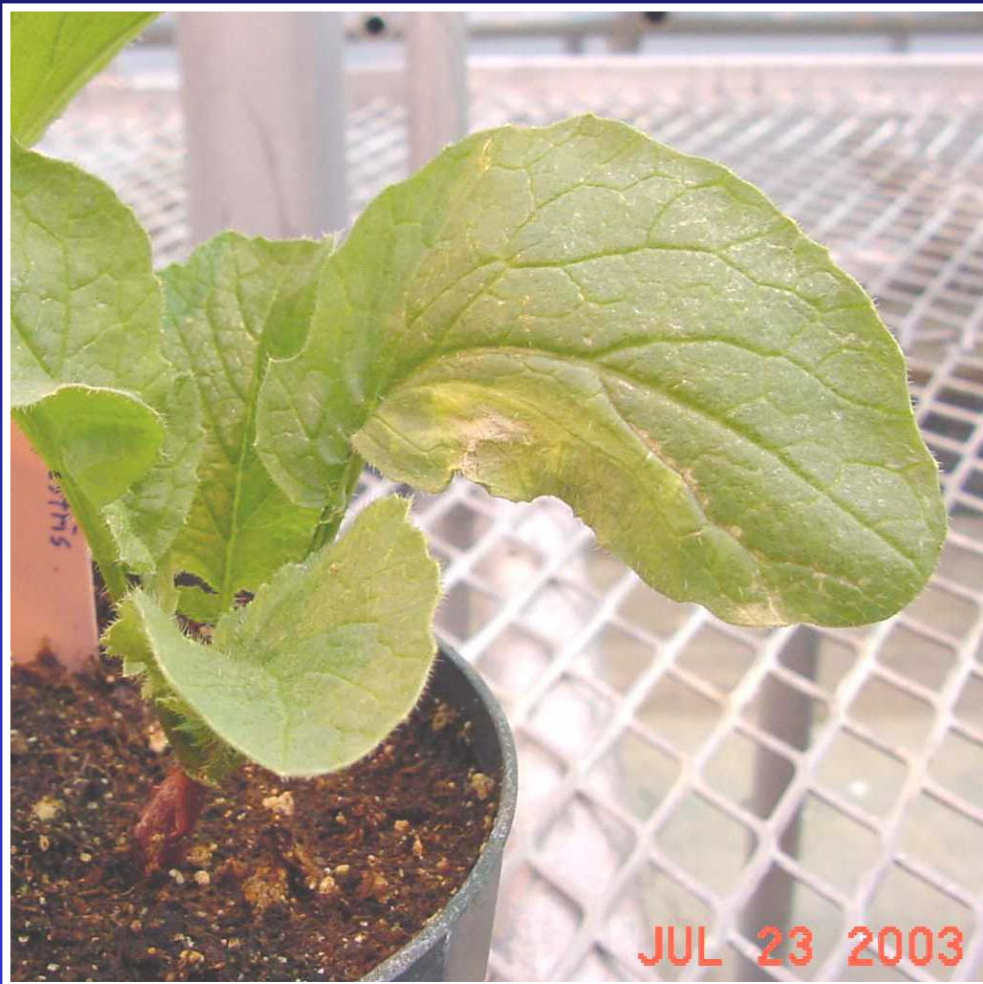


Black rot of crucifers:
Xanthomonas campestris pv. *campestris*



Black rot of crucifers:
Xanthomonas campestris pv. *campestris*



Black rot of crucifers:
Xanthomonas campestris pv. *campestris*



Photos from R.L. Gabrielson



Xanthomonas leaf spot of crucifers:
Xanthomonas campestris pv. *armoraciae/raphani*



Peppery leaf spot of crucifers: *Pseudomonas syringae* pv. *maculicola*



Xanthomonas campestris & *Pseudomonas syringae* pathogens of crucifers

	Black rot	Xanthomonas leaf spot	Xanthomonas leaf spot	Peppery leaf spot
Pathogen	<i>X. c. pv. campestris</i>	<i>X. c. pv. raphani</i>	<i>X. c. pv. armoraciae</i>	<i>P. s. pv. maculicola</i>
Symptoms	Yellow leaves, wilting, black veins	Circular, water-soaked leaf spot, chlorotic halo; dark lesions on petioles		Circular to angular spots, chlorotic halo
Systemic	+	-		
Seedborne	+			
Dispersal	Splashing water, seed, insects			
Overwinter	Debris, Crucifer weeds, soil			
Favorable conditions	<u>Warm to hot</u> , wet	<u>Cool to warm</u> , extended wet periods	<u>Cool to warm</u> , extended wet periods	<u>Cool</u> , wet
Host range	Crucifers (including weeds)	Cabbage, broccoli, cauliflower, kale, radish, <u>tomato</u> , <u>pepper</u>	Cabbage, broccoli, cauliflower, kale, radish, <u>horseradish</u>	Cabbage, broccoli, cauliflower, Br. sprouts, turnip

