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

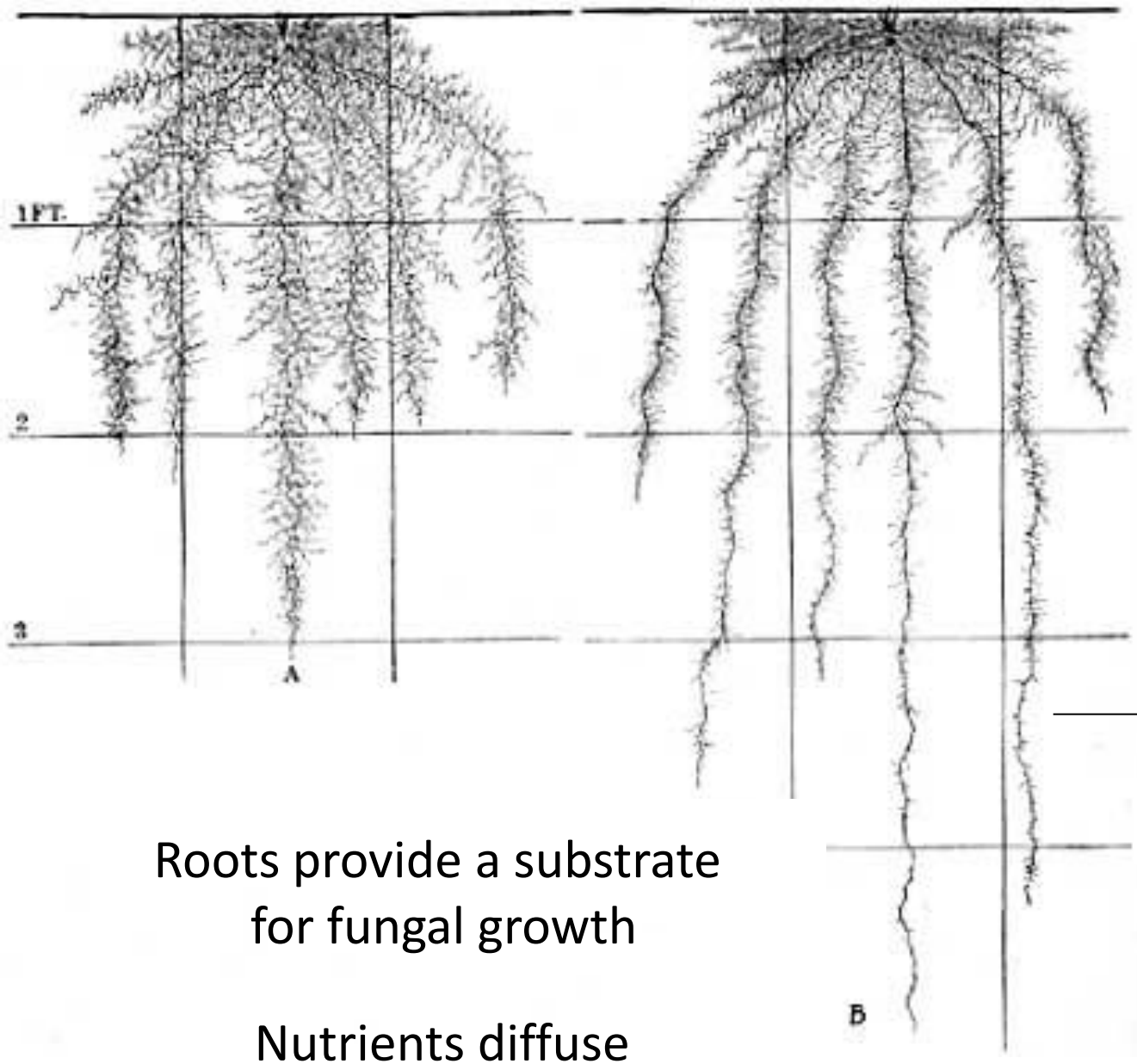
Many are detectable in soil but are not active there

