IDENTIFICATION AND MANAGEMENT OF SOILBORNE DISEASES OF PISTACHIO

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Soil-borne diseases:

The relative importance of soil-borne diseases has changed over time with changes in choice of rootstocks.

Historically (*Pistacia atlantica* rootstock):

- Verticillium wilt

New soil borne diseases (UCB-1 rootstock):

- Phytophthora root and crown rots

Secondary (minor) diseases:

- Macrophomina charcoal rot
- Fusarium crown rot

Verticillium Wilt

Verticillium wilt:

- Historically, the most destructive disease of pistachio in California (1970s and 80s) when trees were planted on ***P. atlantica***,
- *Pistacia atlantica* is highly susceptible
- The development of resistant rootstocks (**PGI, UCB1**) in mid to late 80s has solved the Verticillium wilt problem of pistachio in California
- Still observed sporadically in the southern half of the San Joaquin Valley

Verticillium wilt:

- Soilborne fungus*: Verticillium dahliae*
- Wide host range: over 300 plant species (including solanaceous crop)
- Common crops affected in CA include cotton, tomato, pepper, potato, strawberry
- In locations where highly susceptible crops were grown previously (cotton, pepper, tomato…)




Verticillium wilt: Almond

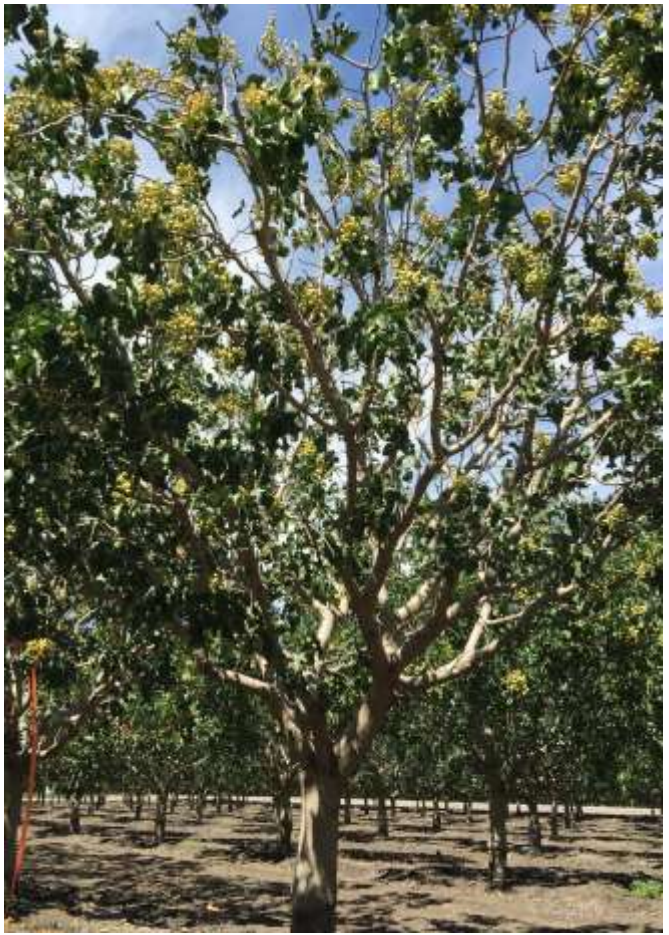
Verticillium wilt: Pistachio

Verticillium wilt:

Verticillium wilt:

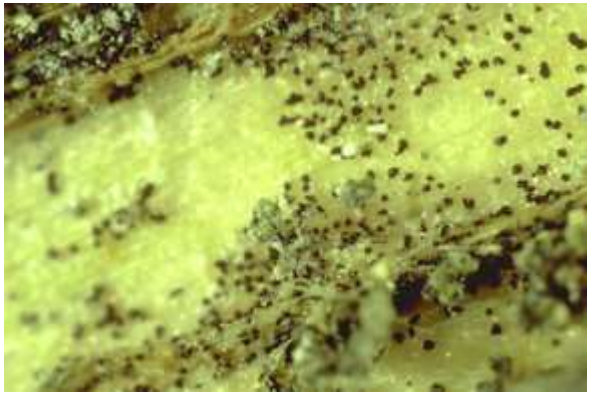
Verticillium thin leaf:

- Symptoms develop slowly over several years and are characterized by a slow loss of vigor and a reduction in growth and yield.
- A gradual thinning of the leaf canopy occurs: “see-through” symptom
- Diagnosis is more difficult



Verticillium thin leaf:

Verticillium wilt:



- Survive in the soil as microsclerotia
- Microsclerotium: hard dark resting body of certain fungi, consisting of a mass of hyphal threads
- Persist in soil for long periods.
- Survive on weed hosts

Disease cycle:

- Microsclerotia germinate in the presence of root exudates
- The pathogen invades the cortical cells of young roots, then the current year's xylem vessels
- It produces conidia that are transported into the tree trunk
- Colonization of the xylem results in disruption of water and nutrient transport

Verticillium wilt:

Management:

