

Principles of Plant Disease Spread and Management

15 March 2023, Orcas Island Garden Club, Eastsound, WA

Lindsey du Toit, Washington State University





plant problem

biotic

abiotic

pathogens:

1. fungal
2. bacterial
3. viral
4. nematode

insects/mites:



"macro" organisms
e.g., rodents, deer, snails,...

physical
chemical
mechanical



PNW University Plant Diagnostic Clinics



OSU Hermiston Plant Pathology Lab
<http://oregonstate.edu/dept/hermiston/>

OSU Corvallis Plant Clinic
Melodie Putnam
<http://plant-clinic.bpp.oregonstate.edu/>

WSU Puyallup Plant Clinic
Jenny Glass
<http://puyallup.wsu.edu/plantclinic/>

WSU Pullman Plant Clinic
Cassandra Bates
<http://plantpath.wsu.edu/diagnostics/>

University of Idaho Parma REC
James Woodhall
<https://www.uidaho.edu/cals/parma-research-and-extension-center/plant-pathology>

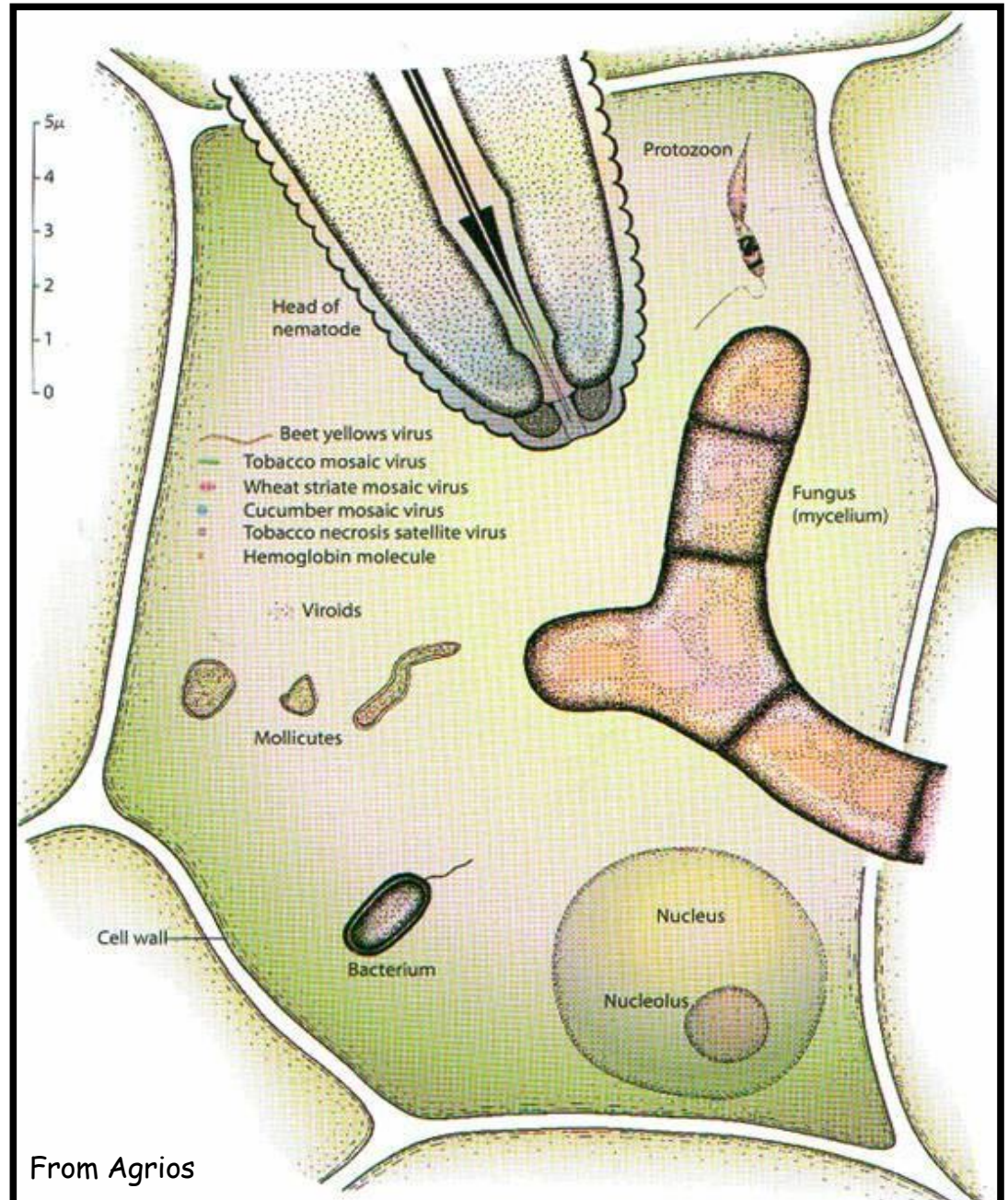
PNW Disease Management Handbook - <https://pnwhandbooks.org/plantdisease>