Fungi do not grow in soil

They grow in organic substrates within soil

They grow through soil

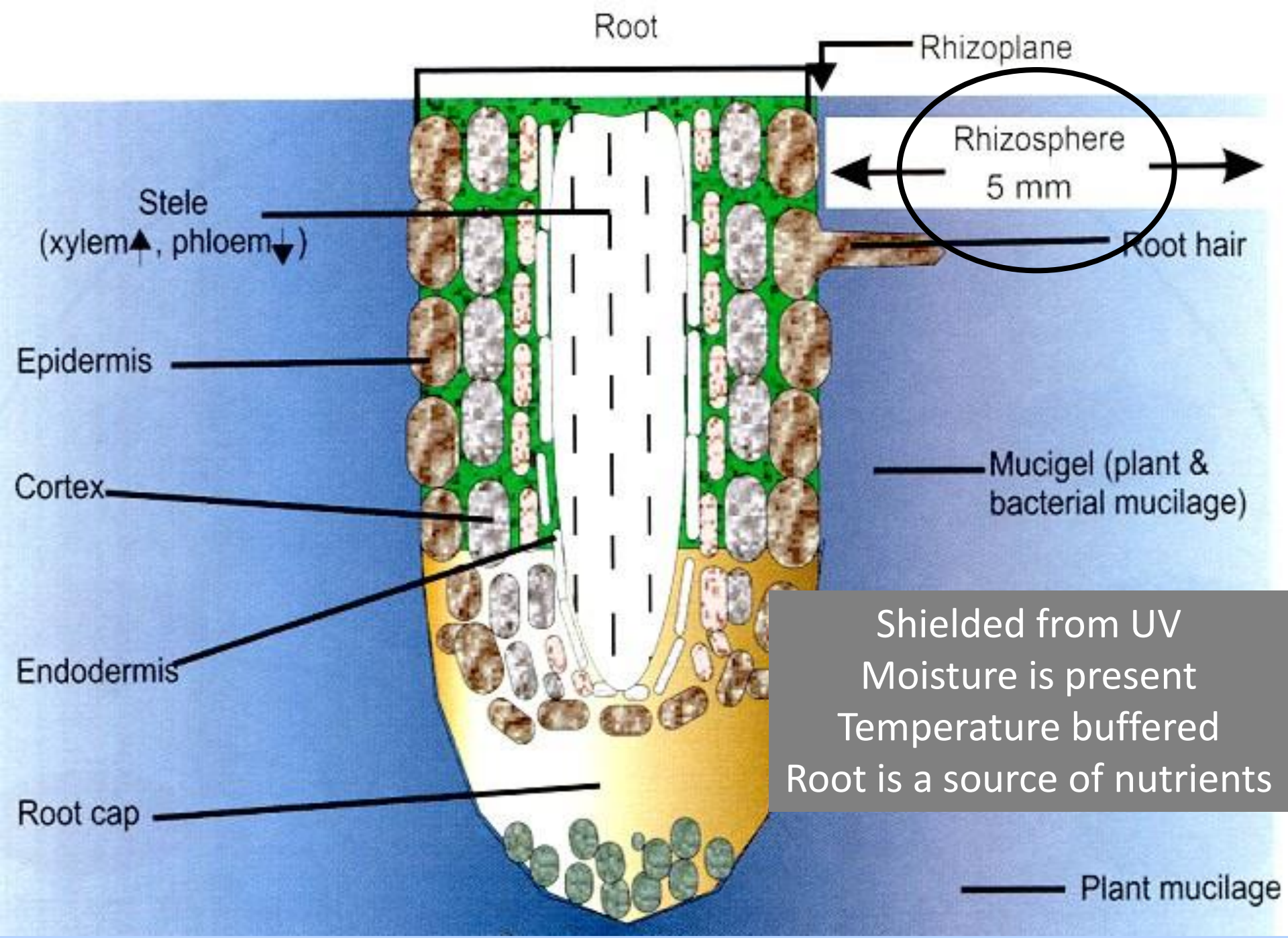
from a substantial food base



Sugars
Amino acids

Roots provide a substrate for fungal growth

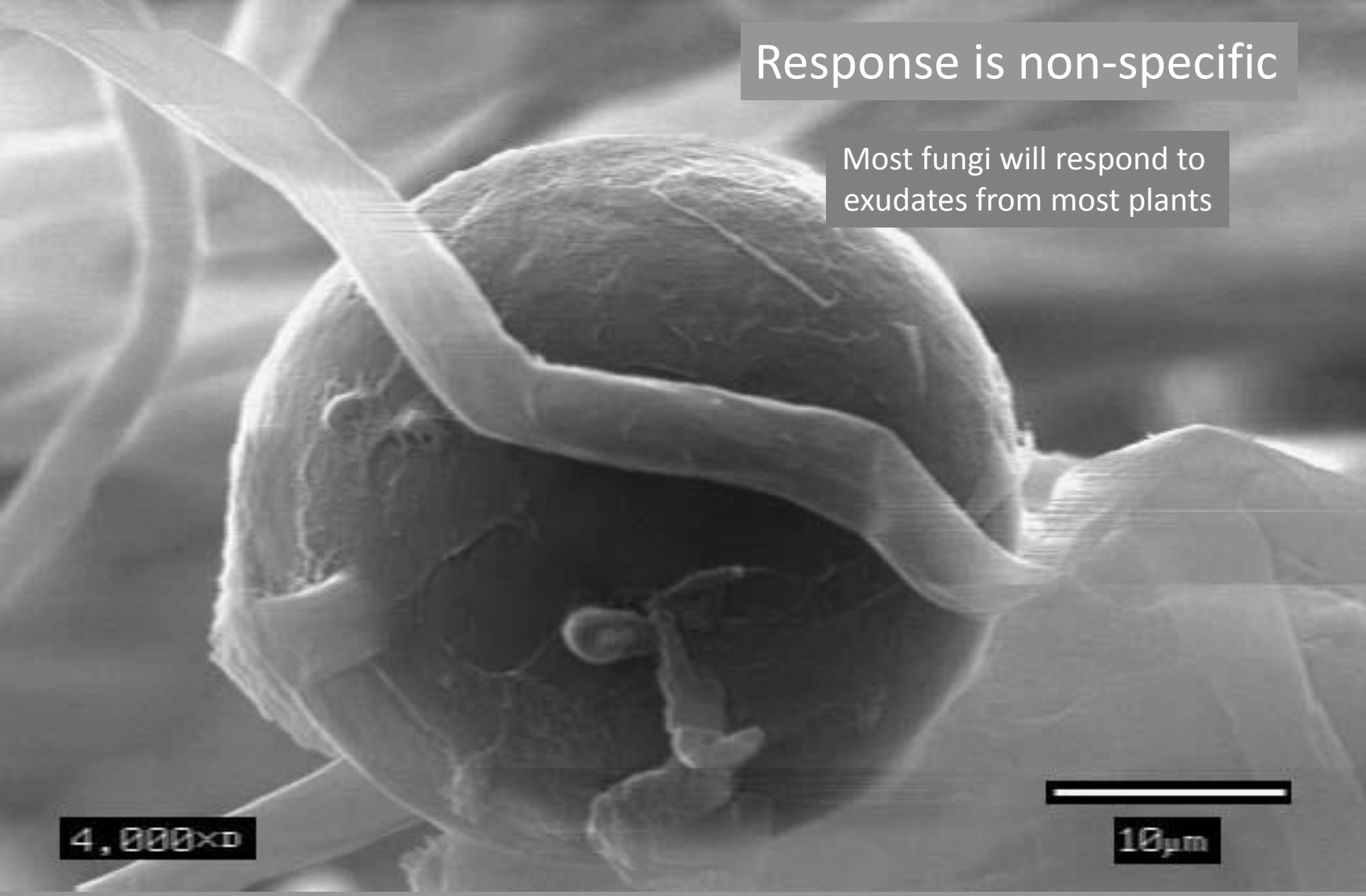
Nutrients diffuse away from the root



Shielded from UV
Moisture is present
Temperature buffered
Root is a source of nutrients

Response is non-specific

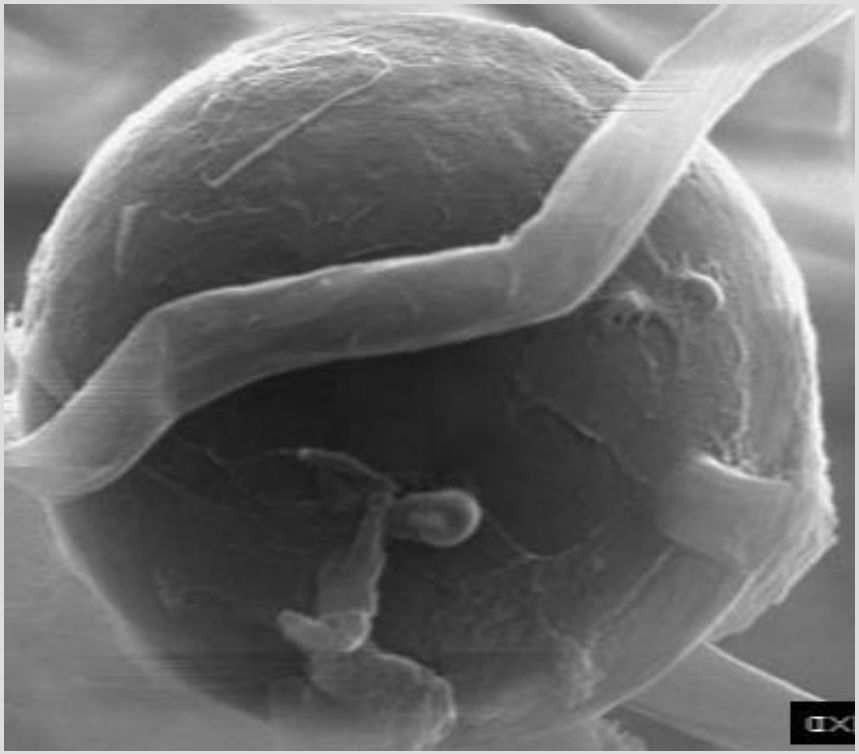
Most fungi will respond to exudates from most plants



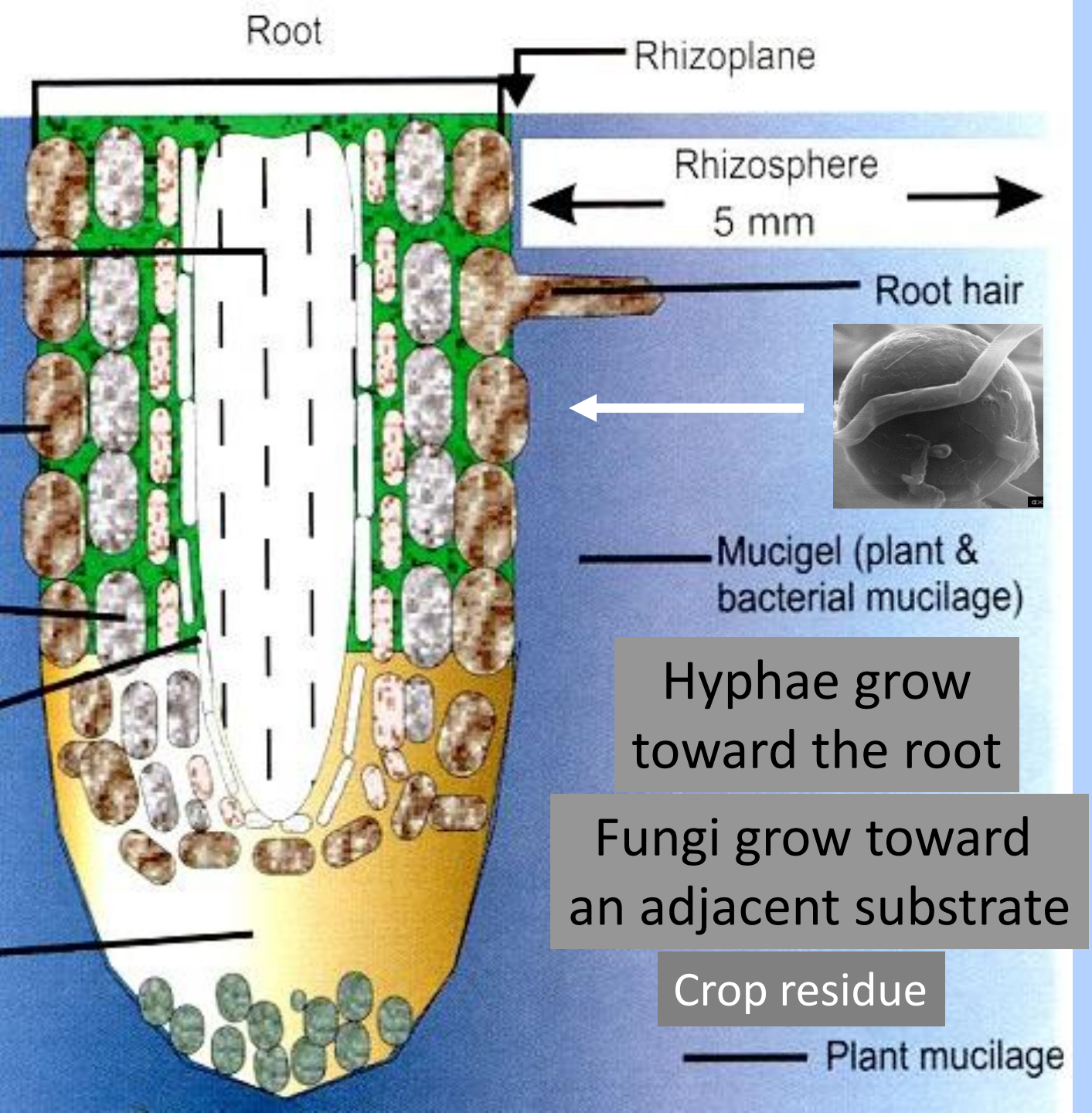
Fungal spores within the rhizosphere germinate