- **Use of resistant/tolerant rootstocks (PGI, UCB-1)**
- **Avoid planting in soils with history of susceptible crops**
- **Avoid inter-cropping pistachio trees with a susceptible host crop**
- **Submit soil samples to commercial lab for analysis: # microsclerotia/g soil**
- **For almond/pistachio, 3 microsclerotia per gram of soil is considered high risk**
- Reduce inoculum: flooding fallow field, solarization, fumigation, growing grass crops for several seasons
- Minimizing tree stress through maintenance of soil fertility and soil moisture will help trees tolerate the disease and encourage their recovery, but do not over-irrigate
- **Potassium deficiency increases tree loss due to Verticillium at low inoculum levels**

Current Research on Rootstock tolerance to Verticillium

Root Inoculations using a conidial suspension
(PGI, Platinum, UCB1)

1- Conidia: Mycelial spread on PDA plate 7 Days

2- Jiffy bags cut on 4 sides of jiffy bag

3- Plants Soaked for 30 min in $1x10^7$ conidia/ml solution

4- Replant into sterile soil, measure disease severity on a weekly basis

Disease Severity Scale

1

Mild wilt, leaf reddening

2

Moderate wilt, leaf necrosis, or defoliation

3

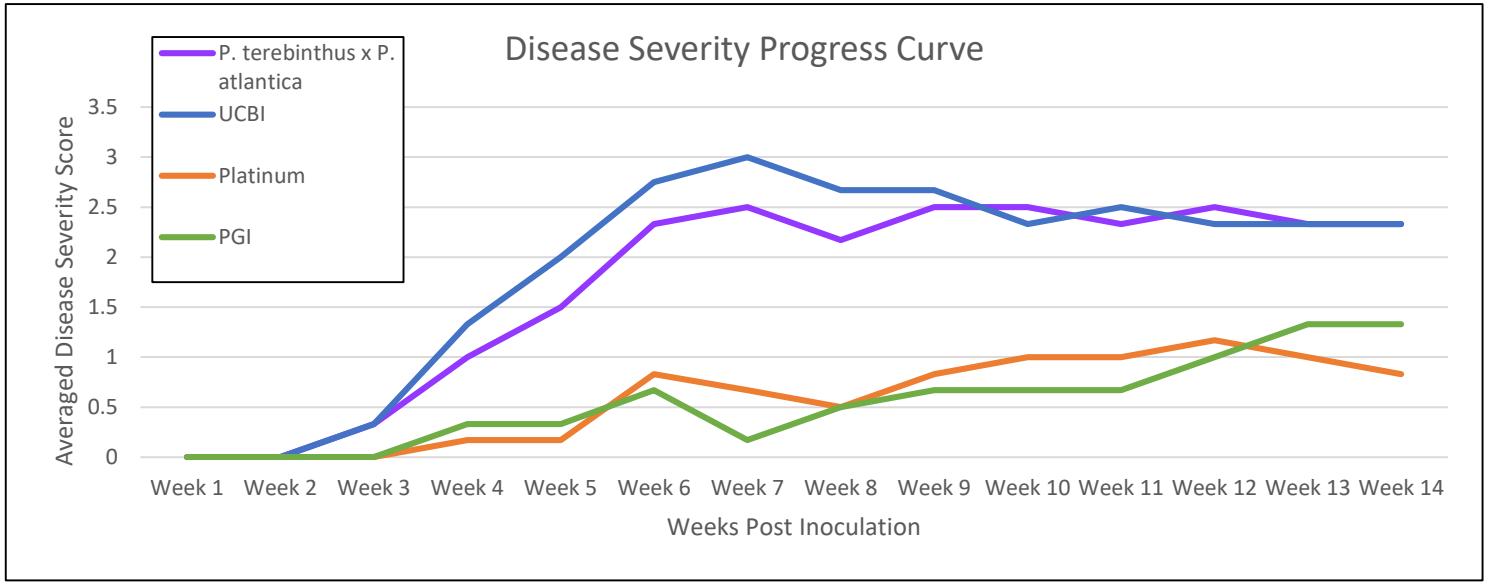
Severe wilt, leaf necrosis, or defoliation

4

Complete wilt, death, or defoliation

Disease Severity Progress Curve

- 4-month-old potted plants, 14-week incubation



Platinum – Rootstock Stem Cross-Sections

Control

Inoculated

PG1 - Rootstock Stem Cross-Sections

Control

Inoculated

UCB1 - Rootstock Stem Cross-Sections

Control

Inoculated

P. terebinthus x P. atlantica - Rootstock Stem Cross-Sections

Control

Inoculated

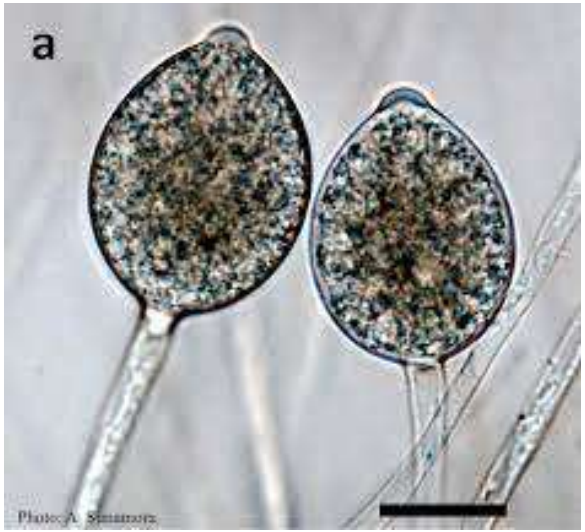
Verticillium wilt: Platinum on Golden Hills