PNW VEG - http://mtvernon.wsu.edu/path_team/vegpath_team.htm

HortSense - <http://hortsense.cahnrs.wsu.edu/Home/HortsenseHome.aspx>

Types of Plant Pathogens

- Fungi
- Oomycetes
- Bacteria
- Phytoplasmas
- Viruses
- Viroids
- Nematodes



Downy mildew
Oomycete =
water mold

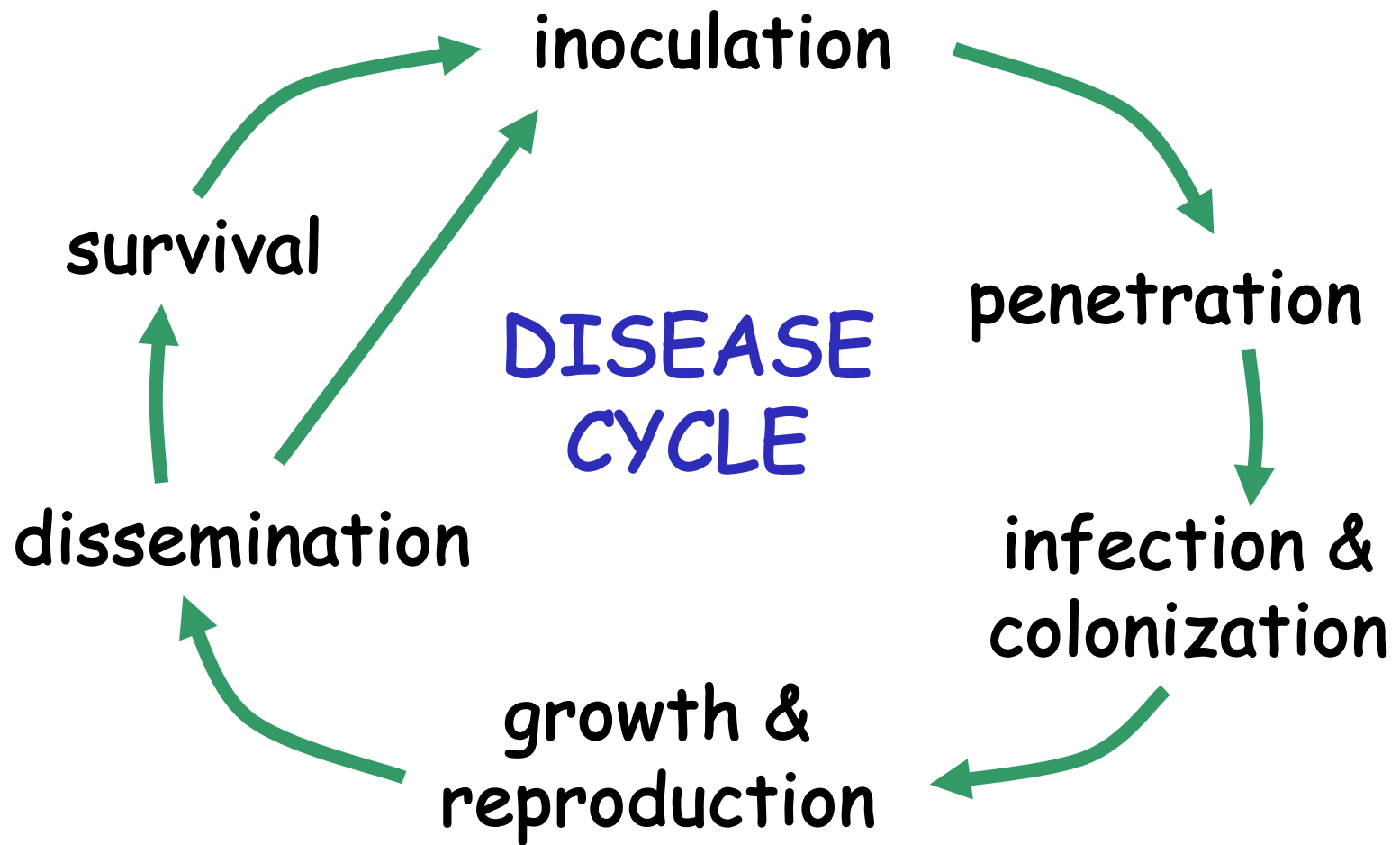


Black rot
Bacterium

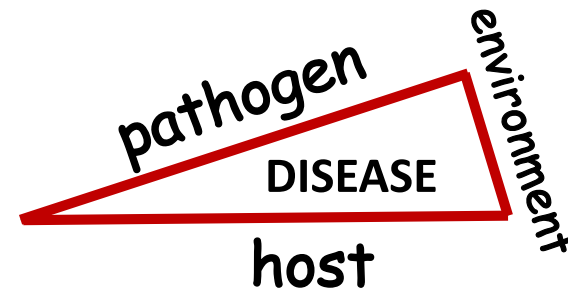
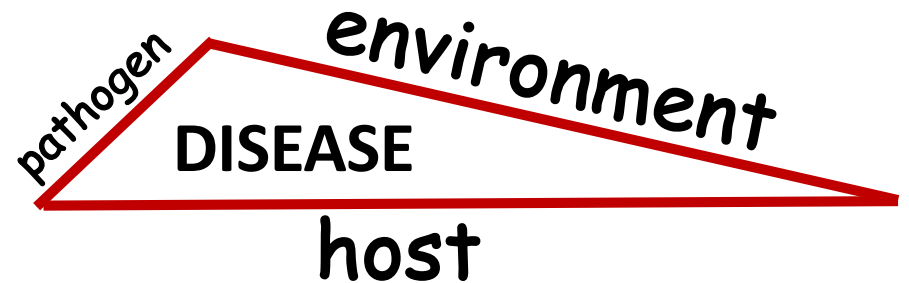
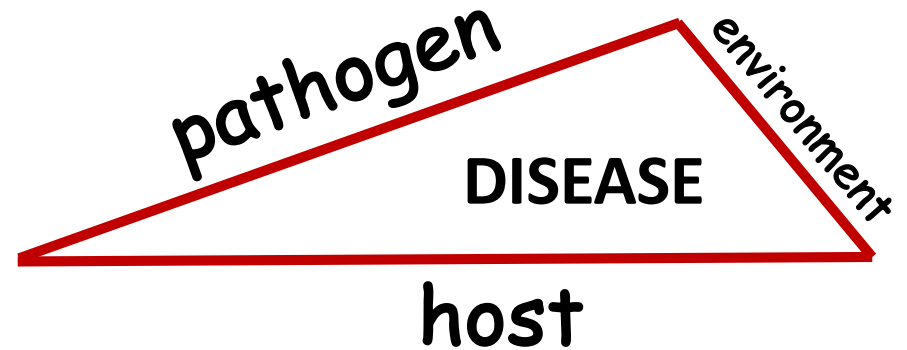
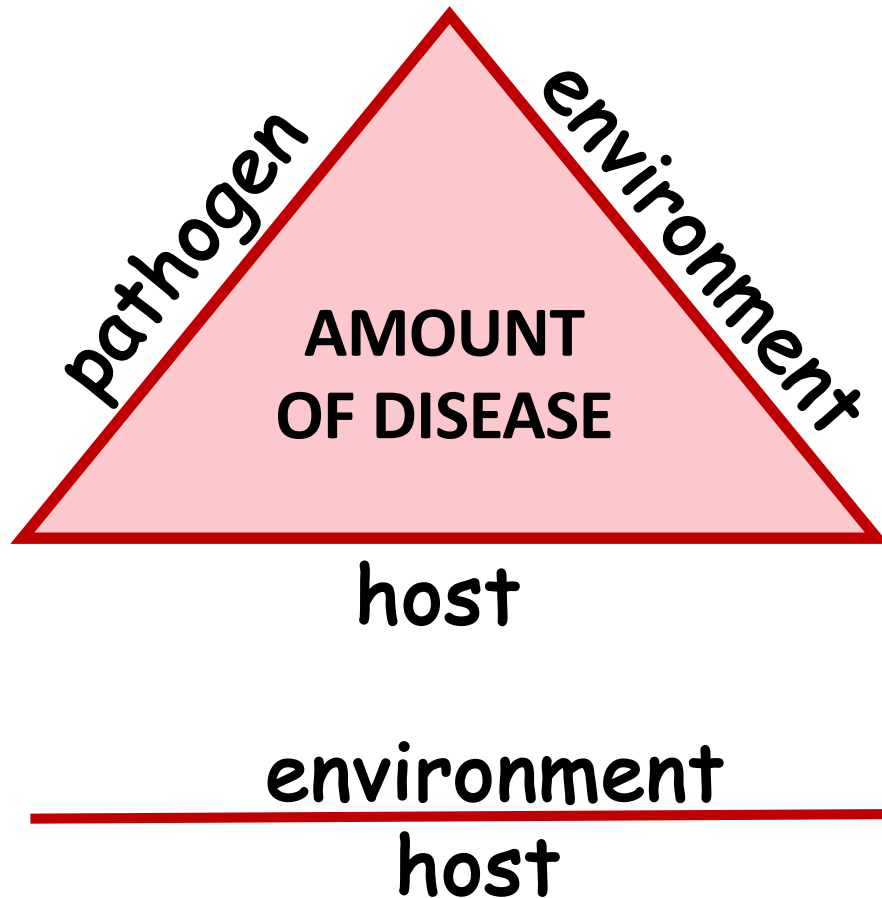


