Soil Borne 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:

- Verticillium wilt
- Armillaria root rot
- Rhizoctonia seedling blight

New soil borne diseases:

- Phytophthora root and crown rots
- Macrophomina charcoal rot
- Fusarium crown rot

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Verticillium wilt:

- Historically, the most destructive disease of pistachio in California
- The development of resistant rootstocks (PGI and UCB-1) has solved the Verticillium wilt problem of pistachio in California
- Still observed sporadically in the southern half of the San Joaquin Valley

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Verticillium wilt:

- Soilborne fungus*: Verticillium dahliae*
- Wide host range: over 300 plant species
- Common crops affected in CA include: cotton, tomato, pepper, potato, strawberry
- Non-cultivated plants, weeds also serve as hosts




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Verticillium wilt: Almond

- All rootstock cultivars susceptible
- Flagging, shepherd hook, vascular streaking
- Trees over 5 years old are rarely affected by the disease



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Verticillium wilt:

- Symptom development on portion of the tree
- Dead leaves remain attached to the tree
- The whole tree may die
- *Pistacia atlantica* is highly susceptible

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Verticillium wilt:

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Verticillium wilt:

- In locations where highly susceptible crops were grown previously (cotton, pepper, tomato, strawberries, etc…)
- Cool spring weather, mild summer and most soils favor the disease
- Hot San Joaquin Valley summer temperatures apparently slow or inhibit *Verticillium*
- Over irrigation when temperatures are cool will increase Verticillium wilt
- Stressed trees are more vulnerable
- Trees of all ages are susceptible to the disease

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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

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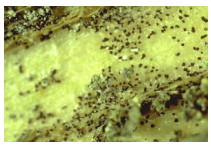
Verticillium wilt:



- 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

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Verticillium wilt:

Management:

- Use of resistant/tolerant rootstocks (PGI, UCB-1)
- Avoid planting in soils with history of susceptible crops
- Avoid inter-cropping your pistachios with a susceptible host crop
- Submit soil samples to commercial lab for analysis: # microsclerotia/g soil
- For almond/pistachio, three 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

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Armillaria root rot:

- Soil borne pathogen
- *Armillaria mellea* or the oak root fungus
- Basidiomycetes (mushroom)
- Orchards planted where oak trees once grew can be severely damaged
- Plants along streams and river get more affected
- Rare in pistachio

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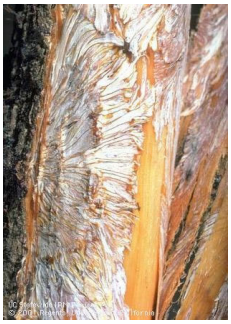
Armillaria root rot:

- The presence of mycelial plaques is sufficient to confirm the disease
- Plaques are white, fan-shaped sheets of fungal mycelium and occur between the bark and wood
- Symptoms are reduced growth, yellowing of leaves, defoliation
- The disease progress to adjacent tree
- The fungus survives on dead roots
- Control is difficult and consist of removing infected roots from soil before new planting



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Rhyzoctonia seedling blight:

- 1995: found in a nursery in CA where it resulted in the death of over 10,000 rootstock seedlings
- Leaves turn brown, wilted, and hanged to shoots
- Brown cortical lesions develop on roots
- Seedlings are stunted, blighted, and die
- *P. atlantica*, *P. integerrima*, and UCB-1 were all similarly infected
- The disease has not been observed on planted trees in an orchard

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Phytophthora root and crown rots: Symptoms

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Phytophthora root and crown rot:

- Can affect old trees as well


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Phytophthora crown rot: Symptoms

- Affects the tree trunk at or near the ground level; girdling of trees; relatively fast decline



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Phytophthora crown rot: Symptoms



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Phytophthora crown rot: Symptoms



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Phytophthora crown rot: Symptoms

- Girdling of trees causing a relatively fast decline


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Phytophthora crown rot: Symptoms

- Occurrence of concentric growth rings below the bark


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Aerial Phytophthora or trunk canker:

- Mainly a problem in sprinkler-irrigated pistachio orchards



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Phytophthora root rot: Symptoms

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


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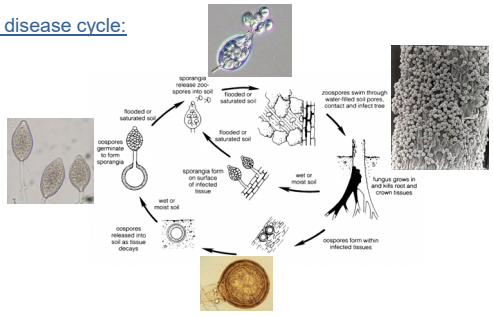
Phytophthora disease cycle:



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Phytophthora root and crown rot:

- Little knowledge about Phytophthora diseases in Pistachio.
- Early reports of *Phytophthora* spp. as causal agents of branch and trunk cankers in the scion (MacDonald et al., 1992).
- Phytophthora root and crown rot generally was considered a minor disease in California pistachio, occurring sporadically in saturated soil conditions.
- *Phytophthora parsiana, Phytopythium helicoides* were recently found in potted pistachio plants in research plots (E. Fichtner et al. 2015, 2016).