Verticillium wilt: PG1 on Kerman

Phytophthora Crown and Root Rot

Phytophthora diseases: Generalities

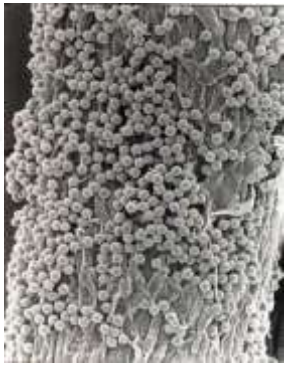
- Soil borne pathogens
- Fungus-like organisms
- Oomycetes: water molds
- Water spores: zoospores – they can swim
- Favored by standing water in the orchard

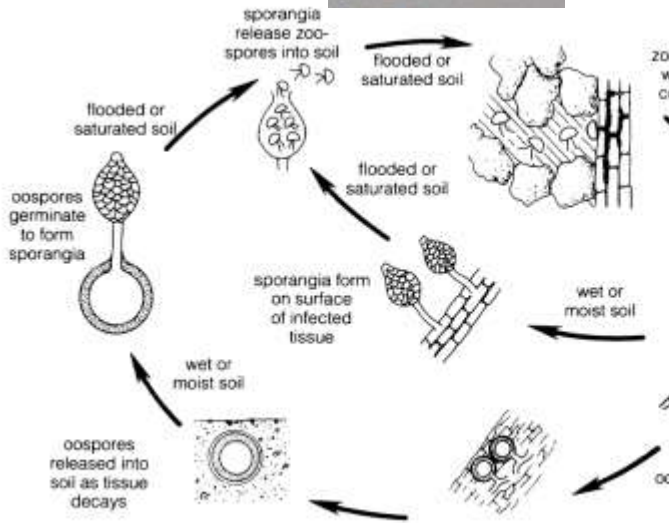


Phytophthora diseases: Generalities

- *Phytophthora* spp. are present **in canal and river water** and generally introduced to orchards irrigated from these sources
- To date, *Phytophthora* has not been found in well water
- Soil with poor water infiltration/drainage (heavy soil, hardpan)
- Prolonged periods of high soil moisture

Phytophthora disease cycle:





Phytophthora crown rot: Symptoms

Phytophthora crown rot: Symptoms

Photo credits: Carla Youngblood

Phytophthora crown rot: Symptoms

Phytophthora crown rot: Symptoms

- Occurrence of concentric growth rings below the bark

Phytophthora crown rot: Symptoms

- Girdling of trees causing a relatively fast decline

Photo credits: Carla Youngblood

Photo credits: Carla Youngblood

Phytophthora crown rot: Symptoms

- Gumming in the scion usually turns black, producing larger gum balls

Phytophthora root and crown rots: Symptoms

- Trees of all ages may die from Phytophthora



Recently planted orchard

Recently planted orchard

Phytophthora root rot: Symptoms

- Affects small roots, kill feeder roots and reduces the uptake of water and nutrients causing trees to slowly decline

Control plants

Roots treated with Phytophthora

Phytophthora species associated with pistachios in CA:

- *Phytophthora niederhauserii*
- *Phytophthora mediterranea*
- *Phytophthora taxon walnut*

e-Xtra*

Identification and Characterization of *Phytophthora* Species Associated With Crown and Root Rot of Pistachio Trees in California