Black leg
True fungus





Principles of Plant Disease Management



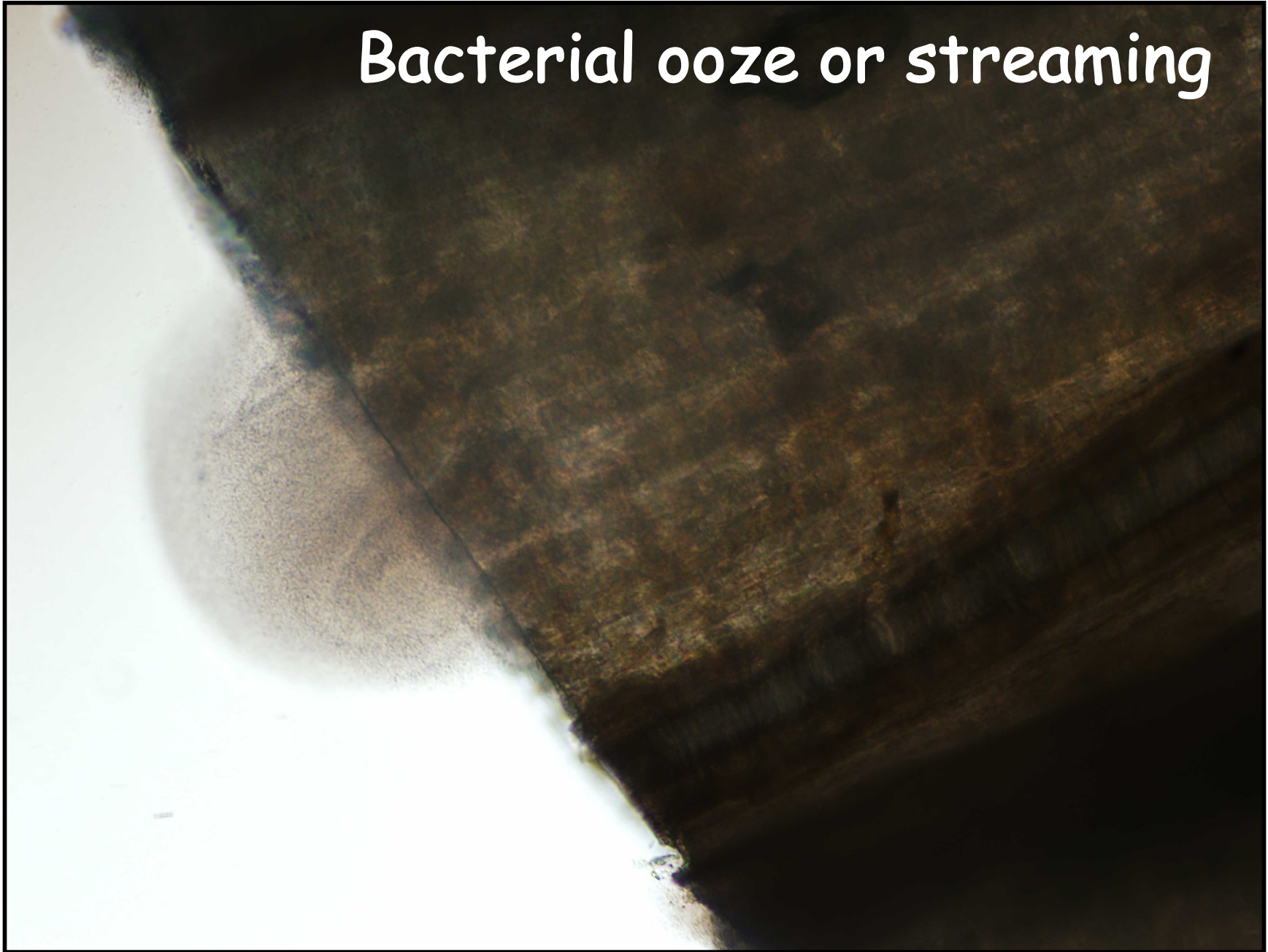
Spread of Plant Pathogens

- **Wind**
 - Primarily foliar fungal & water mold pathogens
- **Water**
 - Fungi, water molds, bacteria, nematodes
- **Soil**
 - Soilborne fungi, nematodes, bacteria, few viruses
- **Planting material**
 - Seed, seedlings (transplants), vegetatively propagated material (e.g., garlic, cuttings, ...)
- **Insect vectors** - thrips, aphids, leafhoppers, ...
- **Fungal & nematode vectors**
- **Humans/animals**
 - Hands, bodies, equipment (pruning tools, tires, boots, ...)



Black rot of brassicas (*Xanthomonas campestris* pv. *campestris*)
September 2022, western WA

