Soil Biology and Soilborne Disease

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Overview

Fungi in soil

Major soilborne diseases
  – Verticillium wilt
  – Fusarium wilt
  – Phytophthora crown and root rot

Others
  – Armillaria root rot
  – Crown gall
Fungi in soil and their interactions with plant roots

Many are detectable in soil but are not active there

Fungi do not grow in soil

They grow in organic substrates within soil

They grow through soil from a substantial food base
Roots provide a substrate for fungal growth.

Nutrients diffuse away from the root.

Sugars
Amino acids
Shielded from UV
Moisture is present
Temperature buffered
Root is a source of nutrients
Fungal spores within the rhizosphere germinate. Response is non-specific. Most fungi will respond to exudates from most plants.
In the absence of an external source of nutrients spores will not germinate

Even spores with sufficient endogenous nutrients
Hyphae grow toward the root

Fungi grow toward an adjacent substrate

Crop residue
Non-pathogenic fungi commonly colonize the root cortex

Both inter- and intracellularly
All plants are infected

Infection ≠ Disease

Relatively non-specific

Impact is minimal
Roots must be permeable to take up water
Consequently they are leaky
Sugars are in higher concentration inside root
So sugars diffuse out into the soil

Root exudates stimulate microbial growth

Region of fungal growth

Cost:Benefit
**Fusarium oxysporum**

Cause of Fusarium wilt

Colonizes root cortex

Invades the vascular tissue
Carried upward in transpiration stream

Stopped by perforation plate

Spores germinate and penetrate perforation plate

Hyphae grow in vessels

Produce microconidia

Carried upward in transpiration stream

Systemic infection
Delayed response

Pathogen is not contained in first vessel

Pathogen has spread laterally before plant responds

Vessel occlusion compromises water-conducting capacity
How long can fungi survive in soil?

Durability of propagules

**Verticillium dahliae**
- Microsclerotia: 3-5 years

**Fusarium oxysporum**
- Chlamydospores: 1-2 years
What determines the rate of attrition?

Microbial activity

Removes organic matter that protects pathogen propagules

Warmer is better

Wet is better
Survival of Fusarium in field soil

- **Cotton Fusarium**: 3,000 CFU/gram
- **Lettuce Fusarium**: 17.5 CFU/gram
Two or three years out of a susceptible crop may be sufficient to reduce inoculum to levels that will not produce significant damage. If pathogen propagules are not especially durable. If rotation crops do not support extensive development.
Major soilborne diseases

Verticillium wilt
  – veggies (tomato, watermelon, strawberry, lettuce and others)
  – almond

Fusarium wilt of tomato

Phytophthora crown and root rot
  – tomatoes and cucurbits
  – walnut, cherry, almond

Less common:
  – Armillaria root rot of trees and vines
  – crown gall
Verticillium Wilt

- Caused by the soilborne fungus *Verticillium dahliae*
- Survives in soil indefinitely
- Cross pathogenic among many crop plants as well as ornamentals
- Millions of spores produced within each infected plant
Verticillium dahliae races 1 and 2

- ‘V’ shaped chlorosis followed by necrosis
- light vascular discoloration
- wilting and premature senescence
Vascular discoloration

Verticillium wilt in...

Chinese pistache

Maple

Tomato
Verticillium dahliae
- Conidia
- Microsclerotia
- No sexual stage
• Cross pathogenic
  - Many crops
  - Non-domesticated plants
• Seedborne
entry into xylem vessels

formation of conidia and systemic colonization of vascular system

chlorosis, necrosis, and wilting of foliage

colonization of senescing tissues

development of microsclerotia in dead tissues

root exudates stimulate microsclerotial germination

microsclerotia free in soil or within plant debris

direct penetration of root tips

colonization of root cortex

Drawing by Vickie Brewster, colored by Jesse Ewing.
Colonization of lateral root tip

Colonization of root elongation zone

Systemic colonization of lateral root

Vascular discoloration 6 to 8 weeks

Mature microsclerotia embedded in taproot tissues

Microsclerotia development 10+ weeks

Taproot colonization coincides with foliar symptom development

8 to 10 weeks

Subbarao, UC Davis
Vascular wilts

- Verticillium strains are capable of cross infectivity
- Fusarium strains are crop specific
- Millions of spores are produced in each infected plant
- Because Verticillium and Fusarium retain their saprophytic ability, they remain in soil indefinitely, sustaining themselves on other crops and weeds.
Verticillium and Crop Residues