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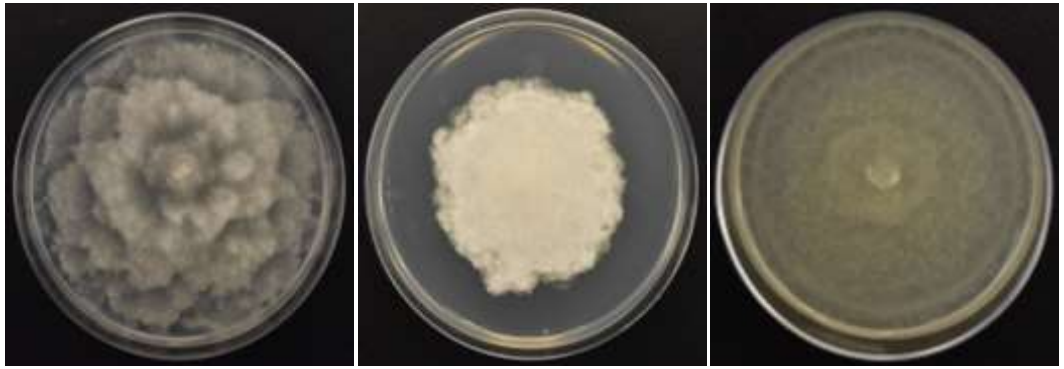
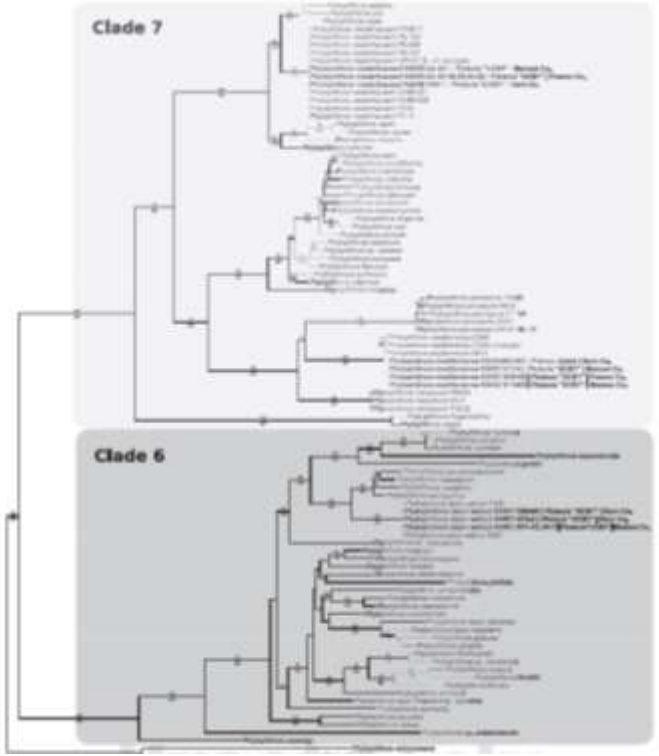
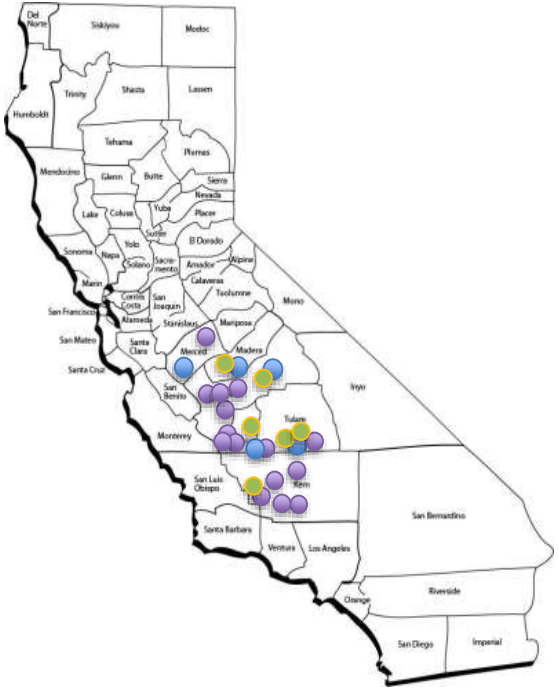




Disease surveys of pistachio orchards

- *Phytophthora niederhauserii*
- *Phytophthora mediterranea*
- *Phytophthora taxon walnut*



Phytophthora crown rot is on the rise in CA pistachios

2021 and 2022 farm calls (12 orchards visited)









Emergence of Phytophthora Disease

- Increased planting in last 15 years
- 20-25% of current acreage planted in marginal soils
  - Heavy/hardpan soils
  - High saline and saline-sodic soils
  - Poor water infiltration
- Mainly in orchards that use of surface water
  - Phytophthora inoculum source
- Can be found in orchards that use well water
- Over irrigation
- Increased soil compaction

Phytophthora: Disease Management

- Move drip emitters away from the trunk to avoid excessive wetting of the root crown



Phytophthora: Disease management

- Water management is the basis for control of Phytophthora root and crown rot
- Avoid puddling forming around the crown
- Avoid to wet soil longer than 24 hours at a time
- Do not apply water if adequate soil moisture is present
- Improving water penetration, drainage, infiltration rates (soil amendments)
- Planting on berms
- Phosphites (e.g. KPHITE), Mefenoxam (Ridomil Gold), Oxathiapiprolin (Orondis)
- Soil application (chemigation) in spring
- Foliar application in spring + fall (Phosphites)
- Best used as preventive treatments
- Trade issues and MRL requirements (Phosphites)
- Rootstock selection

Current Research on Rootstock tolerance to Phytophthora

Alejandro Hernandez

Disease Management: Phytophthora

- Water Management
- Site Selection
- Chemical Treatments
- **Rootstock Selection**
  - UCB1, PGI, Platinum

Methodology

Stem inoculations

Root inoculations

Commercial rootstocks

Platinum

UCB1

PG1

Stem inoculation study:

- Using mycelial plugs of the various pathogens

1- Trunk disinfection

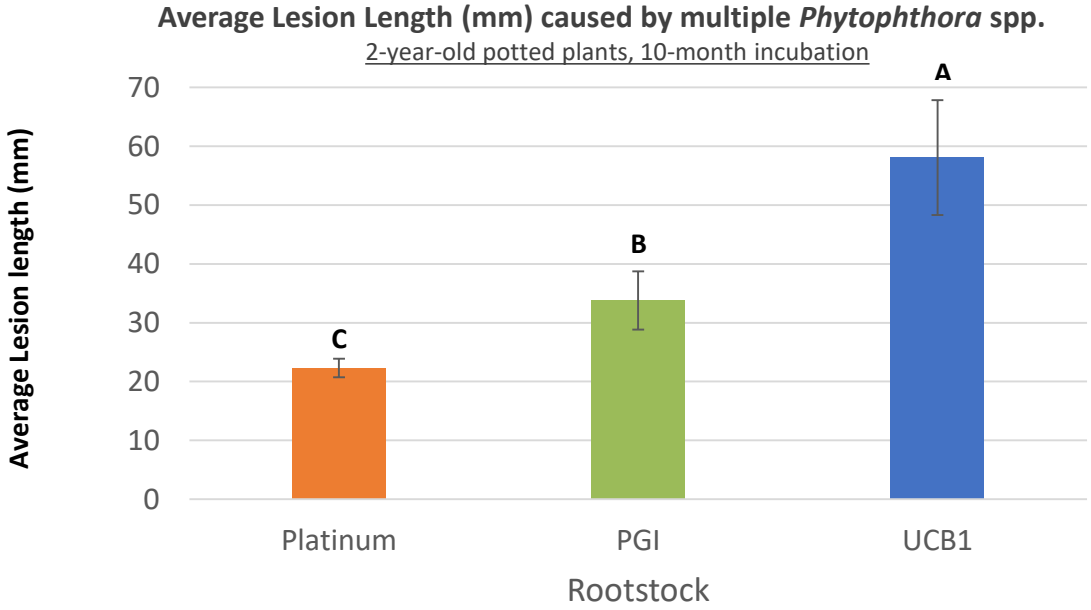
2- Wounding

3- Mycelial plug inoculation

4- Incubation (6-8 months)

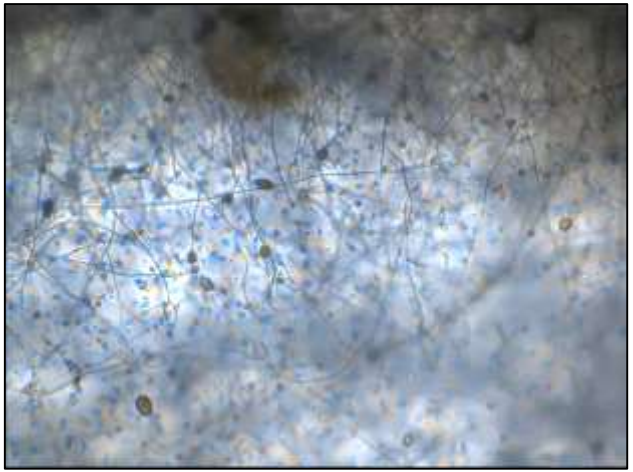
5- Assessing lesion length

Stem inoculations



Root Inoculations:
(Zoospore)

1- Induce sporangia formation and zoospore release (1x10^5 zoospore/ml)