Bacterial leaf spot of beet: *Pseudomonas syringae* pv. *aptata*



Photos at <http://www.ext.nodak.edu/extpubs/plantsci/rowcrops/pp1244w.htm>

Pseudomonas leaf spot diseases of spinach & beet

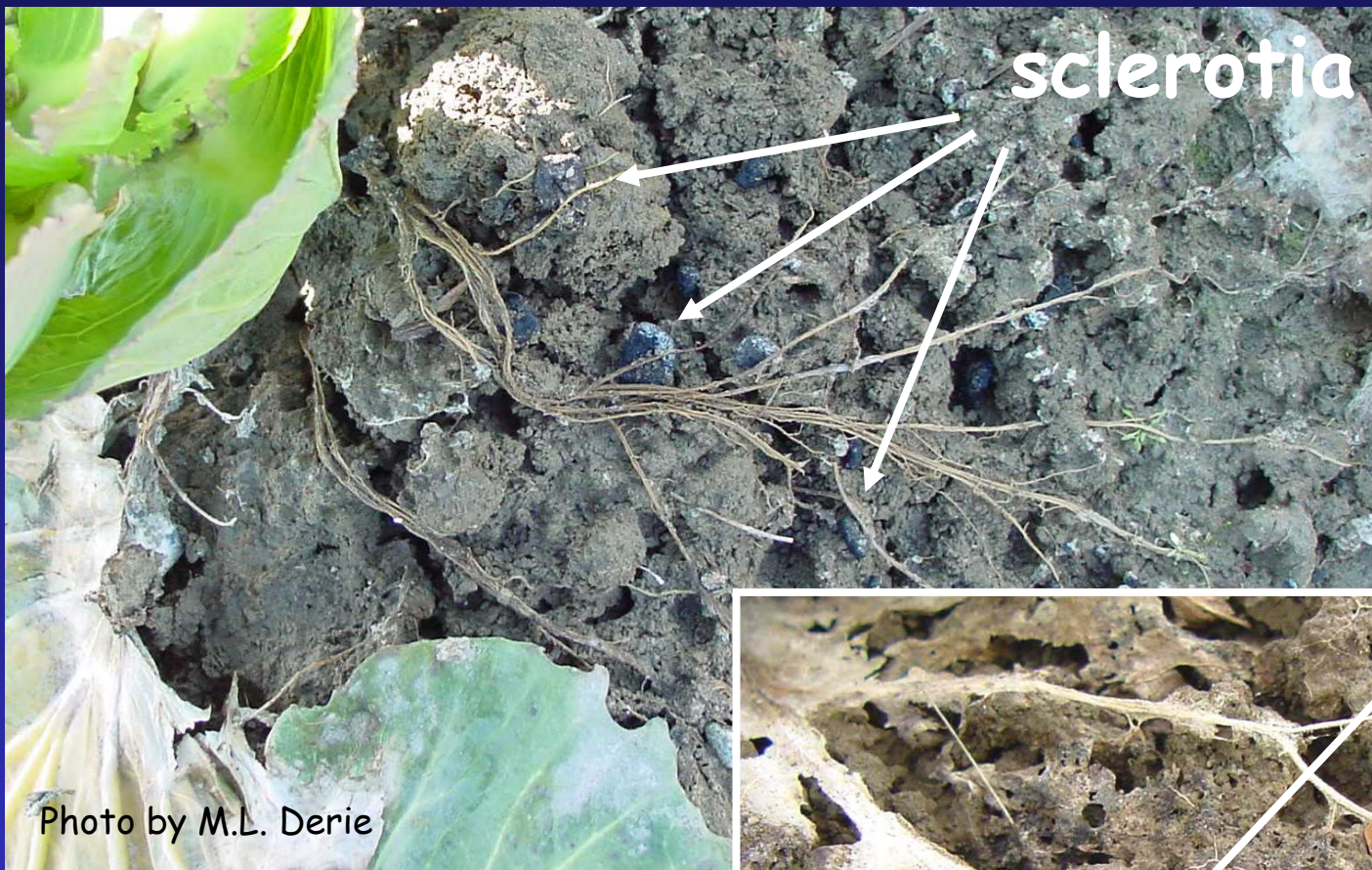
	<i>P. syringae</i> pv. <i>spinaciae</i>	<i>P. syringae</i> pv. <i>aptata</i>
Symptoms	Irregular, water-soaked spots; older lesions dark brown to black, angular; lesions visible from top & bottom of leaf	Circular to irregular leaf spots, tan center, dark margin; leaf margins; coalesce to ragged appearance
Seedborne	- (?)	+
Dispersal	Splashing water, machinery	Splashing water, insects, machinery
Overwinter	Debris?	Debris,
Favorable conditions	Wet, cool?	Wet, <u>cool</u>
Host range	Spinach, others?	Beet, chard, bean, eggplant, lettuce, and pepper