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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

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Phytophthora diseases: Generalities

- Many *Phytophthora* spp. are present in canal and river water
- Generally introduced to orchards irrigated from these sources
- To date, *Phytophthora* has not been found in well water
- Historically not so common on pistachio trees in California
- Increasing cases in the last few years

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Phytophthora diseases:

Favored by:

- Prolonged periods of high soil moisture
- 24 hours soil saturation period
- Low spots in the orchard
- Soil with poor water infiltration/drainage (heavy soil, hardpan)
- Irrigation from surface water
- Flood irrigation systems
- Alternating cycles of wet and dry soil also exacerbate Phytophthora root rots

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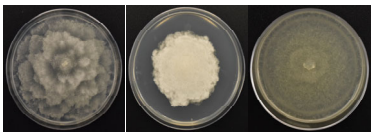
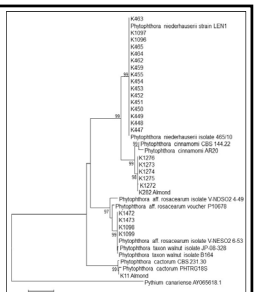
Phytophthora root and crown rot:

Diversity of *Phytophthora* species in CA pistachios:

- *Phytophthora niederhauserii*
- *Phytophthora cinnamomi*
- *Phytophthora taxon walnut*





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

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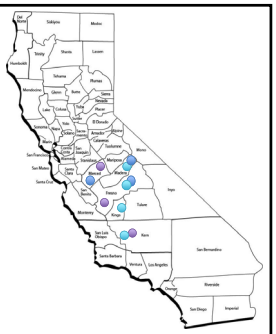
2015-2017 Disease surveys of pistachio orchards

- *Phytophthora niederhauserii*
- *Phytophthora cinnamomi*
- *Phytophthora taxon walnut*



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Root inoculation of UCB1 and Platinum rootstocks:

- Root and crown rots
- Using rootstocks plantlets
- Zoospore inoculum

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Root inoculations with Phytophthora spp.:

After 3 weeks (UCB1 rootstocks)

After 3 weeks (Platinum rootstocks)

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Rootstock inoculations: UCB1 and Platinum

- 21 days after inoculation: 12 plants for each treatment (4 reps X 3 isolates)

Experiment 1

Phytophthora species:	Wilted/dead plants (%) UCB-1 clonal	Wilted/dead plants (%) Platinum
Phytophthora cinnamomi	100	50
Phytophthora taxon walnut	100	34
Phytophthora niederhauserii	58	50
Control	0	0

Experiment 2

Phytophthora species:	Wilted/dead plants (%) UCB-1 clonal	Wilted/dead plants (%) Platinum
Phytophthora cinnamomi	100	100
Phytophthora taxon walnut	100	100
Phytophthora niederhauserii	100	100
Control	12.5	0

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Pathogenicity studies using mycelium plugs

- Inoculation into UCBI rootstocks
- Three to four months incubation period

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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: 2-3 foliar spray applications starting when trees are fully leafed out (May/June) + 1 fall (late September/early October) foliar application
- Best used as preventive treatments
- Trade issues with MRL requirements
- Mefenoxam (Ridomil Gold) is not currently registered for pistachio in California

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Phytophthora: Disease Management

- Avoid placing drip hoses at the base of a tree

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Macrophomina charcoal rot:

- Declining of recently planted UCBI rootstocks
- Heavy soils (clay)
- West side

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2015-2017 Disease surveys

- *Macrophomina phaseolina*

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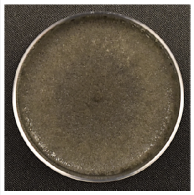
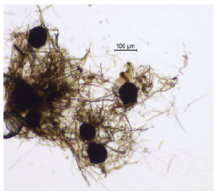
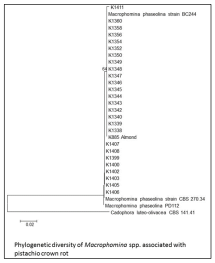
Macrophomina charcoal rot:

- Caused by *Macrophomina phaseolina*







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

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Macrophomina phaseolina:

- Causal agent of Charcoal rot in many plant species (row crops)
- Little information about *Macrophomina phaseolina* affecting perennial woody crops
- We have isolated *Macrophomina phaseolina* from declining table grapes and cherry rootstocks
- Produce microsclerotia, which is enhanced under low water potentials that occurs during drought

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Root inoculations with *Macrophomina phaseolina* :

22 days (UCB1 rootstocks)

22 days (Platinum rootstocks)

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Root inoculations with M. phaseolina :

- UCB1 clonal rootstocks and Platinum
- Three isolates of *Macrophomina phaseolina*
- 5 repetitions per isolate
- Using microsclerotia
- Incubation period 22 days