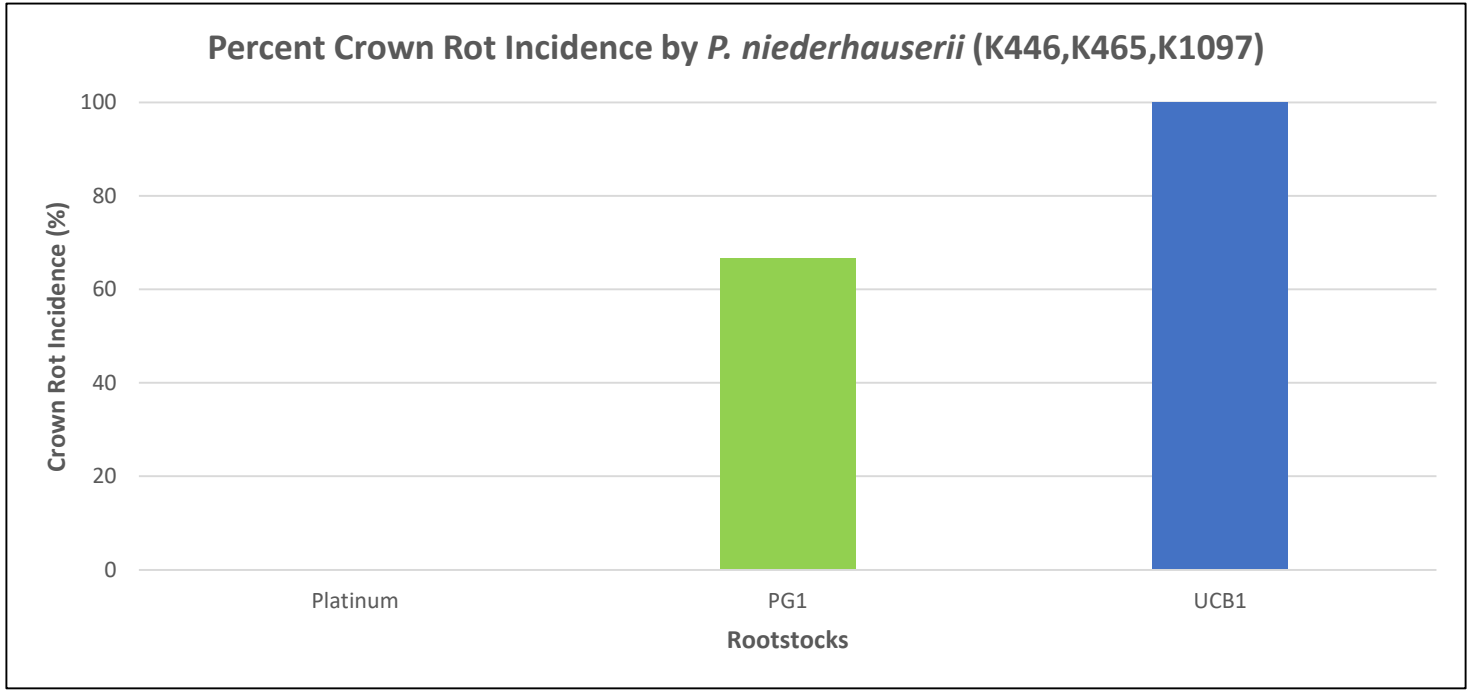


2- Inoculate 25 ml (1x10^5 zoospore/ml) + 4hr flood

3- Assess percent of plant death; root mass loss

Root Inoculations:

(Zoospores)



- 5-month old plantlets, 6-month incubation, 2021

UCDAVIS

Conclusion

- Platinum is the rootstock of choice for managing Phytophthora crown and root rot in California
- Uncertainty regarding the performance of Platinum against Verticillium
- Research to be continued

Orondis®

syngenta®
United States

Active Ingredient: Oxathiapiprolin*: 18.7%
Other Ingredients: 81.3%
Total: 100.0%

Crop: Pistachio
Disease: Phytophthora



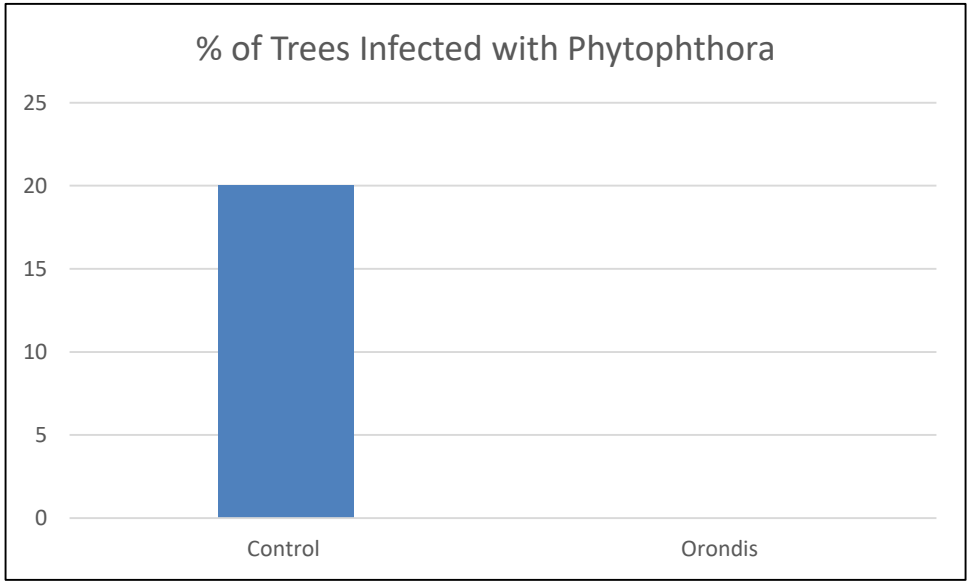

Orondis®

syngenta®
United States

- Chemigation trial (Trees were treated on 06/01/2020 and roots were sampled on 12/01/2020)

Results:

- We sampled treated and control trees 6 months after treatment application



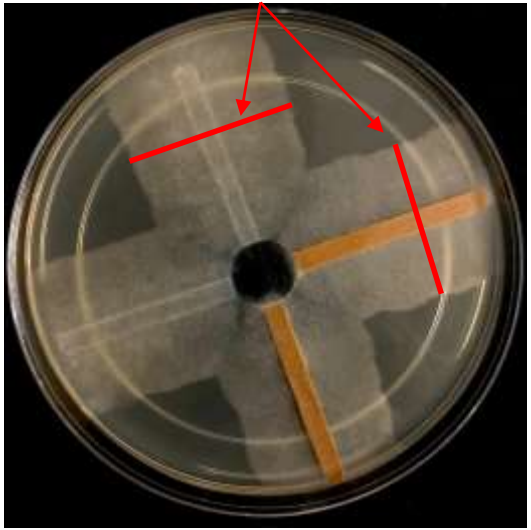
- 20% of trees were infected with Phytophthora in the water only control treatment
- 0% of trees were infected in the Orondis treatment

Testing fungicide efficacy

Adaskaveg et al, 2018. 2019,

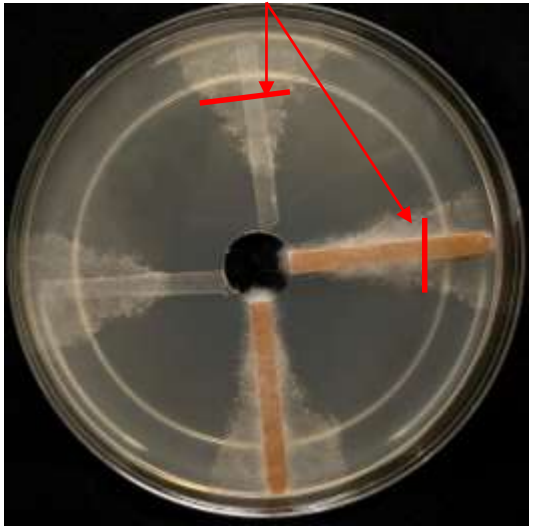
Common name	Trade name	Company	FRAC
Mandipropamid	Revus®	Syngenta	40
Oxathiapiprolin	Orondis®	Syngenta	49
Mefenoxam	Ridomil Gold® SL	Syngenta	4
Fluopicolide	Presidio®	Valent	43
Ethaboxam	Elumin®/Intego®	Valent	22
Potassium Phosphite	Kphite ®7LP	Plant Food Systems	P07 (33)