White mold:
Sclerotinia
sclerotiorum

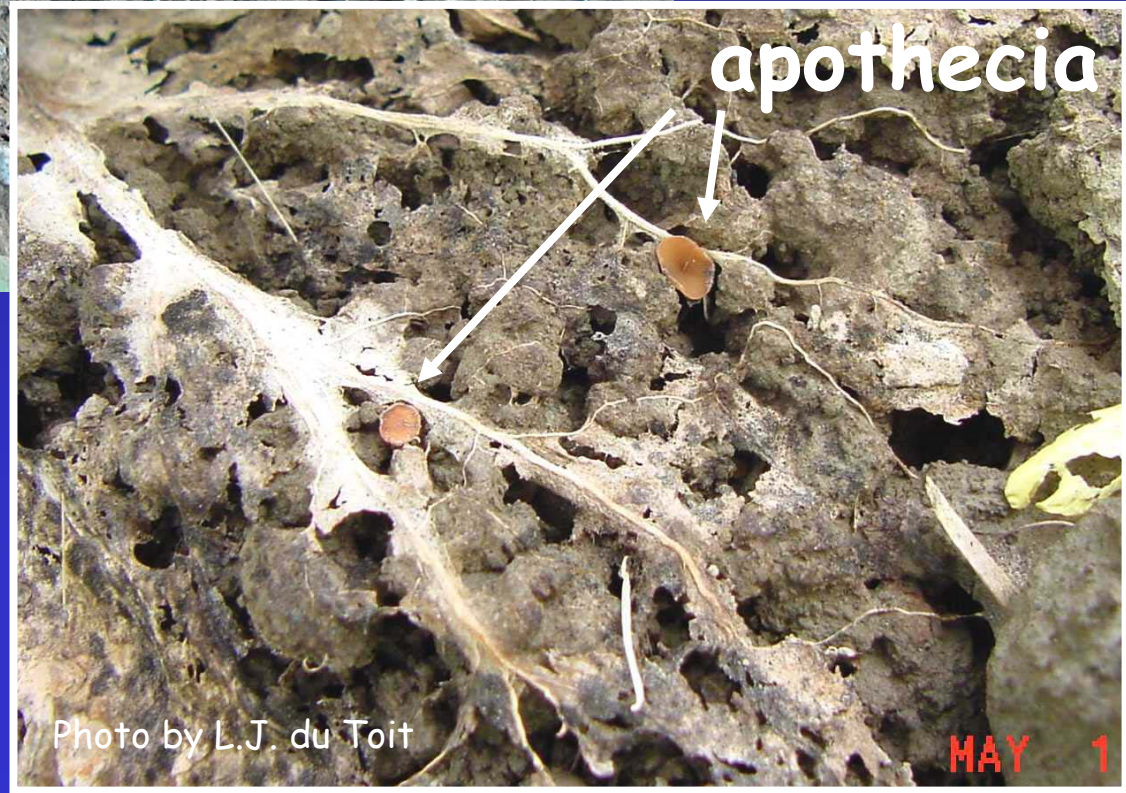


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sclerotia