Bacterial ooze or streaming





Pseudomonas syringae strain PS 2, culture and fixation M



**Angular leaf spot
of cucurbits**
Pseudomonas syringae pv.
lachrymans

Bacterial blight of carrot

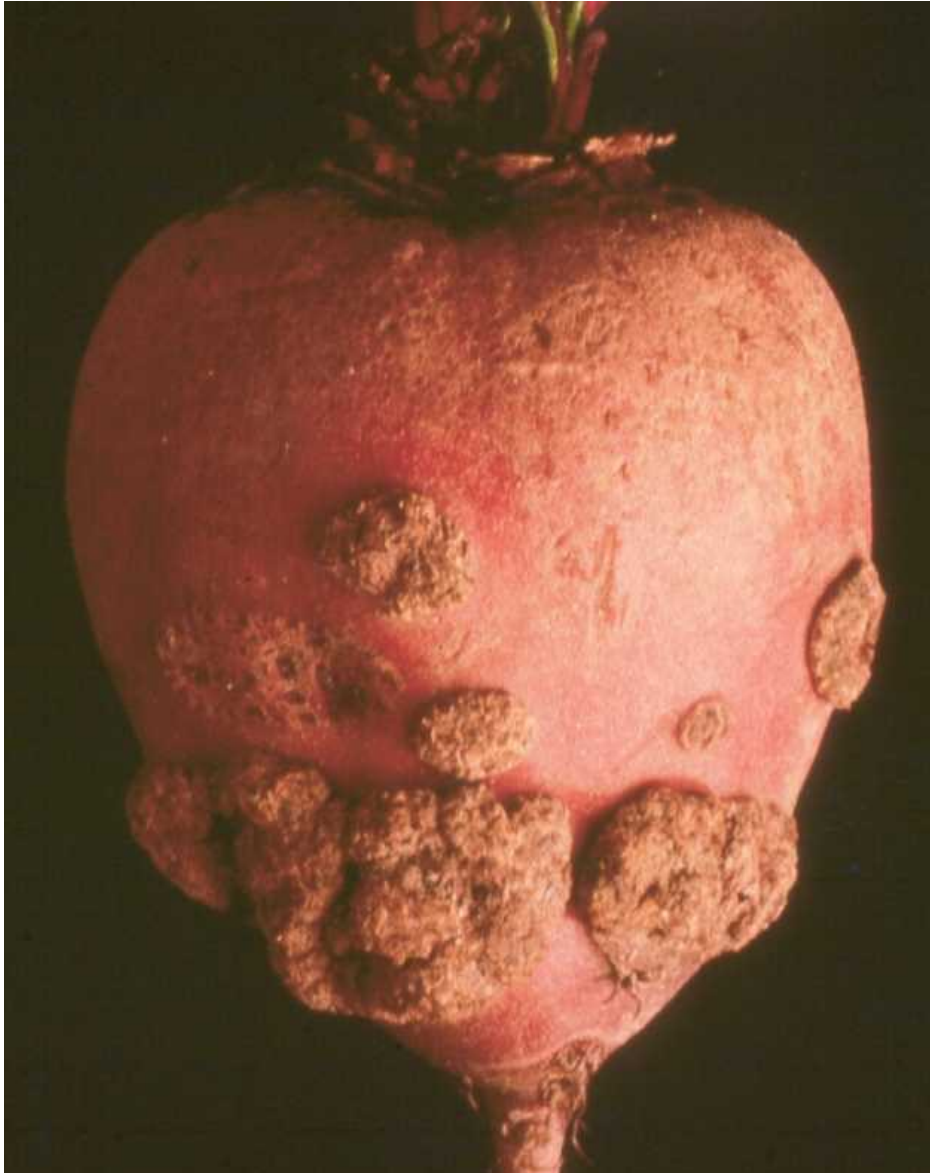


Halo blight of bean

Bacterial soft rots



Scab (*Streptomyces scabies*) = soilborne



Cultural Practices for Disease Control

Geographic or regional location

- **Continental:**

- environments less favorable for disease
- bean seed: ID, WA, & CA - bacterial blights, anthracnose
- pea seed: ID, WA, CA - *Pseudomonas pisi*, *Ascochyta* blight
- brassicas: western & central WA - black leg, black rot

- **Local:**

- avoid frost pockets, areas prone to fog, excessively wet soils, ...

Isolation spatially & temporally

- overlapping biennial seasons
- commercial crops & seed crops in same region
- break the "green bridge" temporally & spatially
- **diversification = management tool** (e.g., gardens; smaller, diversified farms)

Spread of *Xanthomonas hortorum* pv. *carotae* between carrot seed crops on dust/debris during threshing



du Toit et al. 2005. Plant Disease 89:896-907.

Biennial table beet seed production in western WA





UC-Davis

Seed crop isolation

Avoiding a
green bridge



Cultural Practices for Disease Control

Crop rotation

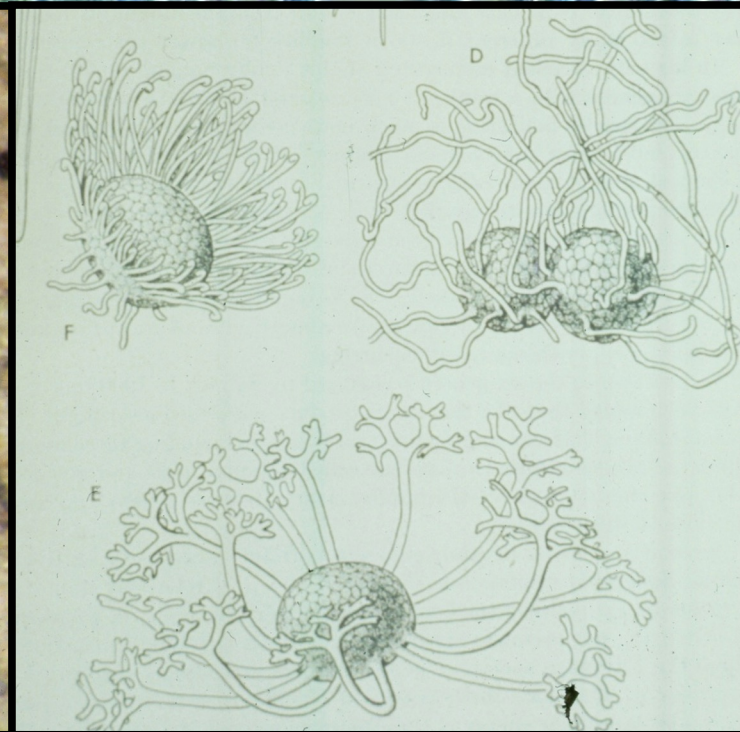
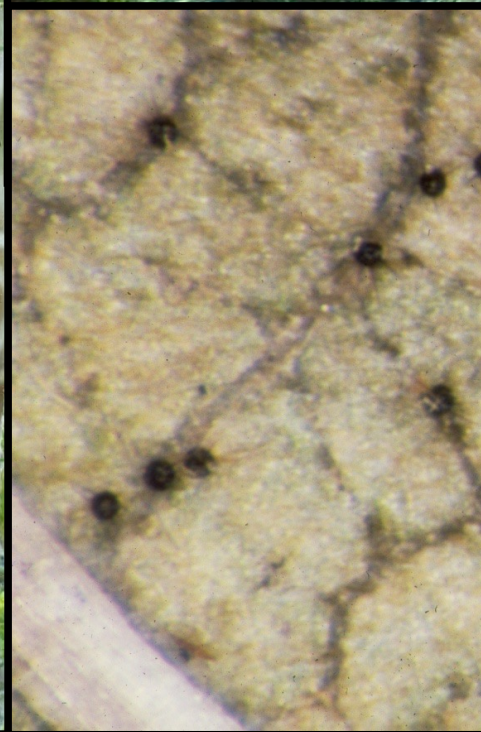
- Non-host, resistant, or 'antagonistic' crops
- Duration needed for disease control depends on:
 - pathogen host range
 - foliar vs. soilborne pathogens
 - longevity of inoculum survival
 - resistance of cultivar or parent lines
 - cultural practices, ...
- Be aware of asymptomatic hosts, including weed hosts