100% Mycelial Growth



Water Control

50% Mycelial Growth Inhibition

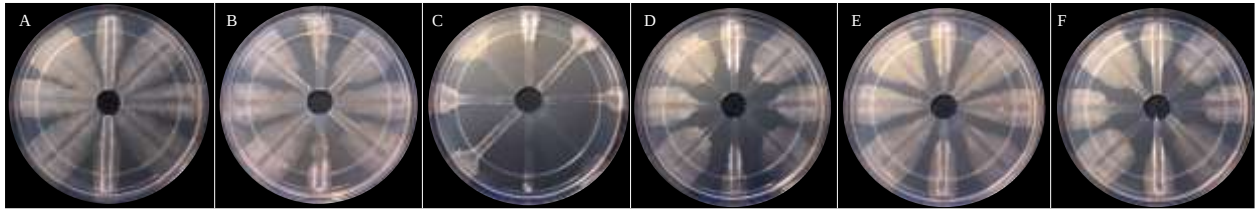


Fungicide

Testing fungicide efficacy

Table 1. Range of EC_{50} values for mycelial growth inhibition of *P. mediterranea and P. niederhauserii, P.* taxon walnut.

EC50 Values for Mycelial Growth (ug/ml)						
Species	Mefenoxam	Oxathiapiprolin	Mandipropamid	Ethaboxam	Fluopicolide	potassium phosphite
P. mediterranea	0.030-0.063 (0.041)	0.0001-0.0003 (0.0002)	0.0053-0.0072 (0.0063)	0.062-0.081 (0.073)	0.128-0.167 (0.143)	59.25-73.45 (66.10)
P. niederhauserii	0.026-0.269 (0.131)	0.0001-0.0004 (0.0003)	0.0050-0.0157 (0.0101)	0.020-.204 (0.085)	0.049-0.263 (0.102)	14.88-62.89 (34.60)
P. taxon walnut	-	-	-	-	-	67.46-70.95 (68.61)



Secondary (minor) soilborne diseases and abiotic issues

Macrophomina charcoal rot

- Declining of young UCBI rootstocks
- Heavy soils (clay) - West side
- Hot summer days

Macrophomina charcoal rot

- Caused by *Macrophomina phaseolina* (Botryosphaeriaceae)
- Survive in soil as microsclerotia
- Microsclerotia are enhanced under low water potential that occurs during drought

Phylogenetic diversity of *Macrophomina* spp. associated with pistachio crown rot

Macrophomina phaseolina

- Important plant pathogen infecting more than 750 plant species (row crops)
- Causal agent of Charcoal rot (California strawberries)
- Little information about *Macrophomina phaseolina* affecting perennial woody crops
- We have isolated *Macrophomina phaseolina* from declining table grapes and cherry trees