Macrophomina isolates:	Wilted/dead plants (%) UCB-1 Clonal	Wilted/dead plants (%) Platinum
Macrophomina phaseolina KARE1400	100	100
Macrophomina phaseolina KARE1411	100	100
Macrophomina phaseolina KARE1350	100	100
Control	0	0

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Pathogenicity studies using mycelium plugs

- Complete Koch's postulates
- UCB1 rootstocks (clonal and seedlings)
- Using mycelium plugs (crown rots)

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Pathogenicity studies using mycelium plugs

- Inoculation in UCBI clonal rootstocks
- 10 months incubation period

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Fusarium crown rots:

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

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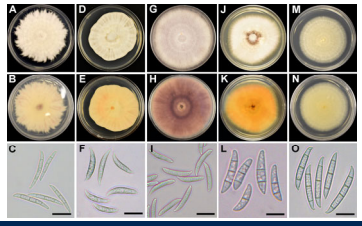
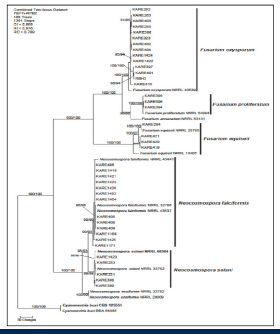
Fusarium taxonomy:

- 5 species isolated from symptomatic pistachio rootstocks





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Fusarium as secondary pathogens:

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

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Pathogenicity studies using mycelium plugs

- Complete Koch's postulates
- UCB1 rootstocks (clonal and seedlings)
- Using mycelium plugs (crown rots)

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Pathogenicity studies using mycelium plugs

- 3 to 10 months incubation period

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Disease management: Rootstock susceptibility study

- UCB1, PGI and Platinum rootstocks were inoculated with *P. niederhauserii, P. cinnamomi, P. taxon walnut, Fusarium* spp. and *Macrophomina phaseolina*
- Inoculation of stems with mycelium plugs
- 10-month incubation period

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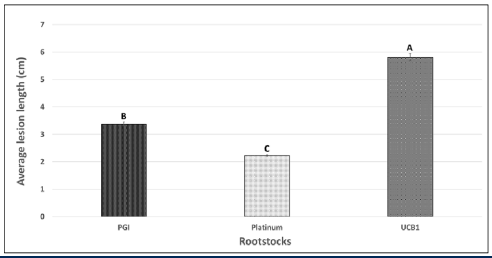
Rootstock susceptibility study: all isolates combined

- Phytophthora



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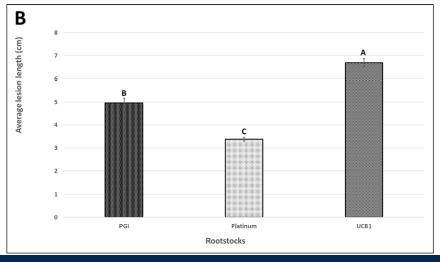
Rootstock susceptibility study: all isolates combined

- Fusarium



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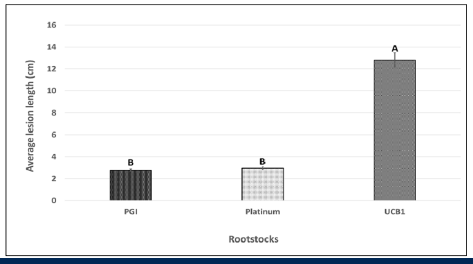
Rootstock susceptibility study: all isolates combined

- Macrophomina



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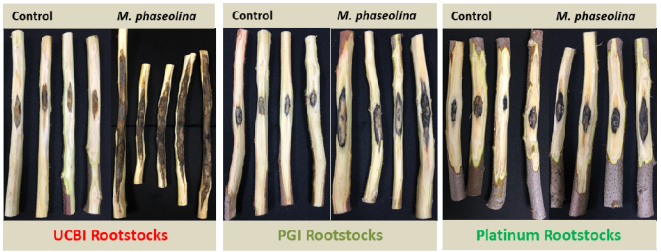
Rootstock susceptibility study: Macrophomina



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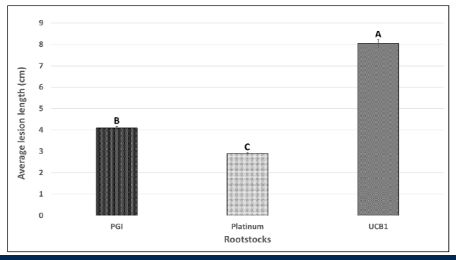
Rootstock susceptibility study:

- All pathogens combined



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Root asphyxiation: "Wet feet"

- Frequently misdiagnosed as Phytophthora root or crown rot



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Root asphyxiation: "Wet feet"

- Overall symptoms similar to Phytophthora diseases.
- More common issue in the field than Phytophthora
- *Pistachio* trees are drought tolerant: deep rooted, can survive in extremely dry conditions
- Less tolerant to soils with high moisture

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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

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Root asphyxiation: "Wet feet"

- Low spots, heavy loam or clay, soil overly wet, etc…
- End of the row
- Fields with poor water infiltration/drainage

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THANK YOU!

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