In the absence of an external source of nutrients spores will not germinate

Even spores with sufficient endogenous nutrients



Fungistasis



Hyphae grow toward the root

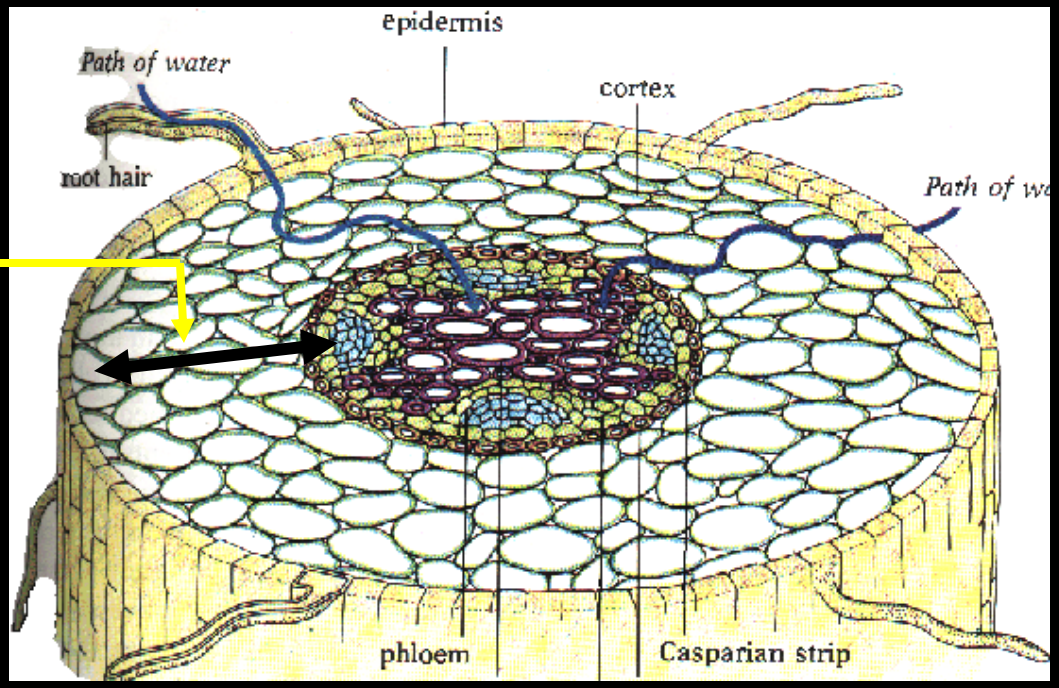
Fungi grow toward an adjacent substrate

Crop residue

Non-pathogenic fungi commonly colonize the root cortex

Both inter- and intracellularly

Region of fungal growth



All plants are infected

Infection ≠ Disease

Relatively non-specific

Impact is minimal

The root cortex is not well defended

Roots must be permeable to take up water

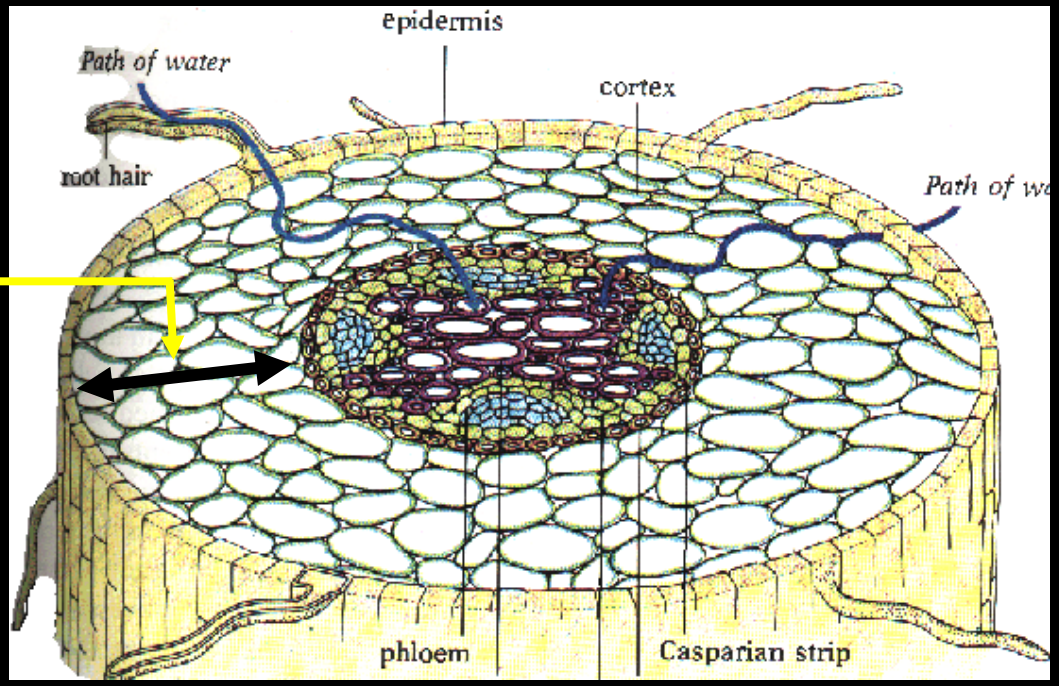
Consequently they are leaky

Sugars are in higher concentration inside root

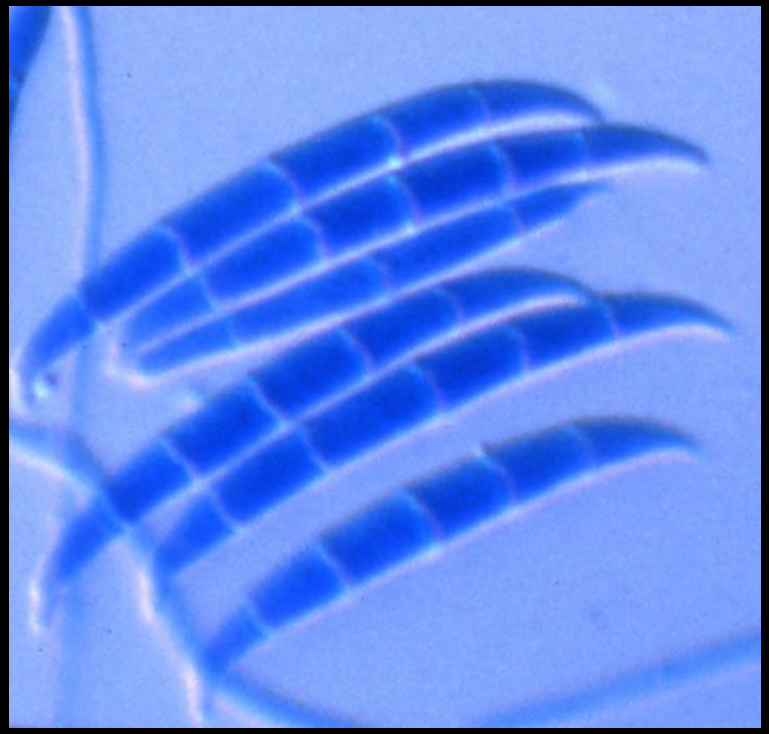
So sugars diffuse out into the soil

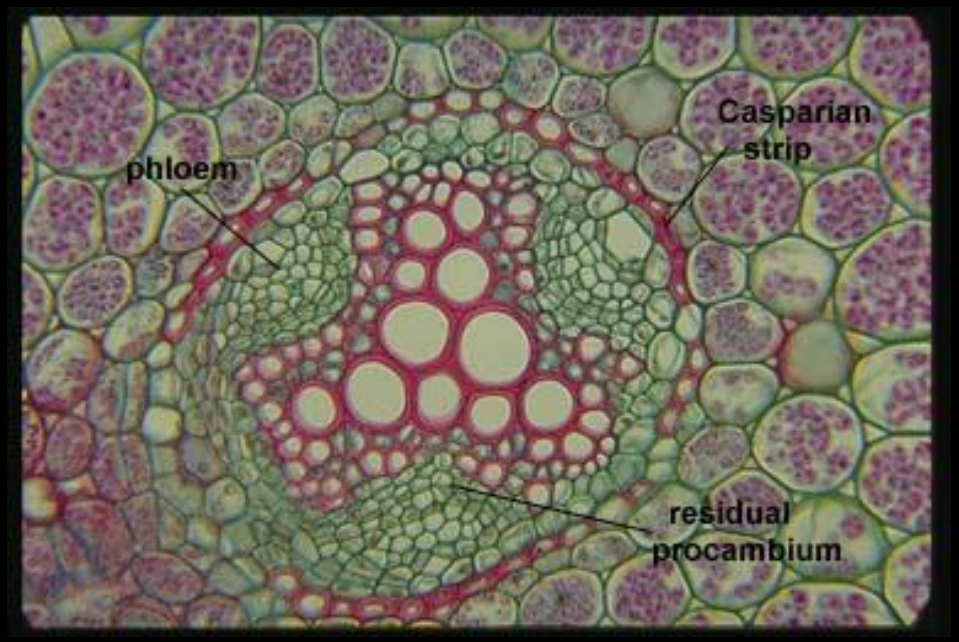
Root exudates stimulate microbial growth