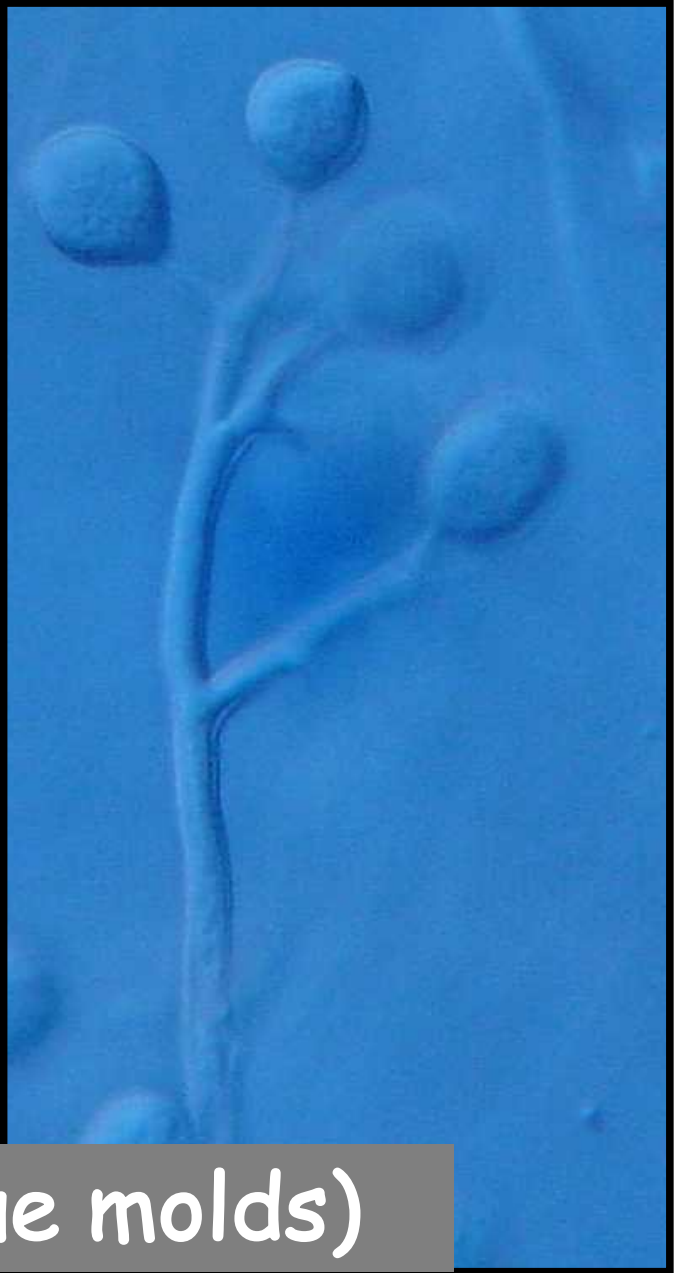
Alternative hosts

- Weeds, volunteers, adjacent crops
- Overlapping biennial/annual crops

Powdery mildews

George Barron

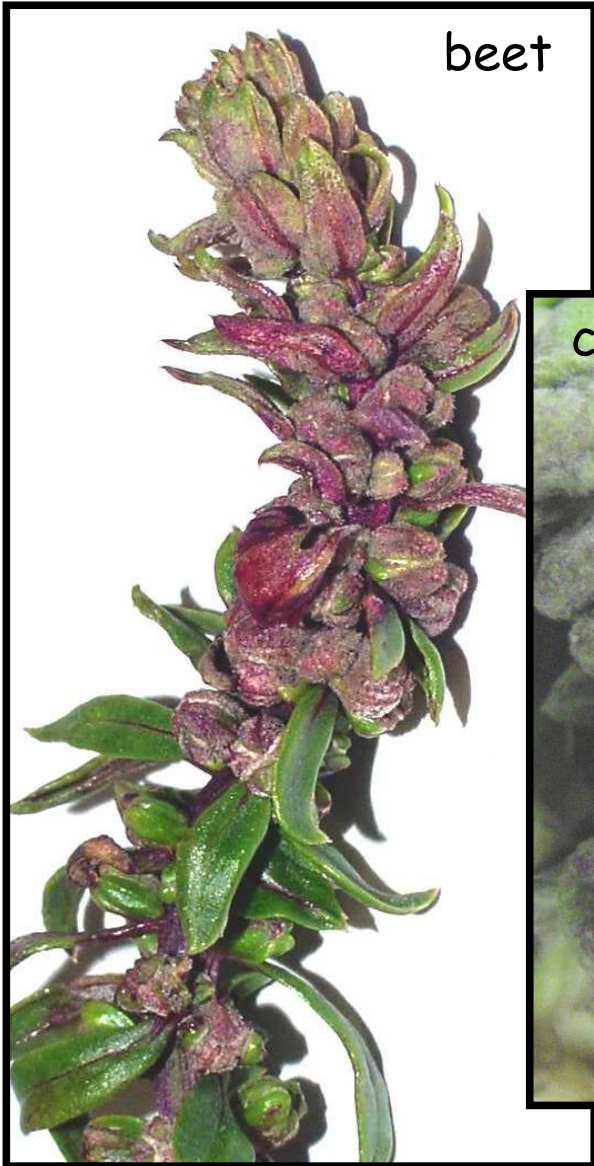




Downy mildews (= blue molds)

Downy Mildews

beet



chard



cabbage



JUL 18 2001

spinach



JUL 3 2001

Damping-off/seedling blights: *Pythium*, *Aphanomyces*, *Fusarium*, *Rhizoctonia*



White rot of *Allium* species: *Sclerotium cepivorum*



White rot: Management

- Exclusion, sanitation, quarantines
- Avoid infested fields
- Rogue plants if low incidence
- Plant when warmer (risky sites)
- Chemical control:
 - fungicide seed treatments
 - fungicide sprays or drenches
 - soil fumigation
 - germination stimulants
 - biological (*Trichoderma*, ...)
- Flooding fields
- Soil solarization in warm climates
- No resistant *Allium* spp.



the
garlic
company

Garlic Juice

For R & D

Ingredients: Garlic, Citric Acid

Lot #: 6506-089

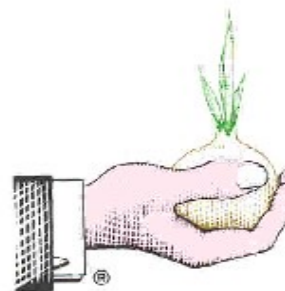
MUST KEEP REFRIGERATED (32-36°F)

NET WT. 45 LBS. (18.14 KG.)