Photo by M.L. Derie

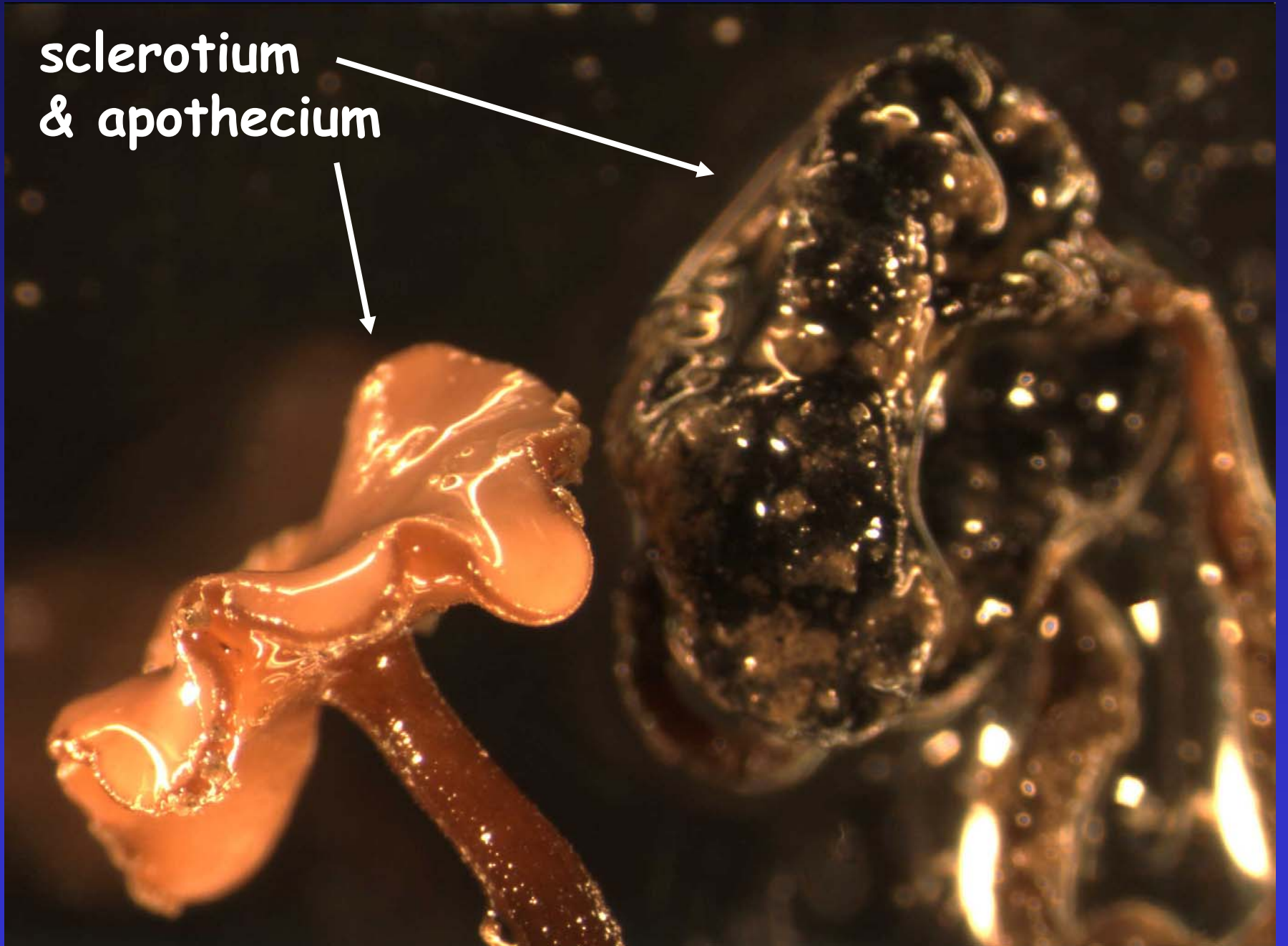


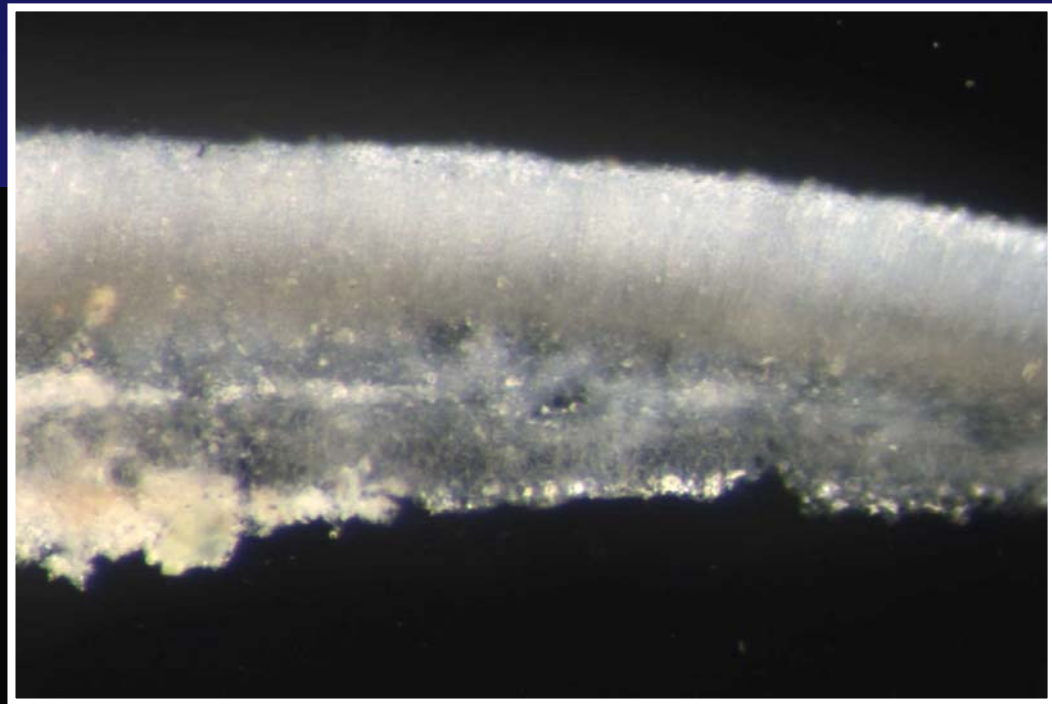
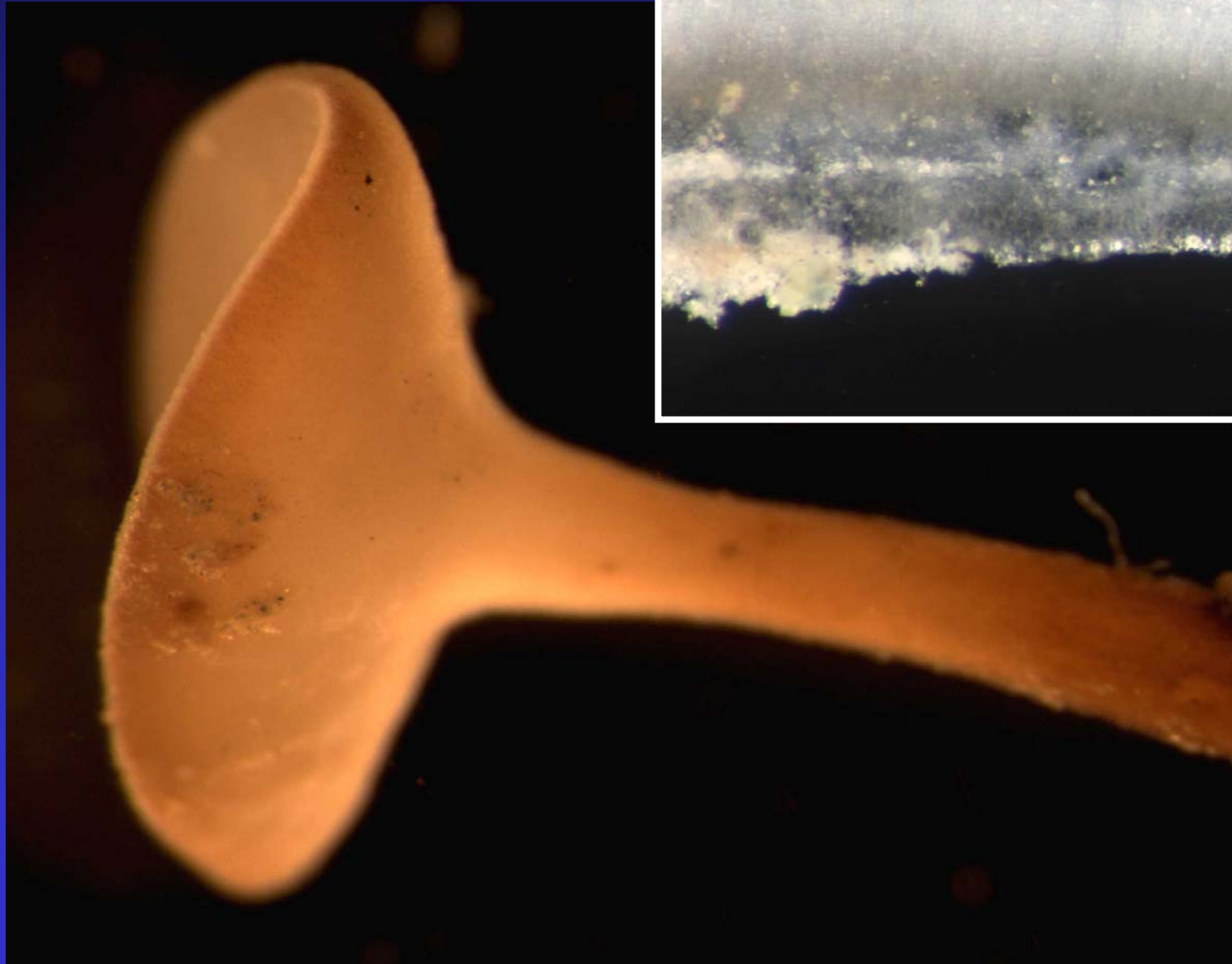
apothecia