Region of fungal growth



Cost:Benefit



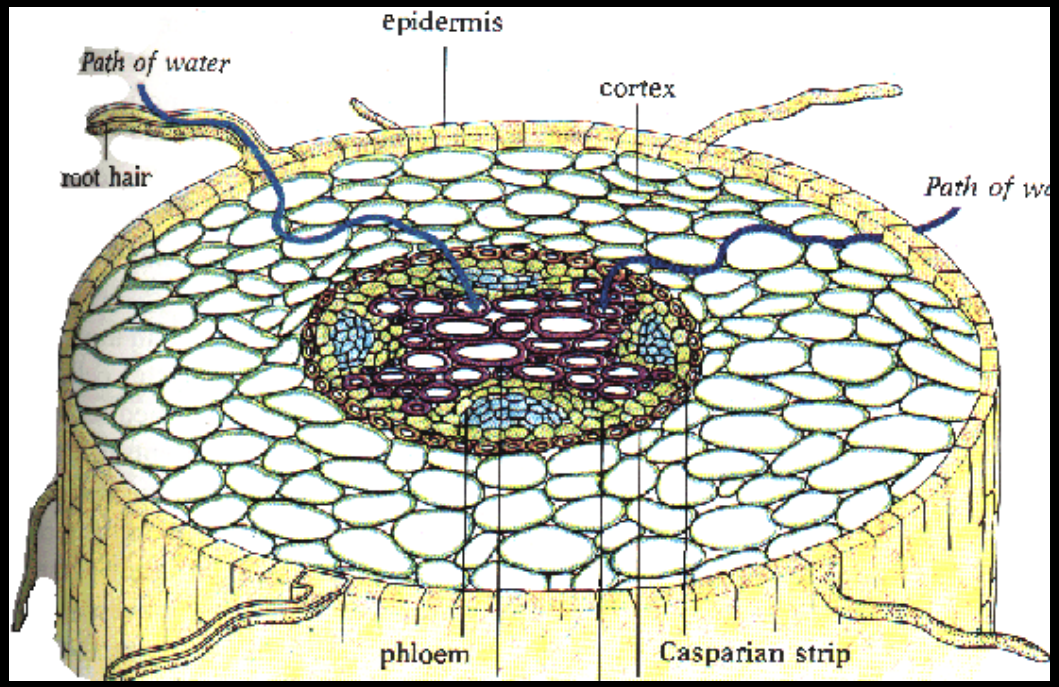


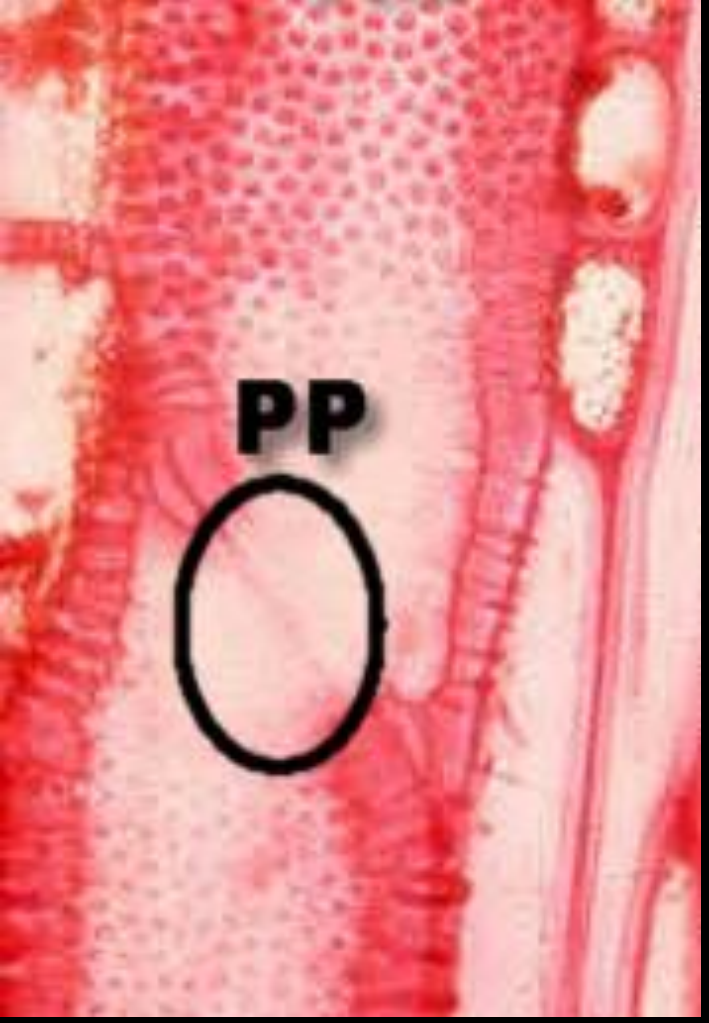
Fusarium oxysporum

Cause of
Fusarium wilt

Colonizes root cortex

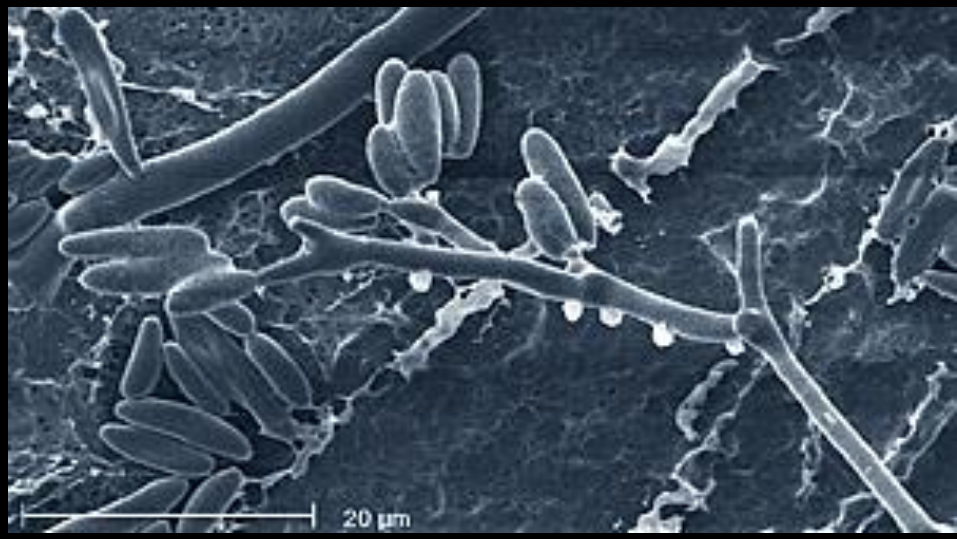
Invades the vascular tissue





Hyphae grow in vessels

Produce microconidia



Stopped by perforation plate

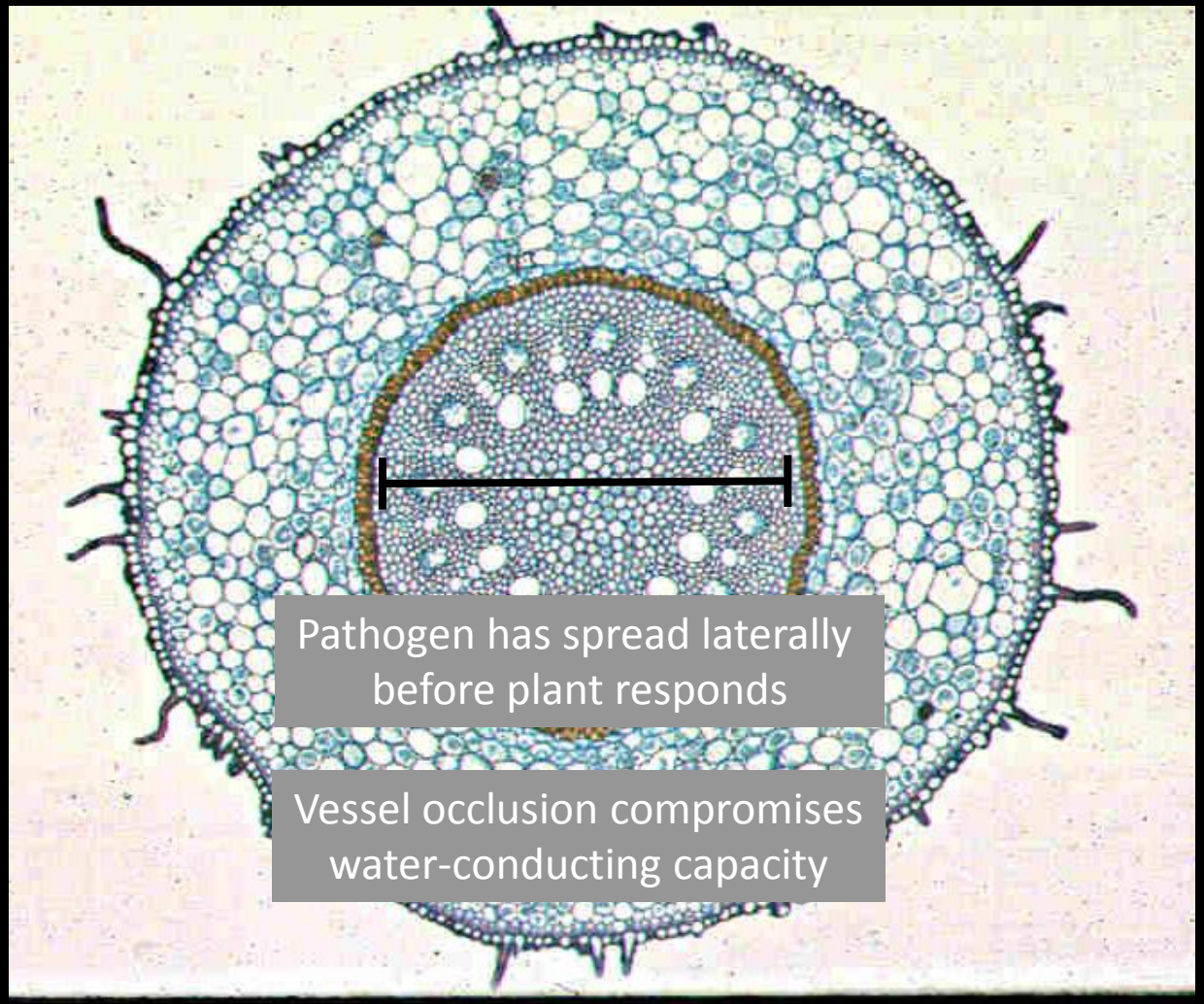
Spores germinate and penetrate perforation plate

Carried upward in transpiration stream

Systemic infection

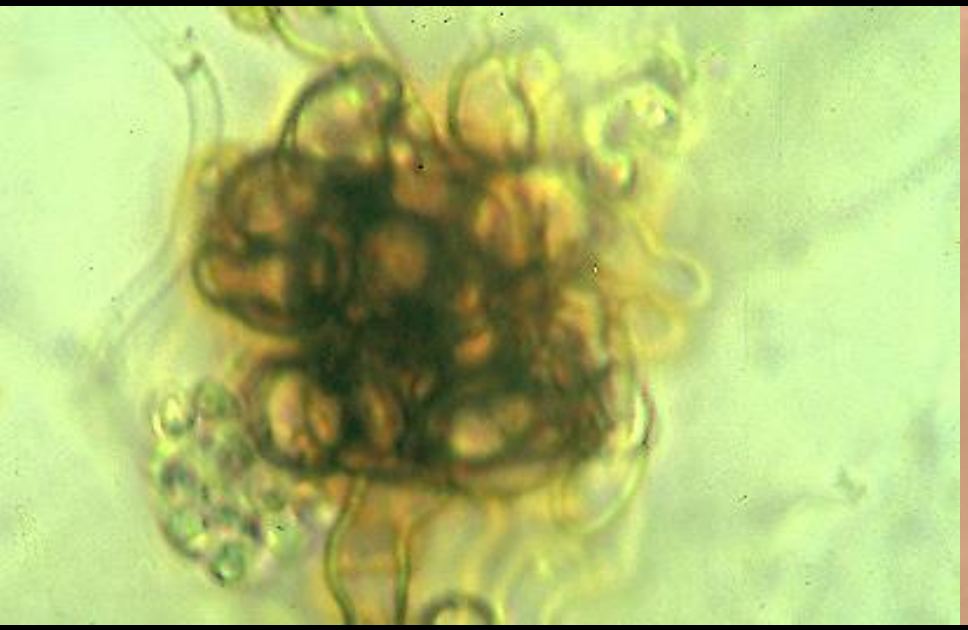
Delayed response

Pathogen is not contained in first vessel



How long can fungi survive in soil?