THE GARLIC COMPANY
BAKERSFIELD, CA 93314-USA

NET CONTENTS: 10 LITRES

ELLIOTT CHEMICALS LIMITED



ALLI - UP™

**A sclerotia germination stimulant for the control
of Onion White Rot in soil**

Contains: 900 g/litre diallyl disulphide and associated diallyl sulphides in the form
of an emulsifiable concentrate

Proprietor: Elliott Chemicals Limited, P.O.Box 18-417, Glen Innes, Auckland
45 Kitchener Rd., Pukekohe

Phone: (09) 238 3170 Fax: (09) 238 4226

Registered pursuant to the Pesticides Act 1979. No. 5196

™ - Trade Mark of United Agri Products, USA

® - Registered Trade Mark of United Agri Products, USA

* - Registered Trade Mark of Elliott Chemicals Ltd, Nz

UAP

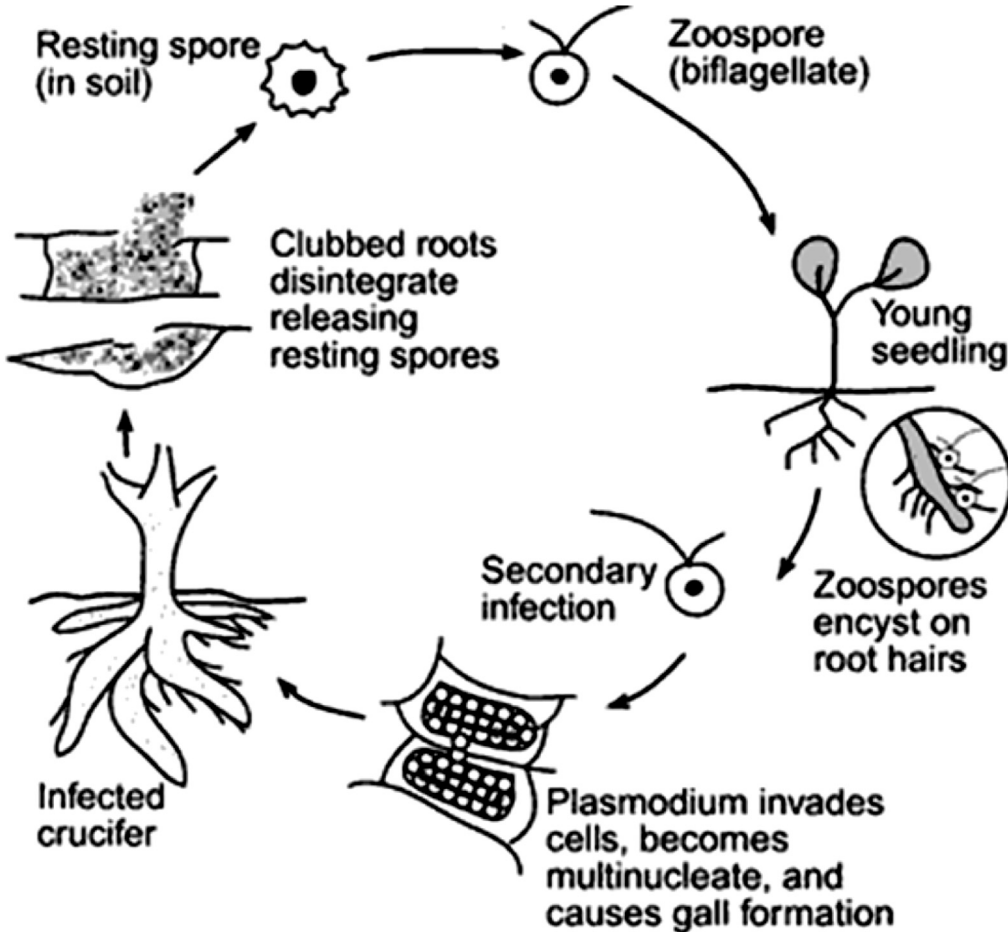
Rules for stimulating germination of sclerotia of the white rot pathogen

1. Do NOT apply too soon following white rot. New sclerotia do not germinate for months. Wait until next season.
2. Do NOT apply if *Allium* volunteers are present or removed recently.
3. Wait >2 months after treatment to plant *Allium* spp.
4. Stimulants remain non-volatile when soil is <45-50°F, and re-activate in spring.
5. In areas with warm summers: apply stimulant in fall when soil is <68°F, and in spring when soil is ~50°F.

Clubroot of Brassicas - *Plasmodiophora brassicae*



Clubroot of Brassicas



Courtesy of Sally Miller, Ohio State University

Management of Clubroot

- PNW Disease Management Handbook
<https://pnwhandbooks.org/plantdisease>
- PNW Vegetable Extension Group (PNW VEG)
http://mtvernon.wsu.edu/path_team/diseasegallery.htm
- Disease-free transplants
- Sanitation:
 - media, trays, water, do not compost infected plants
 - clean equipment of soil, pressure wash, disinfectantsCanola Council of Canada recommendations
- Manage brassica weeds, avoid infested fields
- Long-term rotation out of brassicas
- Good soil drainage, raised beds/hilled plants
- Agricultural limestone (calcium carbonate) to raise soil pH
- Fungicides

Cultural Practices for Disease Control

Destruction of inoculum in the field

- Remove/reduce infected debris/seed left after harvest
- Reduce inoculum of soilborne pathogens
- Suppress inoculum of soilborne pathogens
 - Burn stubble/debris
 - Vacuum fields?
 - Fumigation, including biofumigation
 - Soil solarization (in warm climates)