Photo by L.J. du Toit

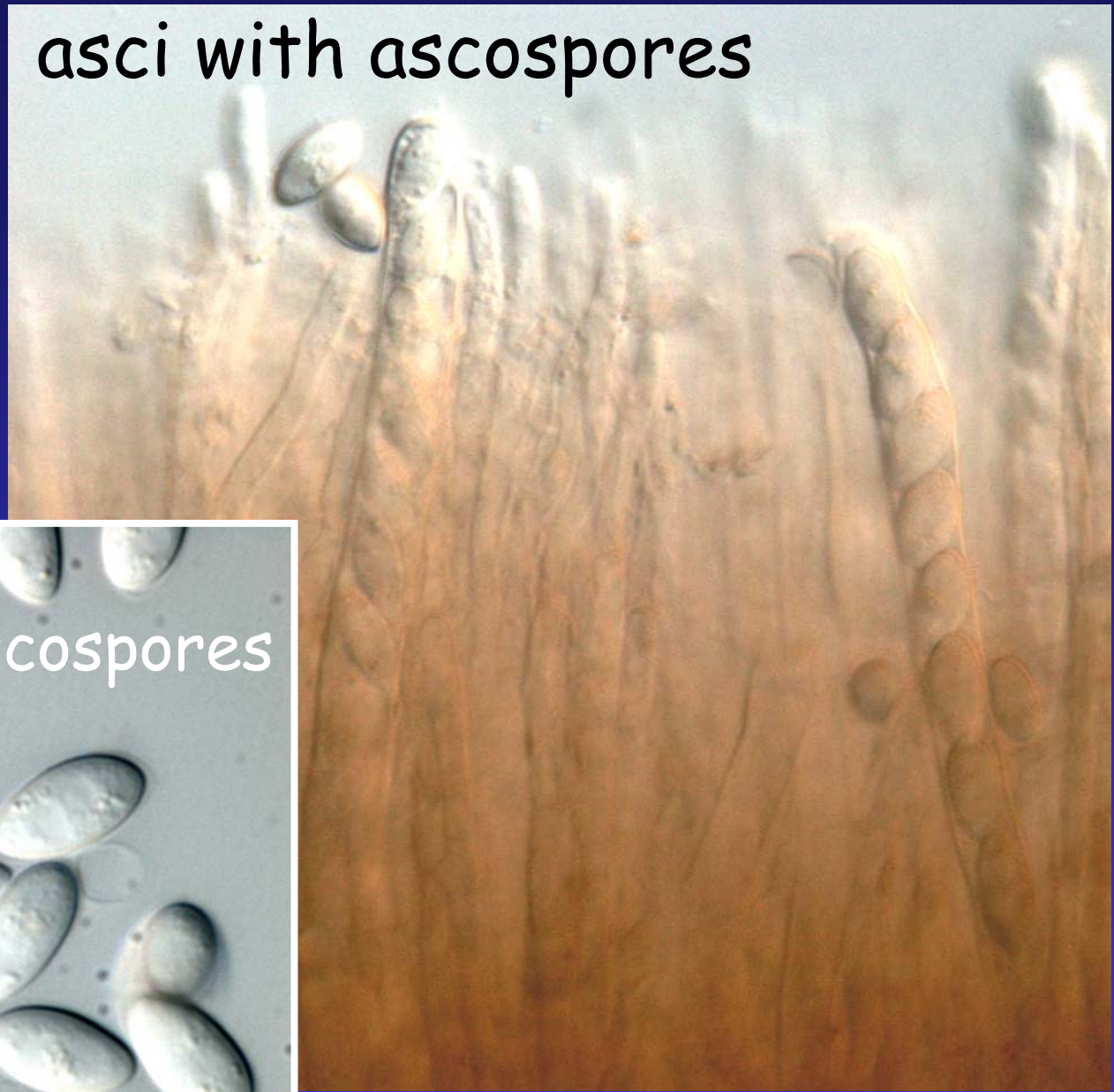
MAY 1

sclerotium
& apothecium

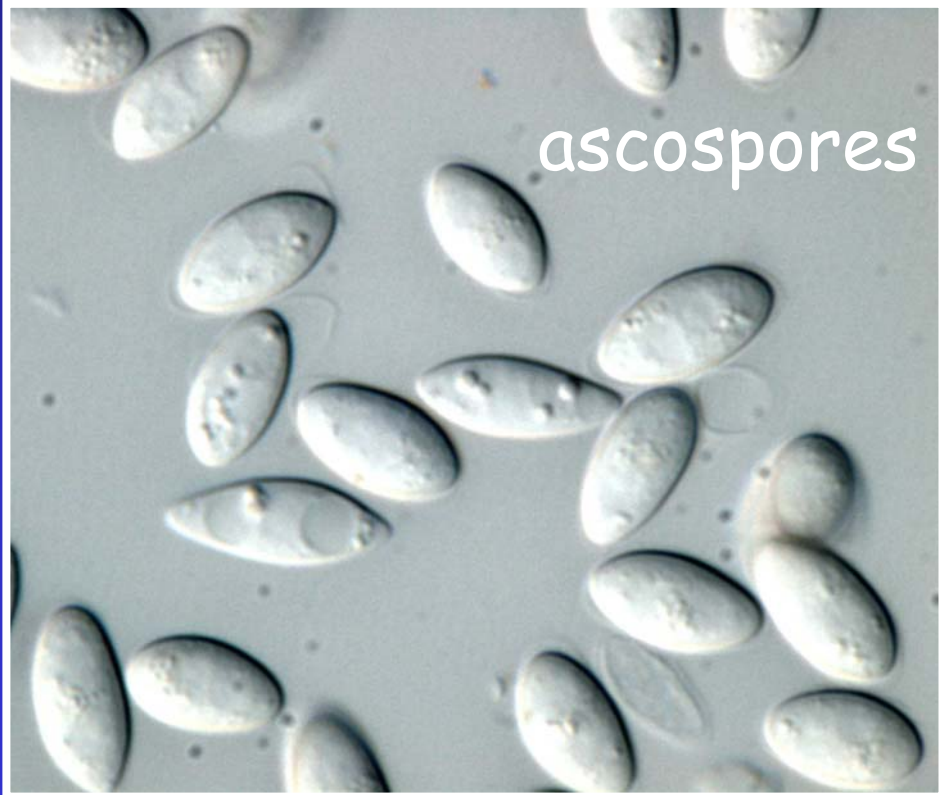




asci with ascospores



ascospores





JU



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Sclerotinia sclerotiorum

- extremely broad host range
(p. 27 of "2003 PNW Disease Mngmt Hdbk")
- long-lived (sclerotia)
- favorable conditions:
 - extended periods of moist conditions
 - high humidity - dense canopy, rain, irrigation, dew
 - cool or warm temperatures

Wilt diseases:

Fusarium oxysporum &
Verticillium dahliae

Wilt diseases:

Fusarium oxysporum vs. *Verticillium*

	<i>F. oxysporum</i>	<i>Verticillium</i>
Soilborne	+	+
Seedborne	+	+
Host range	Narrow (specific)	Broad
Survival in soil	Long-term	Long(er)-term
Favorable conditions for infection/symptoms	Warm, "dry"	Warm, "dry"

Wilt diseases: *Fusarium oxysporum*

<i>Forma specialis</i>	Symptomatic host	Asymptomatic host
<i>F. oxysporum</i> f. sp. <i>spinaciae</i>	Spinach	Beet Swiss chard
<i>F. oxysporum</i> f. sp. <i>betae</i>	Beet Swiss chard	Spinach
<i>F. oxysporum</i> f. sp. <i>conglutinans</i>	Cabbage (strains 1 & 5) Brussels sprout, cauliflower, collard, kale, mustards, rape, rutabaga, ... (strain 1) Flowering stock (strains 3 & 4)	
<i>F. oxysporum</i> f. sp. <i>raphani</i>	Radish (formerly strain 2 of <i>F. oxysporum</i> f. sp. <i>conglutinans</i>)	