Durability of propagules



Verticillium dahliae

Microsclerotia

3-5 years

Fusarium oxysporum

Chlamydospores

1-2 years

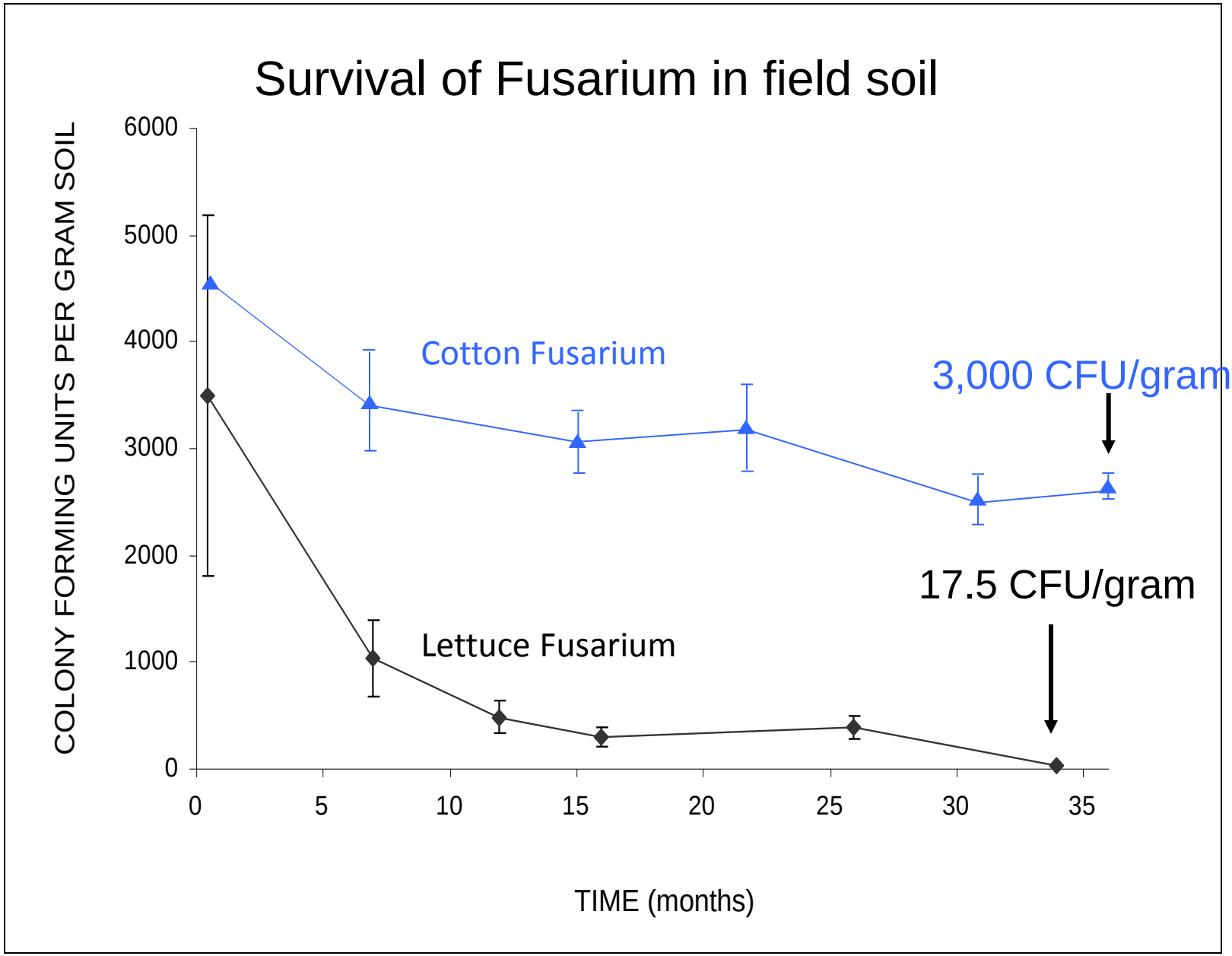
What determines the rate of attrition?

Microbial activity

Removes organic matter that protects pathogen propagules

Warmer is better

Wet is better


Survival of Fusarium in field soil
COLONY FORMING UNITS PER GRAM SOIL
6000
5000
4000
3000
2000
1000
0
0
5
10
15
20
25
30
35
TIME (months)
Cotton Fusarium
Lettuce Fusarium
3,000 CFU/gram
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

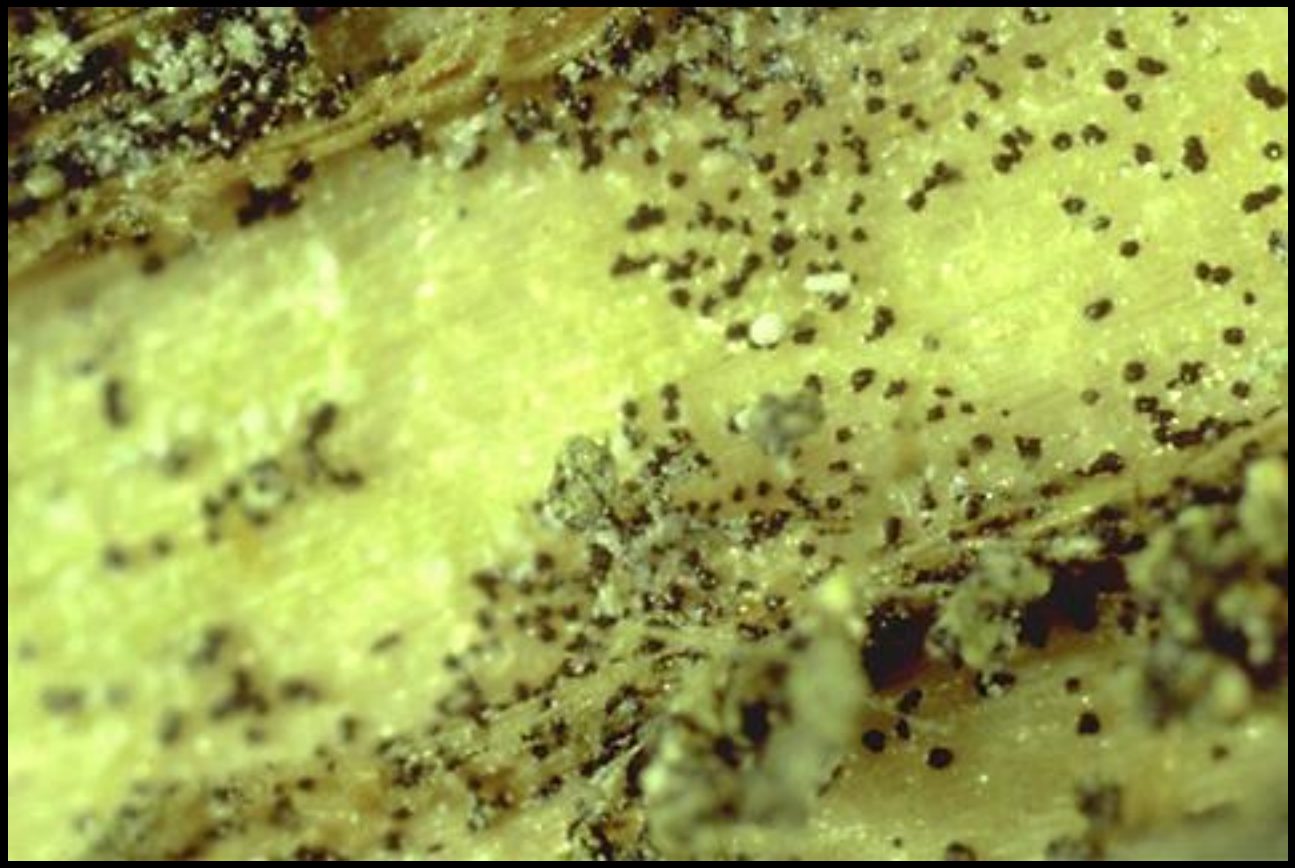
- tomatoes and cucurbits
- walnut, cherry, almond

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


Brent Holtz


Brent Holtz


Brent Holtz

Vascular discoloration

Verticillium wilt in…

Chinese pistache

Maple

Tomato

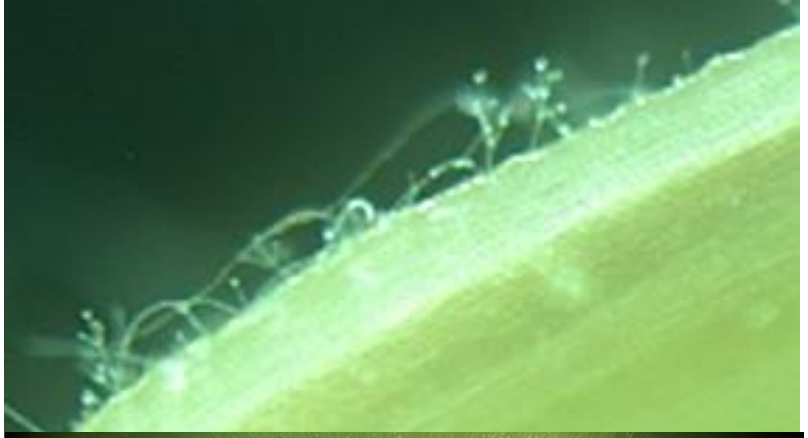
Verticillium dahliae

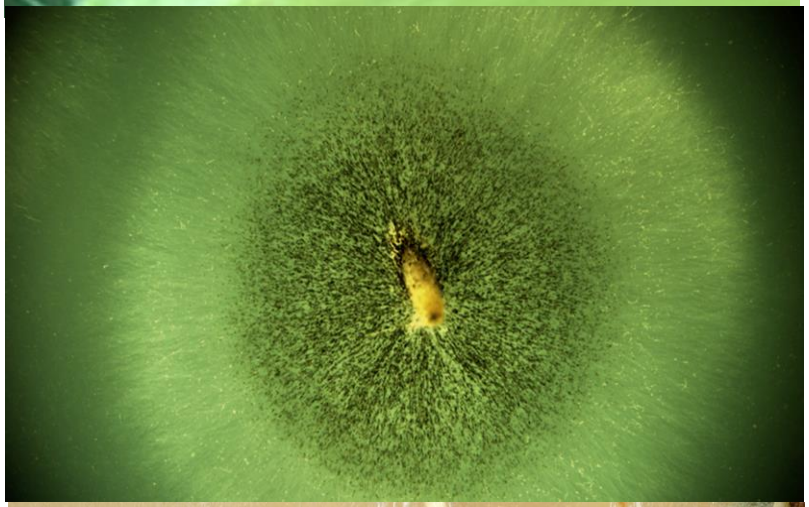
- Conidia
- Microsclerotia
- No sexual stage

