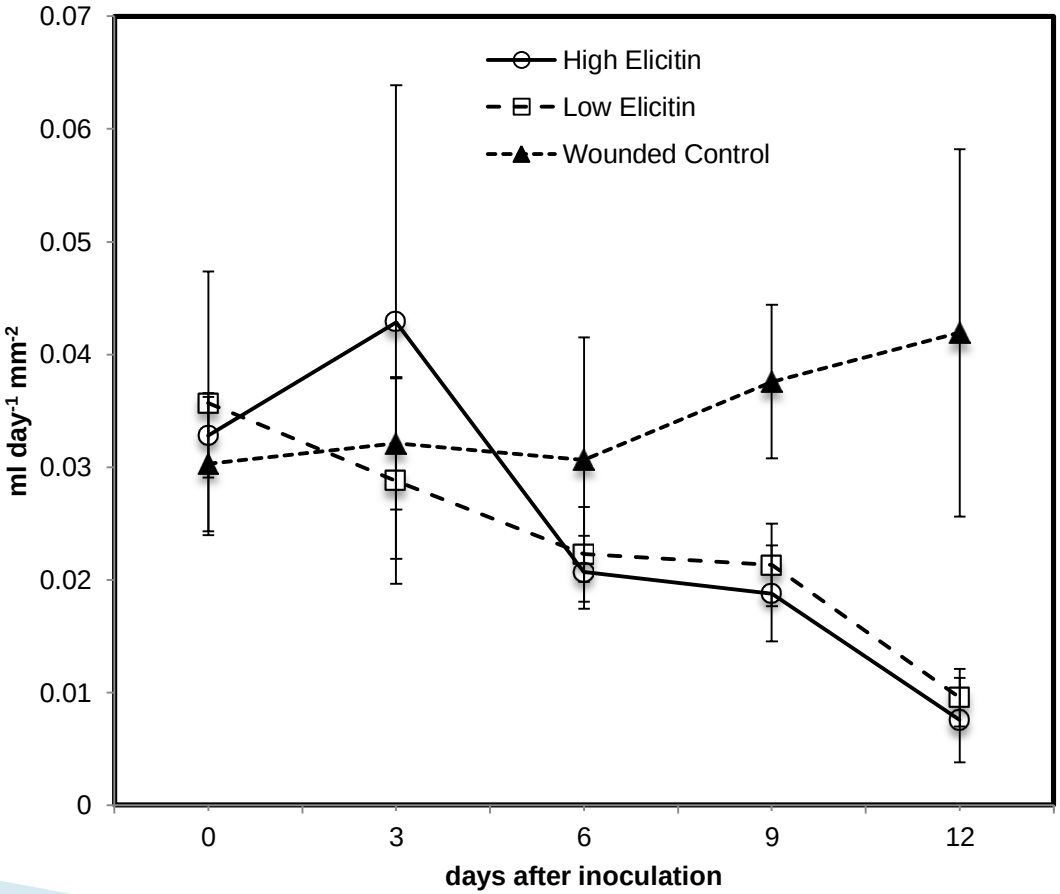


Stomatal conductance



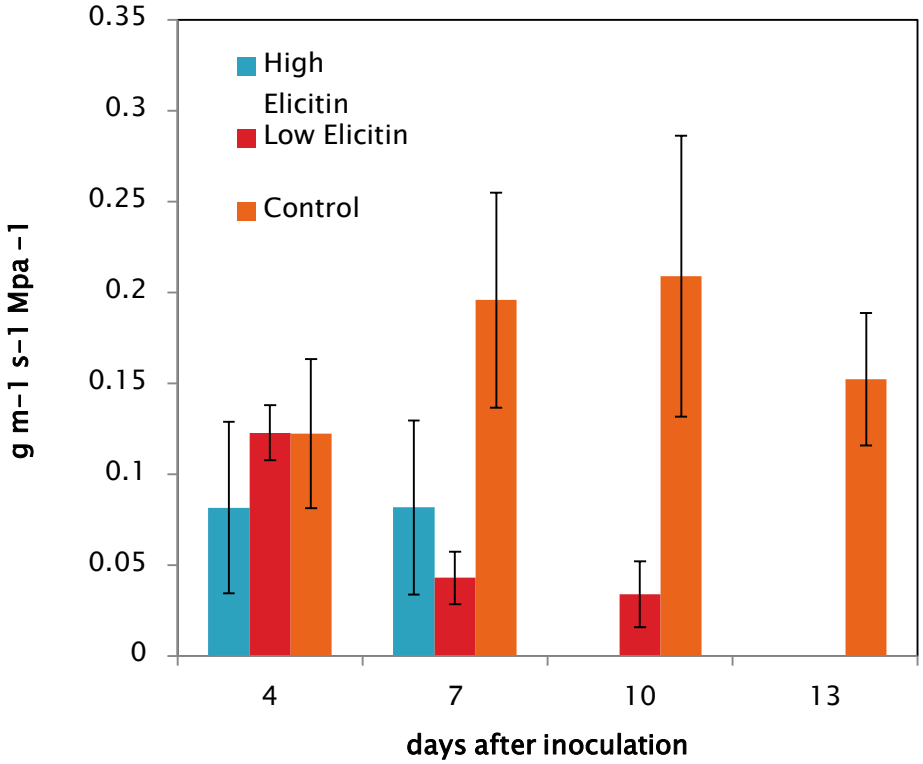
Results – tanoak seedlings

- Water usage



Results – tanoak seedlings

- Stem specific hydraulic conductivity



Conclusions

- How does *P. ramorum* infection impact certain physiological characteristics in tanoak? What happens first?
  - Primary symptom – reduction in stem specific hydraulic conductivity. Preceded effects on photosynthesis.

Conclusions

- Does *P. ramorum* infection impact conductive properties of xylem tissue?
  - Reduced stem specific hydraulic conductivty
  - Increased tylosis frequency

Conclusions

- Is elicitin secretion related to symptom severity?
  - Uncertain; seedling experiments indicate that both low- and high-elicitin isolates caused similar symptoms.

Acknowledgements

U.S. Forest Service PSW