Fusarium wilt of radish: *F. oxysporum* f. sp. *raphani*



Fusarium wilt of radish:
F. oxysporum f. sp. *raphani*



Fusarium wilt of radish: *F. oxysporum* f. sp. *raphani*

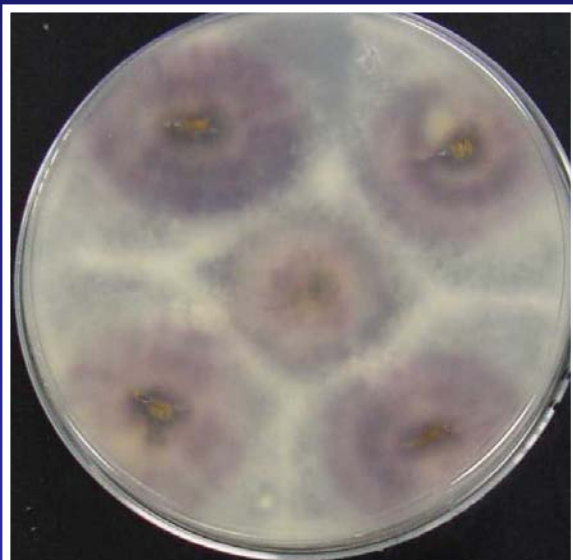


Photo by D.A. Inglis

Fusarium wilt of spinach: *F. oxysporum* f. sp. *spinaciae*



Fusarium wilt of spinach:
F. oxysporum f. sp. *spinaciae*



Verticillium wilt vs. Fusarium wilt of spinach

Verticillium wilt

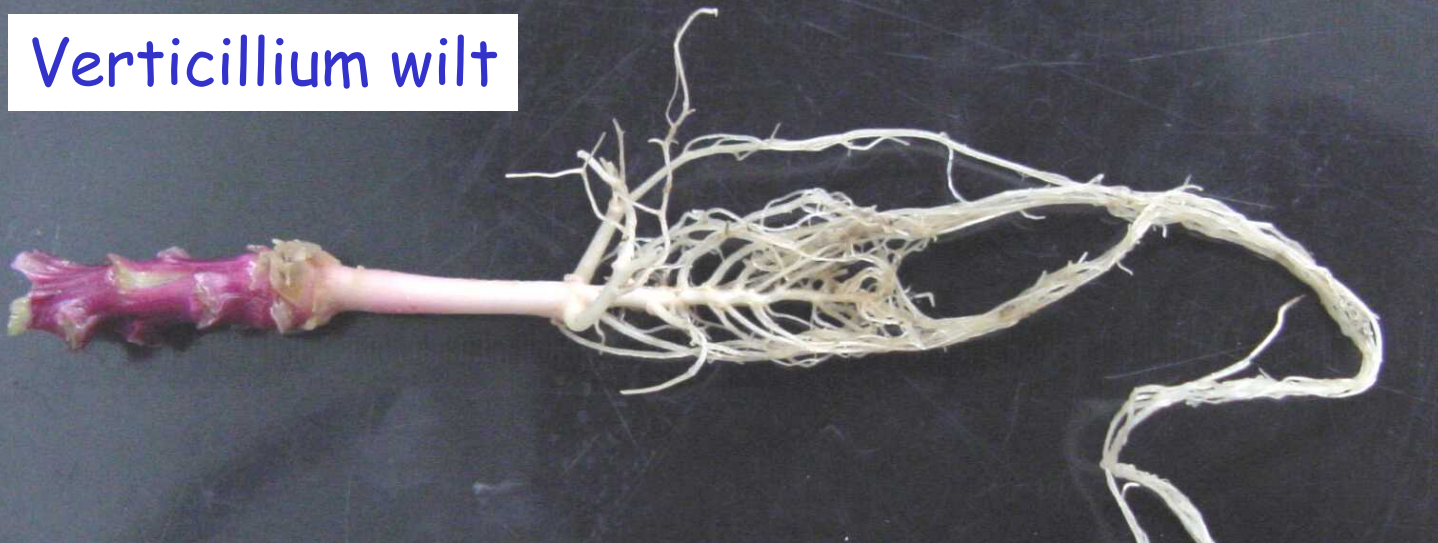


Fusarium wilt



Verticillium wilt vs. Fusarium wilt of spinach

Verticillium wilt



Fusarium wilt

Fusarium wilt

Verticillium wilt

Control



Systemic infection by *Verticillium*



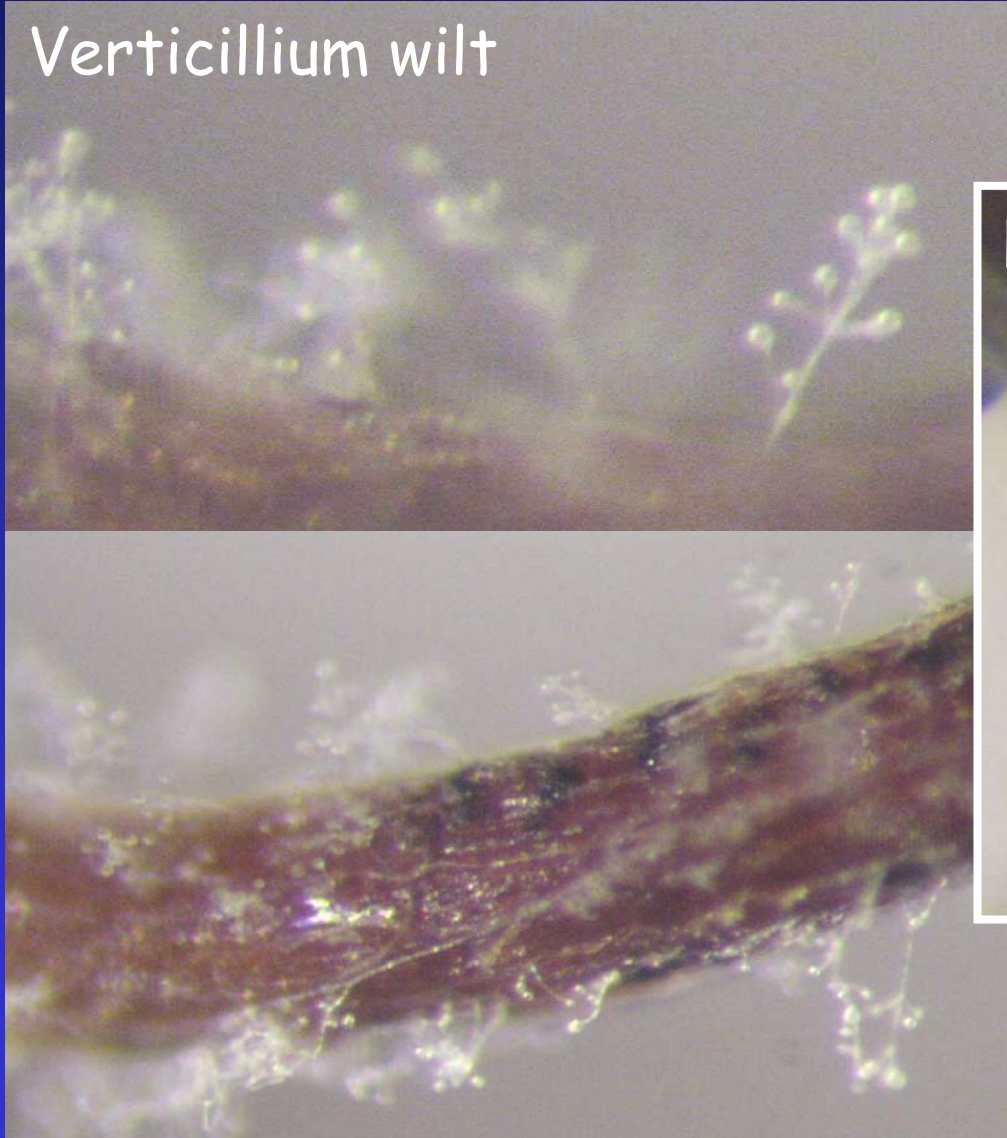
Non-inoculated control



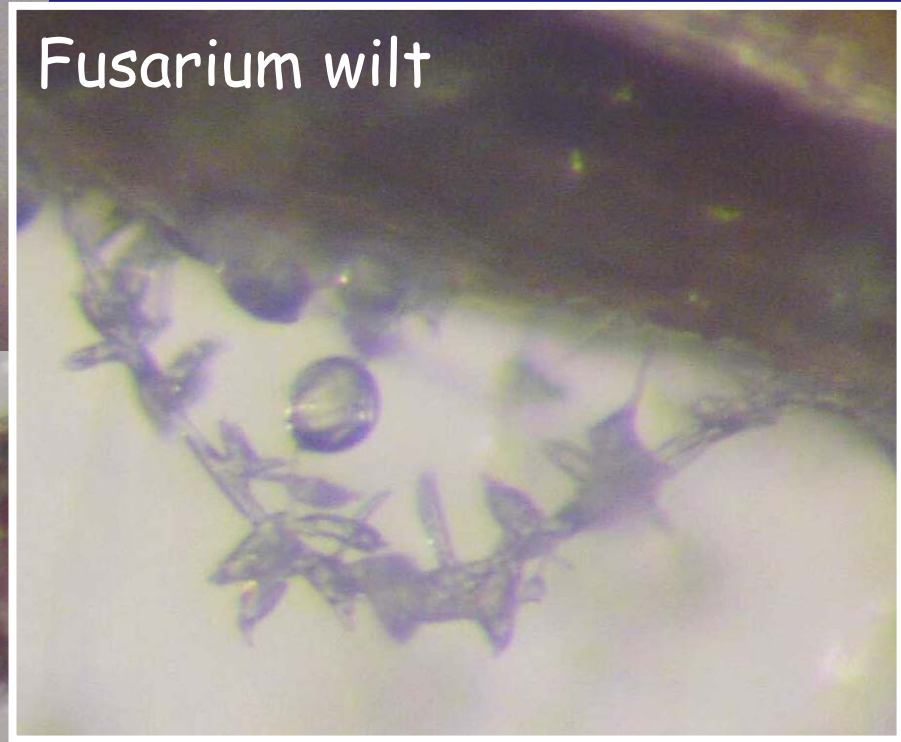
Inoculated with *V. dahliae*

Verticillium wilt vs. Fusarium wilt of spinach

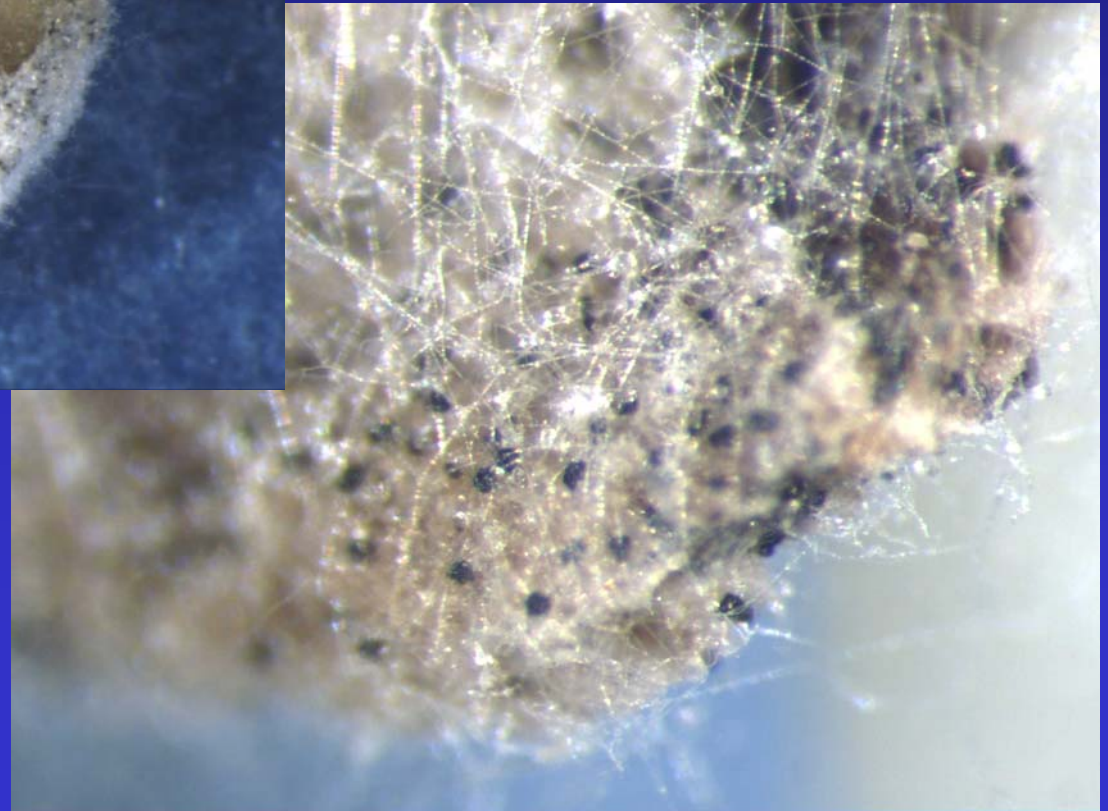
Verticillium wilt



Fusarium wilt



Verticillium wilt of spinach



Spinach wilt:

Fusarium oxysporum vs. *Verticillium dahliae*

	Fusarium wilt	Verticillium wilt
Symptoms	Any stage in development	Only after bolting & initiation of seed set
Foliar symptoms	General wilting, flaccid, off-green, death	Oldest leaves 1 st , initial interveinal chlorosis, then necrosis
Reddening of stem	+	+
External root discoloration	Black	None/Light brown
Vascular discoloration	Black	Light brown
Seedborne/transmitted	+/+	+/+
Host range	Chenopodiaceae	Broad
Host resistance	+	?

Verticillium wilt: *Verticillium dahliae* & *V. albo-atrum*

Crucifer hosts:

Susceptible = cauliflower, Brussels sprouts, cabbage

Resistant = broccoli, mustards

Chenopod. hosts:

Spinach, beets, chard

Other hosts:

Numerous! Dependant on vegetative compatibility group (VCG)



Virus diseases of Chenopodiaceous & Cruciferous vegetables

Tools & techniques for diagnosis of virus diseases