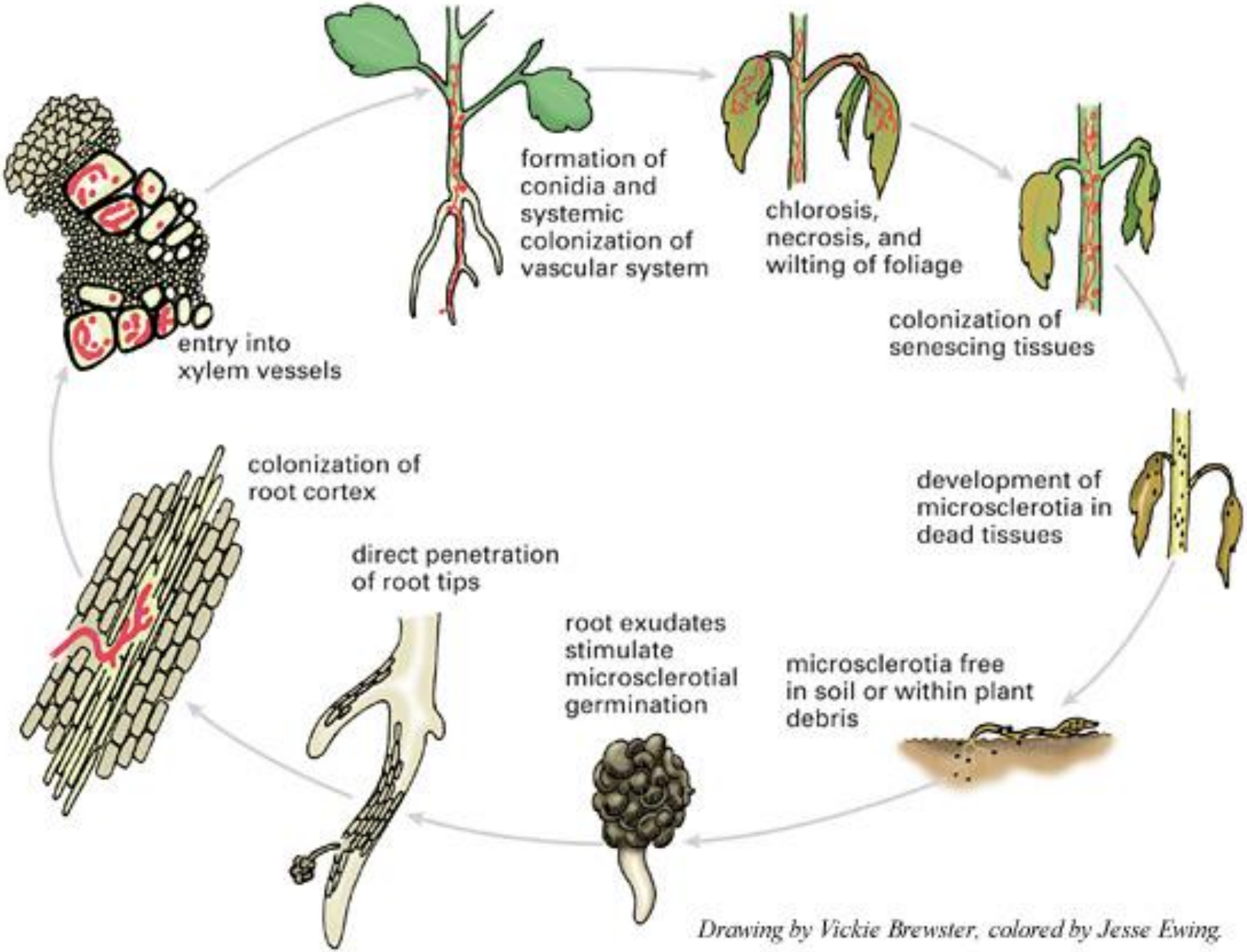
• Cross pathogenic

- Many crops
- Non-domesticated plants

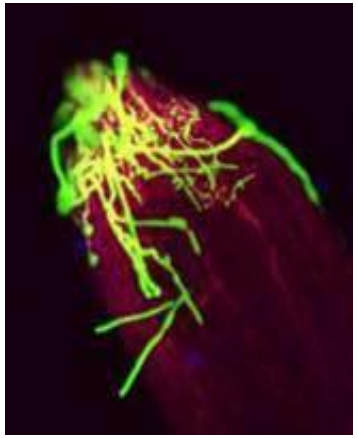
• Seedborne



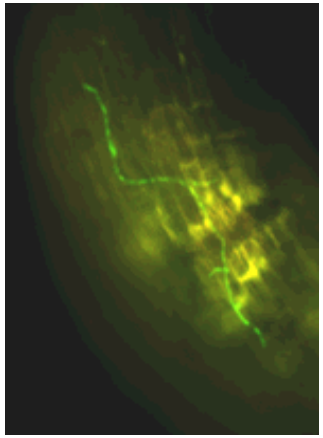




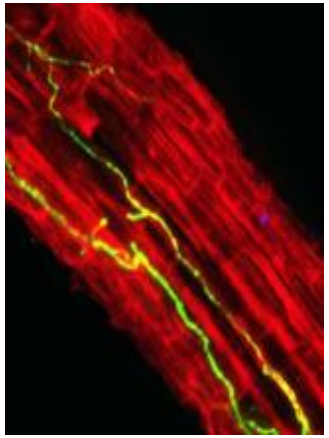
Drawing by Vickie Brewster, colored by Jesse Ewing.