Wilt severity

Vapam  |  broccoli  |  cauliflower  |  none
--- | --- | --- | ---
1 | b | c | c

Subbarao et al Plant Disease 83:124-9
Verticillium wilt management

• ROTATION: For annual crops – reduce disease pressure through rotation to non-host (small grains)
• PRACTICES that promote high soil C and microbial activity
• HOST RESISTANCE
  – VE gene in tomato, but no resistance to race 2
  – crops, varieties and rootstocks vary in susceptibility
• FUMIGATION
  – Standard practice for strawberry production
  – Not commonly practiced for most crops
Fusarium oxysporum races 1, 2, and 3

- yellowing of branches and leaves
- dark vascular discoloration
- general wilting often leading to necrosis/death
Fusarium wilt of tomato

- Fusarium wilt Race 3 becoming more widespread in the Central Valley
- Resistance to Race 3 not common in currently grown varieties
Fusarium wilt of tomato

Movement
- Seed
- Any way soil is moved

Management
- Containment
- Clean seed
- Soil fumigation
- Rotation
- Resistance
### Fusarium wilt

<table>
<thead>
<tr>
<th>Favored by:</th>
<th>Suppressed by:</th>
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<tbody>
<tr>
<td>ammoniacal nitrogen</td>
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<tr>
<td>acid soils</td>
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<tr>
<td>sandy soils</td>
<td>microbially rich soils</td>
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</table>
Lettuce
Alfalfa
Artichoke
Watermelon
Bell Pepper
Tomato
Cabbage
Strawberry
Chili Pepper
Cauliflower
Potato
Mint
Tomato
Lettuce
Watermelon
Eggplant
Cotton
Fusarium
Phytophthora Crown and Root Rot

TOMATO: Caused by *Phytophthora capsici* & *Phytophthora parasitica*
Crown and Root Rot
Foliar infections (blight) and fruit rots

More of a problem in climates with higher humidity or summer rainfall
Disease spread and soil survival

*Phytophthora capsici* produces:

- sporangia and motile zoospores
- oospores which survive as long as 3 years in field soil
Aggravating conditions

- Saturated soil
- Heavy soils, compacted soils
- Warm, wet conditions
- Soil salinity or other plant stress
Cultural control: Vegetables

• Rotation out of tomatoes, peppers and cucurbits for 3+ years
• Clean equipment of soil when leaving infested fields
• Plant susceptible crops on well-drained soils
• In heavy soils, use alternate furrow irrigation or well-managed drip irrigation
• Tolerant varieties when available
Phytophthora crown rot

Almond

Walnut

Cherry
Phytophthora cultural control: Trees

- Plant on well drained soils or at least avoid problem spots (if spot with poor drainage leave unplanted)
- Plant on berms
- Use practices which promote water infiltration and drainage
- In heavy soils, use more frequent but shorter irrigations. Do not allow water to accumulate around tree crowns
- Tolerant rootstocks
  - Almond: Plum rootstocks more resistant than peach or peach x almond (of plum, Mariana 2624 is most tolerant) – consult Brent Holtz, UCCE
  - Walnut: depends on which Phytophthora is present, but in general Paradox is more tolerant than others – consult Joe Grant, UCCE
  - Cherry: depends on which Phytophthora is present, but in general Mazzard and Colt rootstocks are more resistant than is Mahaleb – consult Joe Grant
# Chemical Control of Phytophthora

<table>
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<tr>
<th>Chemical</th>
<th>FRAC group</th>
<th>Products</th>
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<tbody>
<tr>
<td>Metalaxyl/mefenoxam</td>
<td>4</td>
<td>Ridomil, Ridomil Gold, Ridomil Gold Bravo, Ridomil Gold MZ &amp; many others</td>
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<tr>
<td>phosphorous acid materials</td>
<td>33</td>
<td>Various (Aliette, Fosphite and others)</td>
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Always check labels before making recommendations or applications!
Chemical control of Phytophthora

- Resistance management
- Metalaxyl/mefenoxam may degrade rapidly in soils with a history of repeated use
- How to get the materials to where they need to be to prevent infection?
Armillaria Root Rot

For more info
see UC IPM website
http://ipm.ucanr.edu/
Crown Gall

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http://ipm.ucanr.edu/
Questions?

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