- symptoms
- signs
 - virus inclusion bodies - light microscopy
 - virions - electron microscopy
- host range studies
- vector transmission evaluations
- local lesion assays
- biochemical/physical tests
- immunological assays - ELISA, immunogold labeling, ...
- molecular (DNA or RNA) assays - PCR

Virus diseases of Crucifers: *Turnip mosaic virus (TuMV)*



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©T.A. Zitter

Virus diseases of Crucifers:
Cauliflower mosaic virus (CaMV)



Viruses diseases of Crucifers: CaMV vs. TuMV

	CaMV	TuMV
Symptoms	Mosaic, veinal chlorosis, leaf distortion, premature flowering	Black necrotic ring spots; mosaic, leaf distortion, necrosis
Vector	Several aphids: e.g., green peach aphid, cabbage aphid	
Transmission	Non-persistent	
Seedborne	-	
Survival	Cruciferous weeds	
Host range	Crucifers only	Crucifers, lettuce, endive, spinach, zinnia, petunia, ...

Virus diseases of spinach:
Cucumber mosaic virus (CMV)



Virus diseases of spinach: *Cucumber mosaic virus (CMV)*

- crown leaves narrow, curled, wrinkled, margins roll in
- leaves yellow and die
- stunting
- symptoms develop faster at high temperatures
- aphid transmitted
- overwinters in perennial weeds, builds up in vegetables
(especially cucurbits)
- spread by many aphids

Virus yellows of beet

<u>Virus</u>	<u>Name</u>	<u>Host Range</u>	<u>Sheph. Purse</u>	<u>Chenop. capitatum</u>
<u>Closterovirus</u>				
BYV	Beet Yellows Virus	narrow	-	+

<u>Luteovirus</u>				
BWYV	Beet Western Yellows Virus	wide	+	-
BChV	Beet Chlorosis Virus	narrow	-	+
BMYV	Beet Mild Yellows Virus	intermed.	+	+

Table provided by R.T. Lewellen, USDA ARS, Salinas, CA

Virus diseases of beet & chard:
Beet western yellows virus
(BWYV)



Virus diseases of beet & chard:

Beet yellows virus (BYV)



Photos provided by R.T. Lewellen