Colonization of lateral root tip



Colonization of root elongation zone



Systemic colonization of lateral root

Vascular discoloration 6 to 8 weeks

8 to 10 weeks

Taproot colonization coincides with foliar symptom development

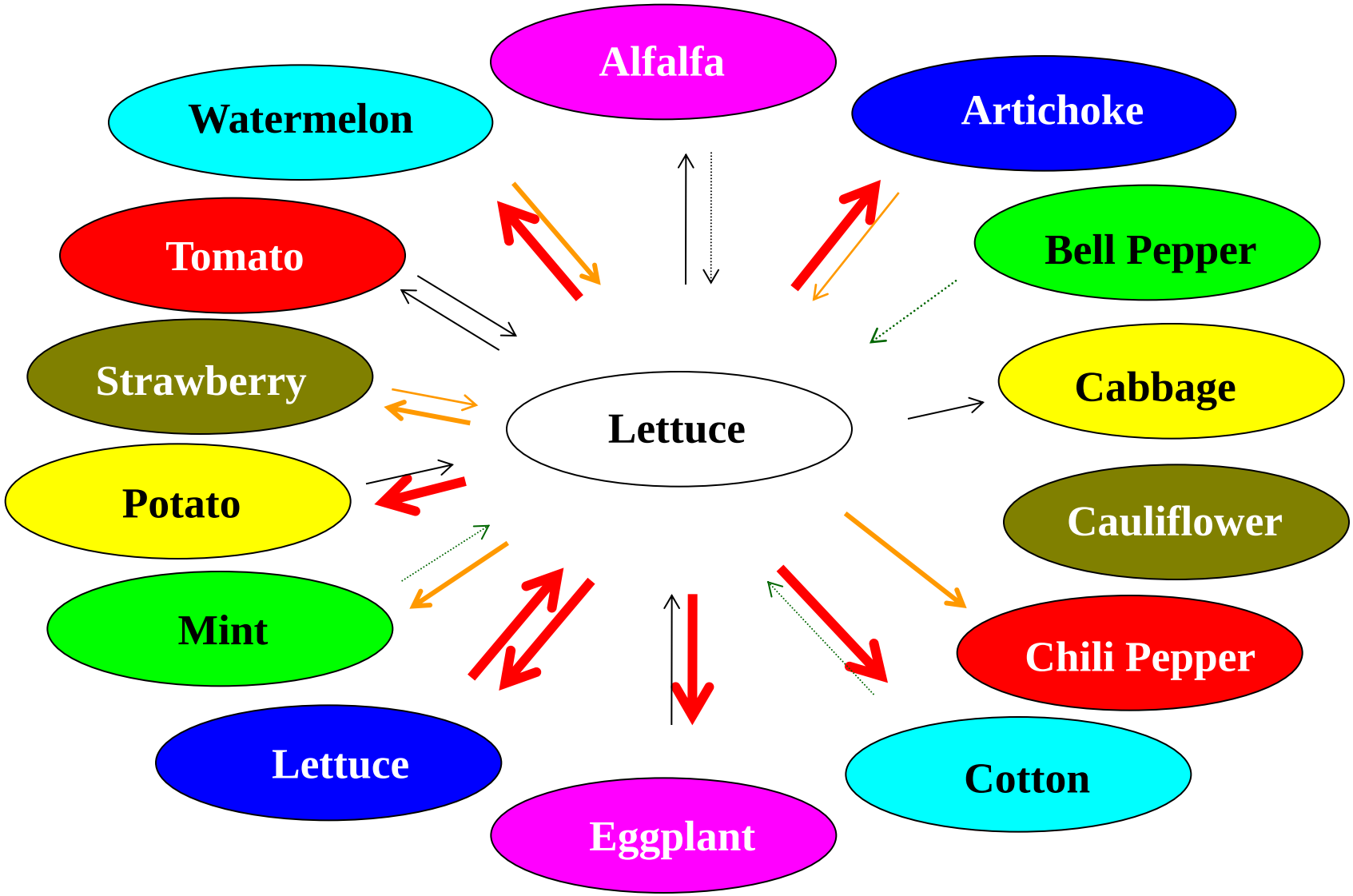
Microsclerotia development

10+ weeks

Mature microsclerotia embedded in taproot tissues

Subbarao, UC Davis

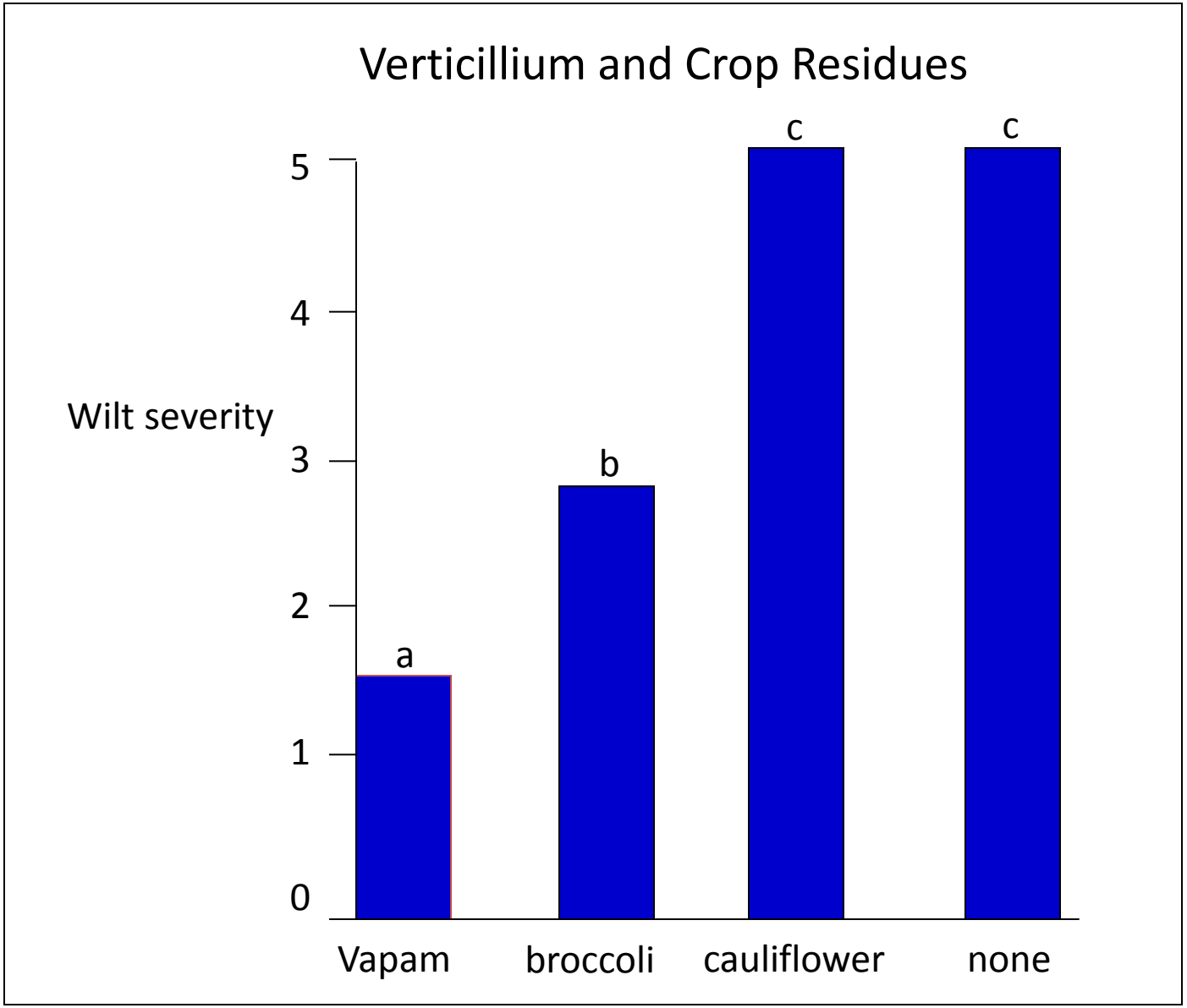
Verticillium



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



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

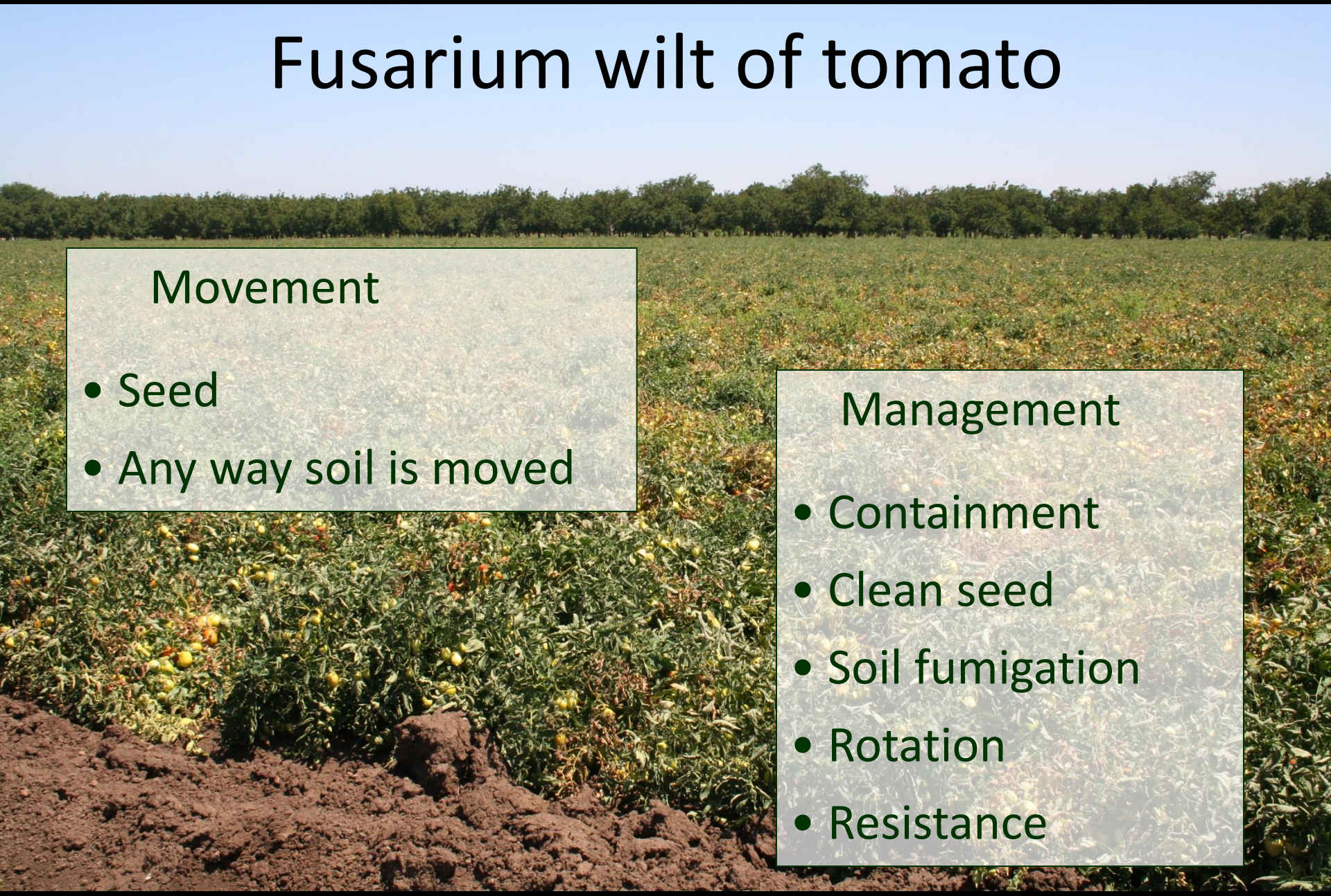
Fusarium oxysporum races 1, 2, and 3

- 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

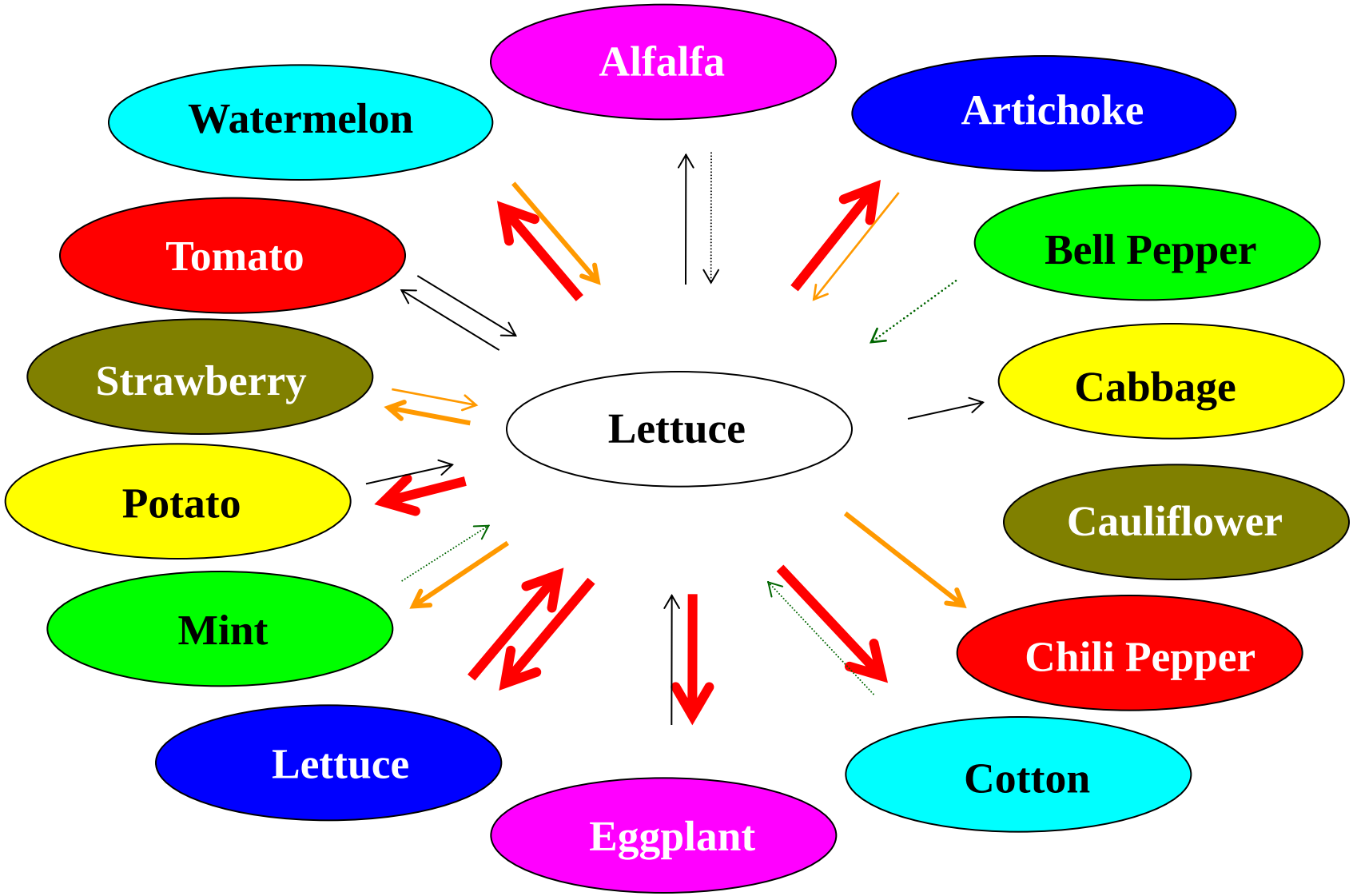
Fusarium wilt

favored by:	suppressed by:
ammoniacal nitrogen	nitrate nitrogen
acid soils	alkaline soils
80-90 F	60-70 F
sandy soils	microbially rich soils

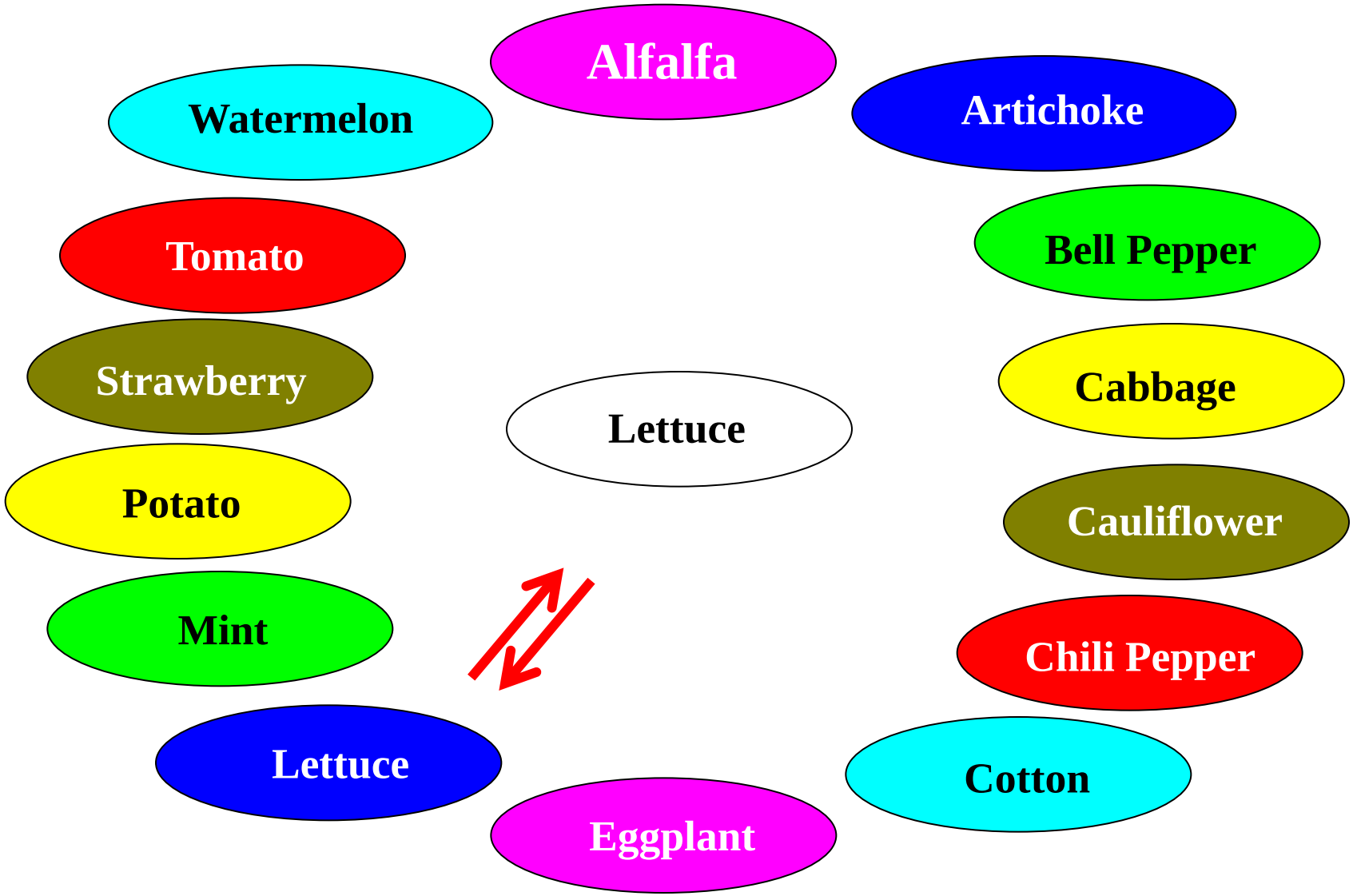
Verticillium wilt

favored by:	suppressed by:
nitrate nitrogen	ammoniacal nitrogen
alkaline soils	acid soils
65-80 F	80-90 F
	microbially rich soils

Verticillium