Leaf spot fungi of spinach seed crops in WA

du Toit & Derie, 2001. Plant Disease 85:920

Photo by M.L. Derie



*Cladosporium
variabile*

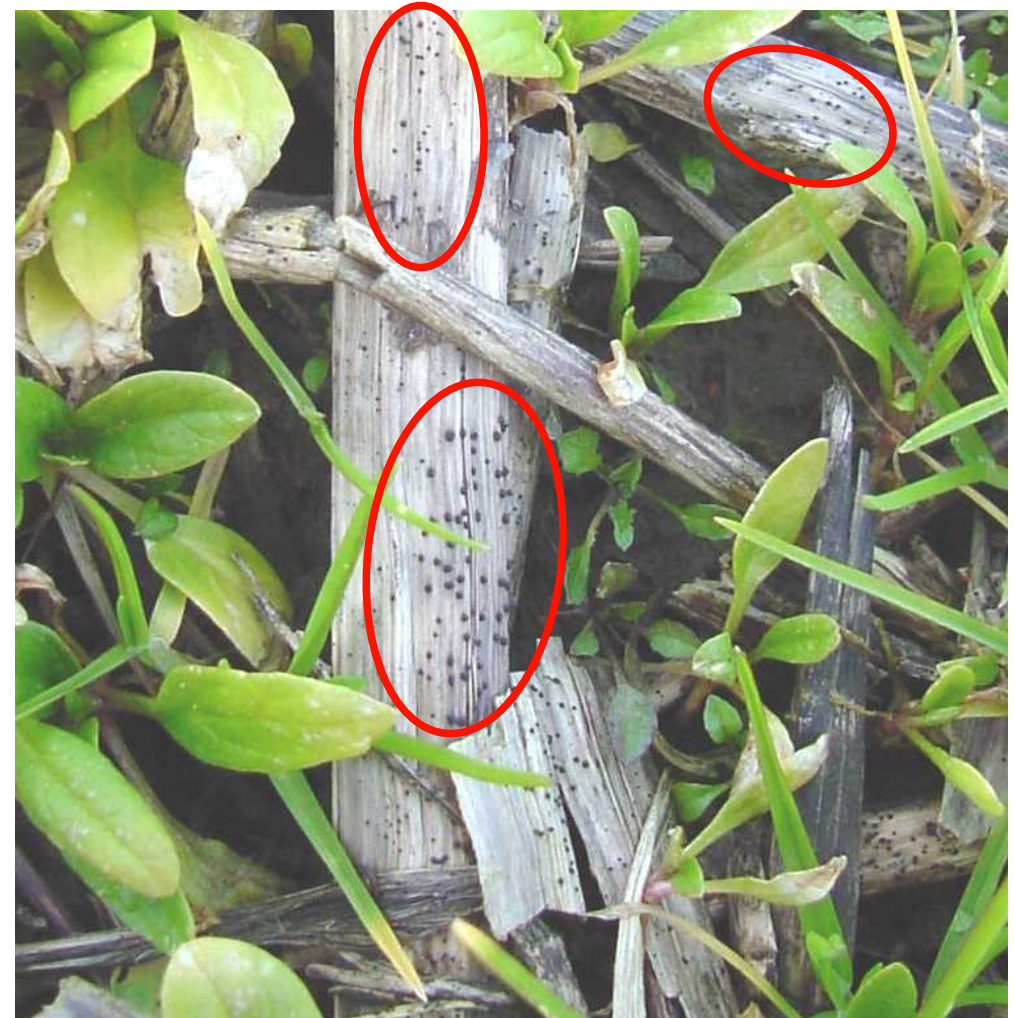
*Stemphylium beticola
(S. botryosum)*

Overwintering of spinach leaf spot fungi

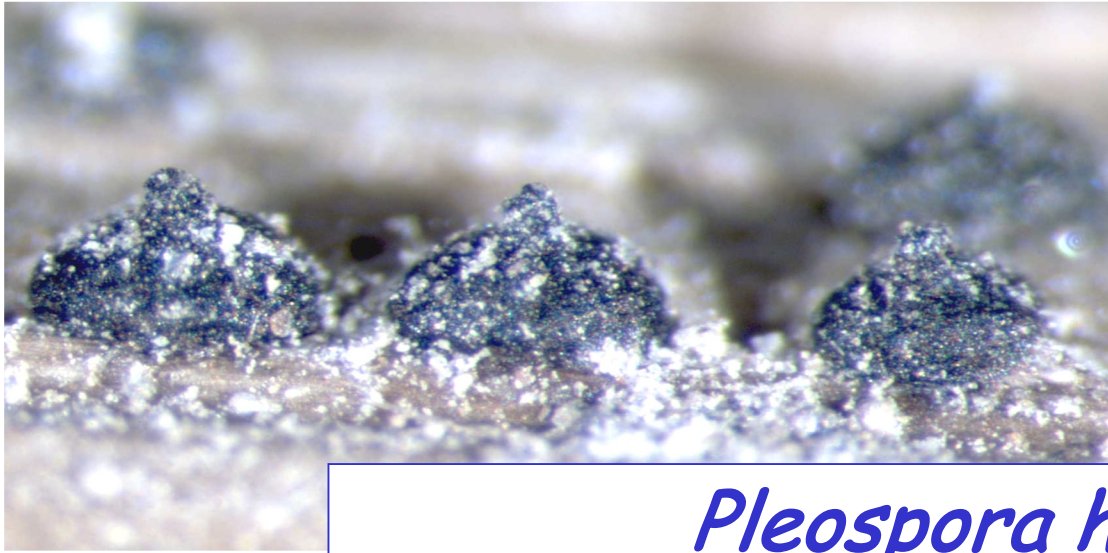
du Toit & Derie, 2003. *Phytopathology* 93:522