Disease survey in pistachio

- *Macrophomina phaseolina*

Macrophomina charcoal rot

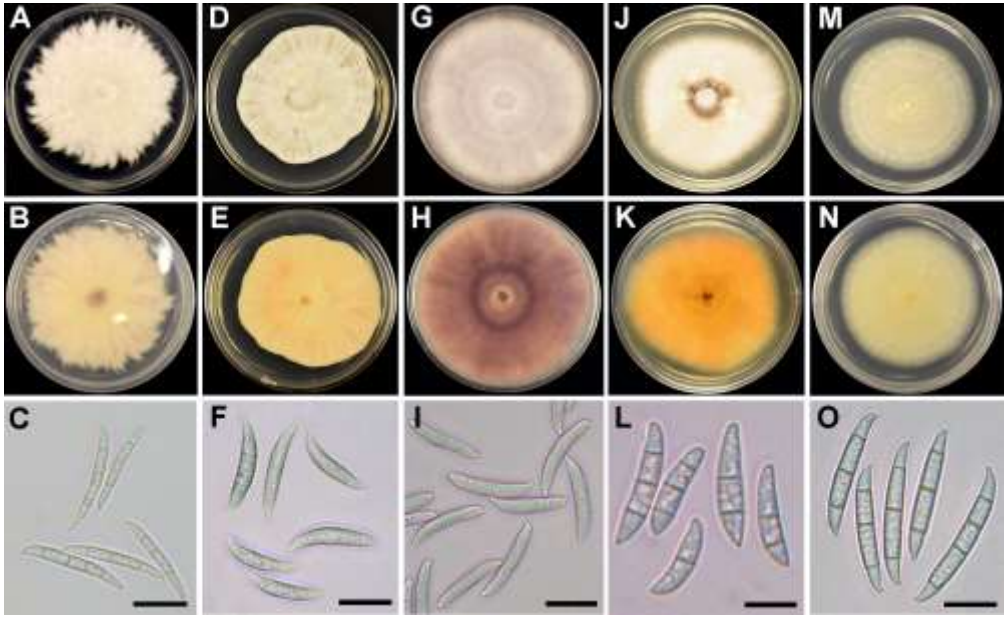
Fusarium crown rots

- Unusual symptoms
- Mainly cambium and phloem tissues affected
- Gumming



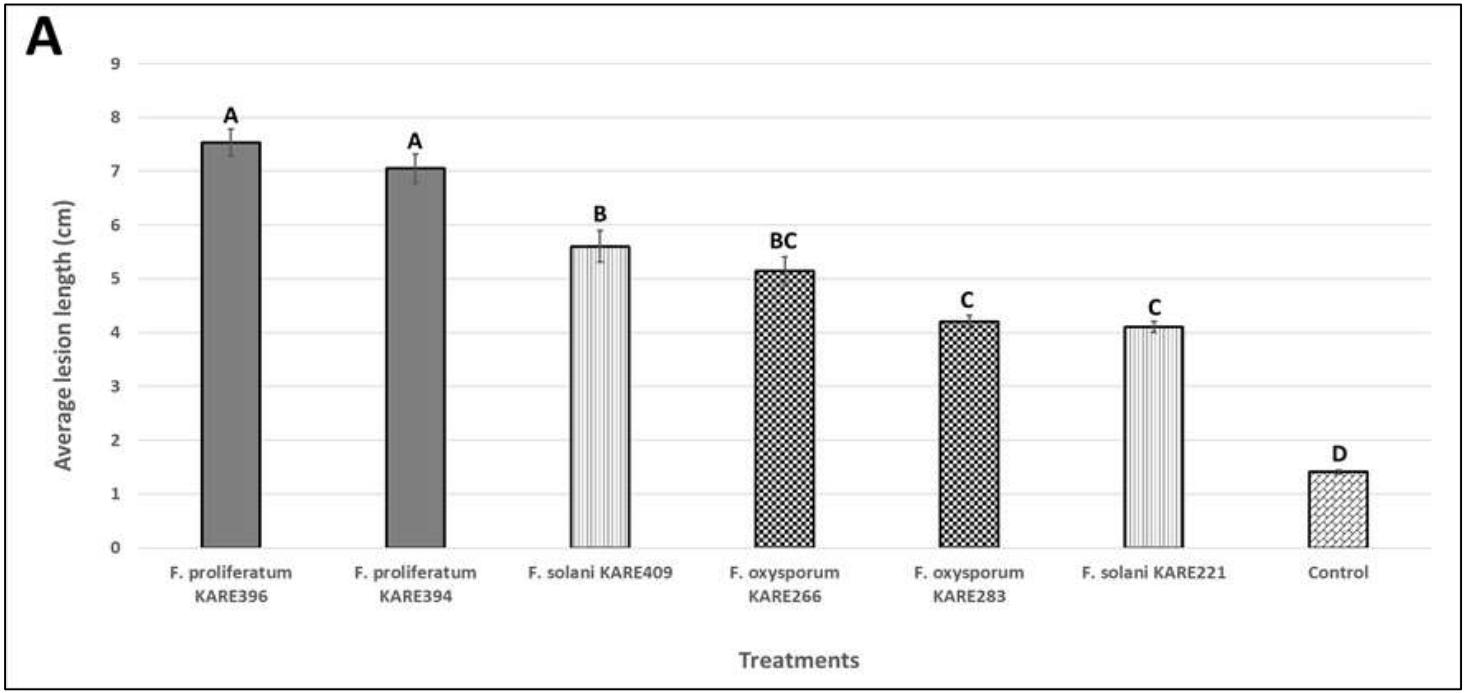

Fusarium taxonomy

- 5 species isolated from symptomatic pistachio rootstocks



Rootstock susceptibility study: all rootstocks combined

- Fusarium



Fusarium as secondary pathogens

- Plant stresses including old Phytophthora infections may allow *Fusarium* species to become virulent in pistachio

Root asphyxiation: “Wet feet”

- Frequently misdiagnosed as Phytophthora root or crown rot

Root asphyxiation: “Wet feet”

- Overall symptoms similar to Phytophthora diseases.
- No gumming
- A common issue in the field
- *Pistachio* trees are drought tolerant: deep rooted, can survive in extremely dry conditions
- Less tolerant to soils with high moisture

Root asphyxiation: “Wet feet”

- Roots need oxygen to grow and to absorb nutrients
- Too much water eliminates air space in soil and around roots
- In water-saturated soil, the oxygen content is low; without oxygen, roots cannot respire properly and cannot take up water and nutrients
- Anaerobic conditions: bad smell
- Trees declining slowly and may die

Root asphyxiation: “Wet feet”

- Low spots, heavy loam or clay, soil overly wet, etc…
- End of the row
- Fields with poor water infiltration/drainage
- Anaerobic conditions
- Trees decline slowly and may die

Trees not growing: late planting, transplanting shock

August 2, 2021

Other dying trees : 1/24 - wire from tag girdling trees

THANK YOU!

Alejandro Hernandez,
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Rosa Frias,
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