Fusarium


Alfalfa
Artichoke
Bell Pepper
Cabbage
Cauliflower
Chili Pepper
Cotton
Eggplant
Lettuce
Mint
Potato
Strawberry
Tomato
Watermelon
Lettuce

Phytophthora Crown and Root Rot

TOMATO: Caused by *Phytophthora capsici* & *Phytophthora parasitica*

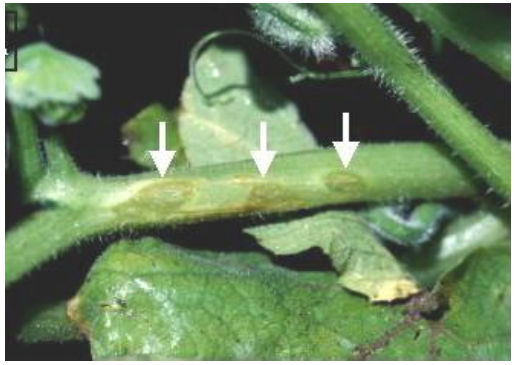
Crown and Root Rot

Clark

Holmes

Foliar infections (blight) and fruit rots

Davis



Babadoost & Islam

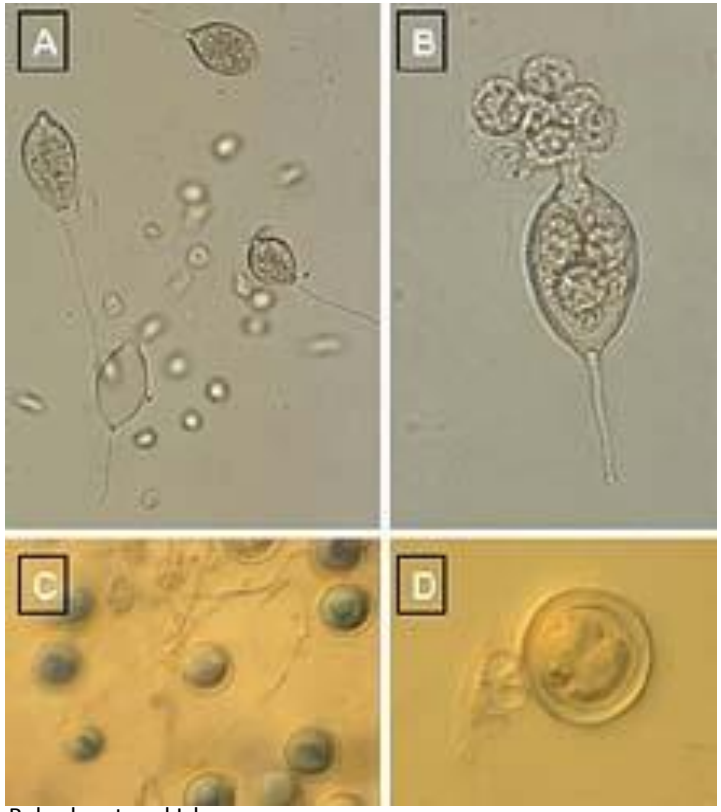
More of a problem in climates with higher humidity or summer rainfall

Disease spread and soil survival

Phytophthora capsici produces:

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

Davis



Babadoost and Islam

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

Chemical	FRAC group	Products
Metalaxyl/mefenoxam	4	Ridomil, Ridomil Gold, Ridomil Gold Bravo, Ridomil Gold MZ & many others
phosphorous acid materials	33	Various (Aliette, Fosphite and others)

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

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

Questions?

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