Virus diseases of beet & chard:
Beet mosaic virus (BMV)



<http://www.ipm.ucdavis.edu/PMG/B/D-SB-BMOV-FO.001.html>

Important aphid-borne viruses of beets:

BWYV, BYV, BMV

	BWYV	BYV	BMV
Symptoms	Interveinal yellowing (older leaves first); red-brown spots between veins (bronze cast); thick, leathery, brittle leaves; poor root growth		Yellow circular spots (young leaves); puckered leaves with mottling; stunting
Vector	Aphids (many)		
Transmission	Persistent	Semi-persistent	Non-persistent
Seedborne	-		
Survival	Alternative crop & weed hosts	Alternative hosts	Overwintering seed crops, weed hosts
Host range	Very broad	Mainly Chenopodiaceae	Moderate

Virus diseases of beet & chard:

Rhizomania



*Beet necrotic
yellow vein virus
(BNYVV)
&
soilborne fungus
*Polymyxa betae**



Photos provided by R.T. Lewellen

Virus diseases of beet & chard: Rhizomania



Virus diseases of beet & chard: Rhizomania

- root stunting, proliferation, vascular discoloration
- upright, yellow leaves, proliferation of leaves
- distinct veinal yellowing is rare but diagnostic
- wilting in higher temperatures
- vectored by the soilborne fungus, *Polymyxa betae*
- vector favored by saturated soils
- spreads in infected soil, on plants
- vector survives in soils >10 years
- potential yield loss is high
- found in sugarbeet fields along Columbia River in 2000
- concern re. table beet seed industry in PNW

Some other viruses of spinach, beet & chard



Photos provided by R.T. Lewellen

Beet curly top virus (BCTV)

- beet leafhopper vector
- very broad host range
- stunting, hairy roots, thickened & rolled leaves



Beet chlorosis virus (BChV)

- non-persistent aphid vector
- interveinal yellowing

Monitoring diseases

- appearance/development
- threshold populations
- need for control
- effectiveness of actions