Cladosporium variabile on
volunteer spinach



Stemphylium beticola on spinach
seed stalk debris



Pleospora herbarum
= sexual stage of *Stemphylium*



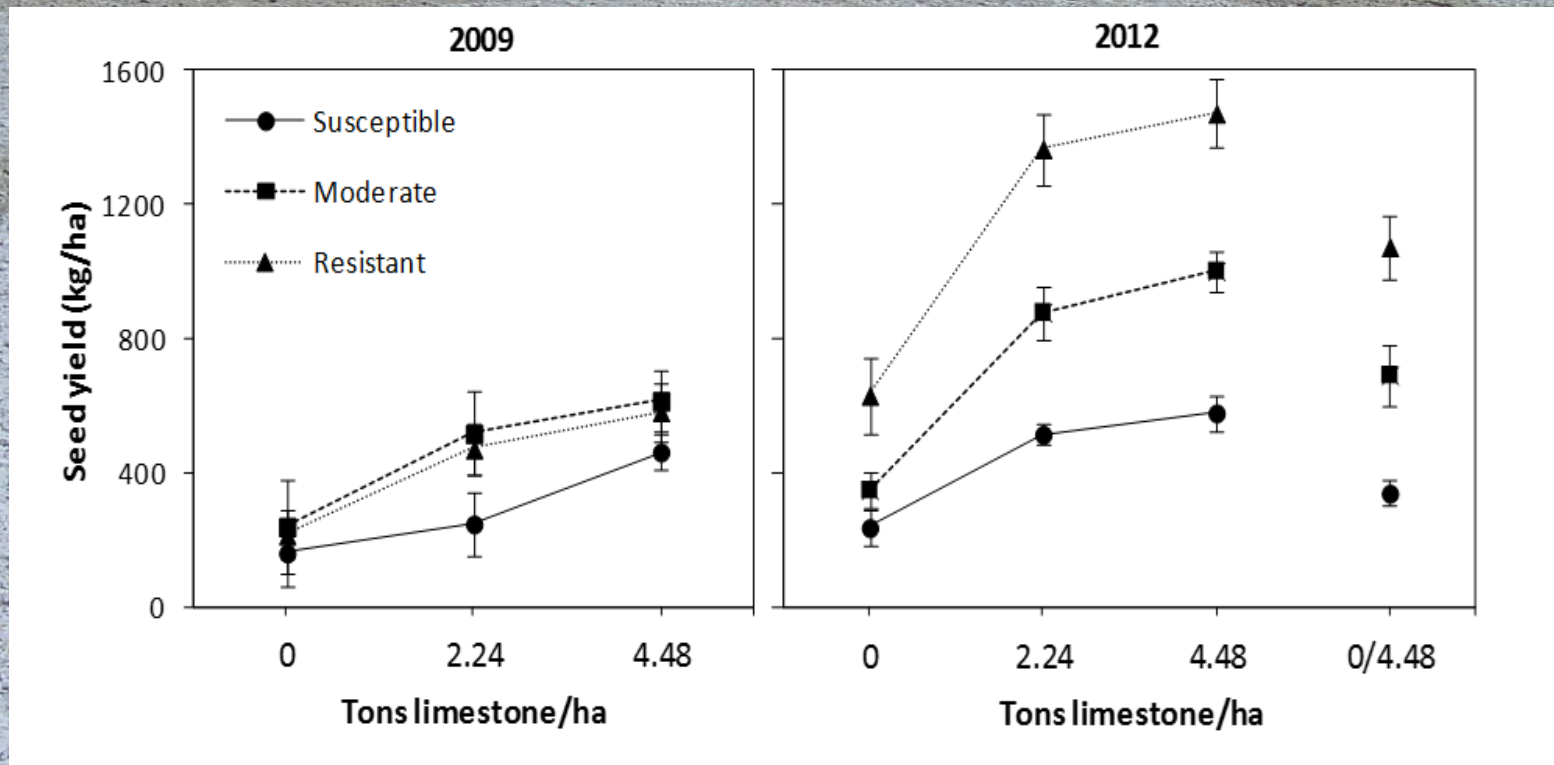
Fusarium Wilt of Spinach

Fusarium oxysporum f. sp. *spinaciae*



Evaluation of Agricultural Limestone Amendment for Suppression of Spinach Fusarium Wilt

du Toit et al., 2007, 2008, 2011; Gatch and du Toit, 2017





Evaluation of mustard vs. winter wheat cover crops in spinach seed production



Cultural practices

Irrigation

- duration of leaf wetness, splash dispersal, relative humidity in canopy
- drip vs. furrow vs. overhead irrigation
- economics, practicality?
- timing of irrigation
- frequency of irrigation
 - duration canopy stays wet
 - rooting depth



Cultural Practices for Disease Management

Planting practices

- planting date selected to escape inoculum
 - insect vectored pathogens
 - pathogens that don't overwinter in a region
- planting date - unfavorable for pathogen &/or favorable for crop
- row spacing, plant spacing
- row orientation into predominant wind direction

Ventilation practices

- thinning, canopy management - air flow



Cultural Practices for Disease Management

Transplanting & hygiene

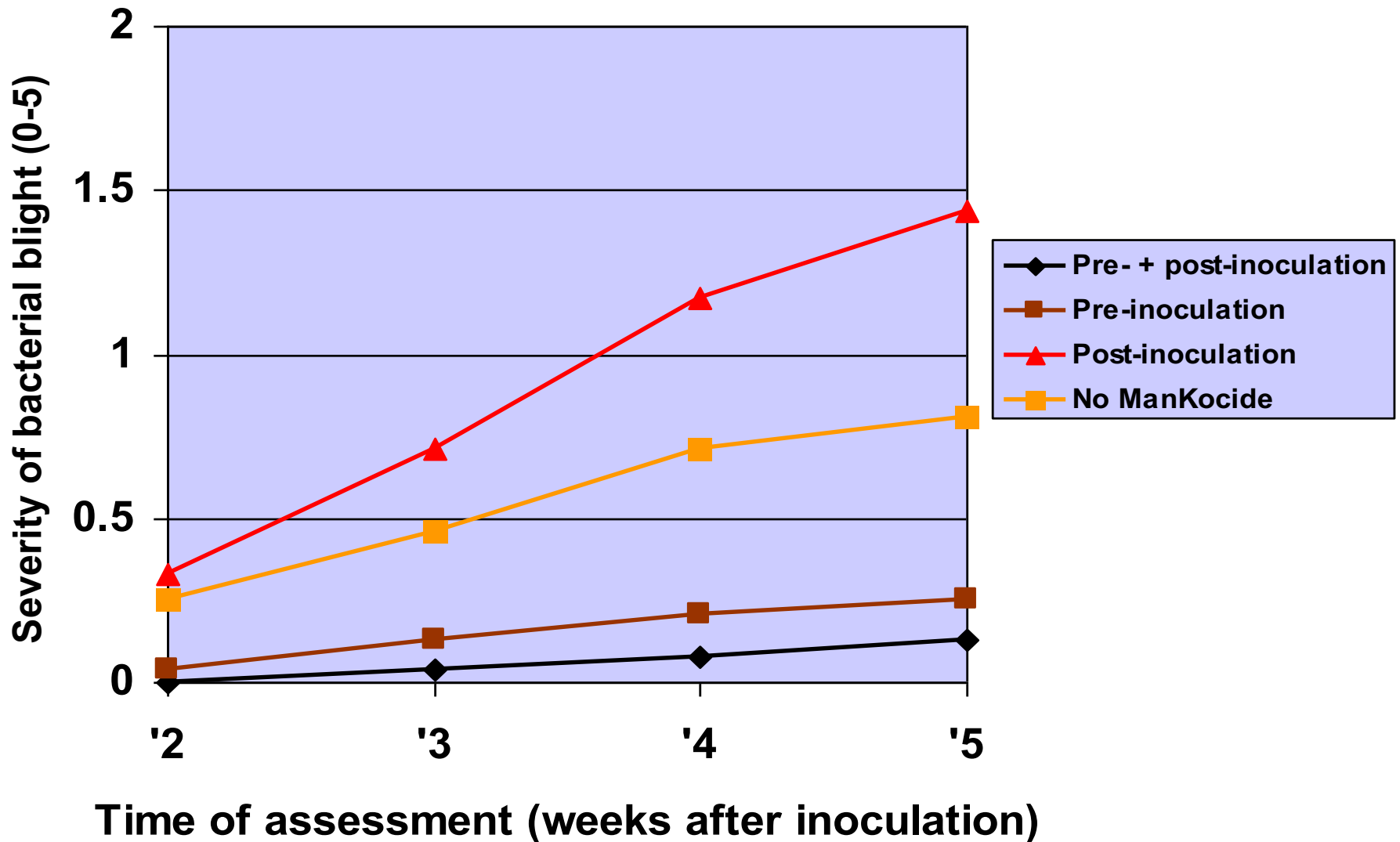
- Avoid mechanical injury during transplanting, staking, tying, cultivation, ...
- Avoid dipping transplants in water
- Mechanical transmission of pathogens by workers:
 - *Septoria apiicola* in celery
 - *Xanthomonas campestris* pv. *campestris* in cabbage
 - Tobacco mosaic virus (TMV) transmission by smokers - wash hands in warm, soapy water; treat hands & equipment with milk (e.g., when handling transplants, hand-pollinating, etc.)

Chemical Plant Disease Management

- **Conventional & organic materials**
 - Consistency, niche environments, target pathogens
 - Potential phytotoxicity (some cultivars)
- **Natural plant products**
 - Oils, plant extracts, compost teas, ...
 - Reliability, consistency?
- **Systemic resistance inducers**
- **Maximize efficacy**
 - Timing of applications
 - Method of application (equipment, gpa, pressure, ...)
= coverage
 - Accurate diagnosis before treatment

Effect of timing of ManKocide application on control of carrot bacterial blight

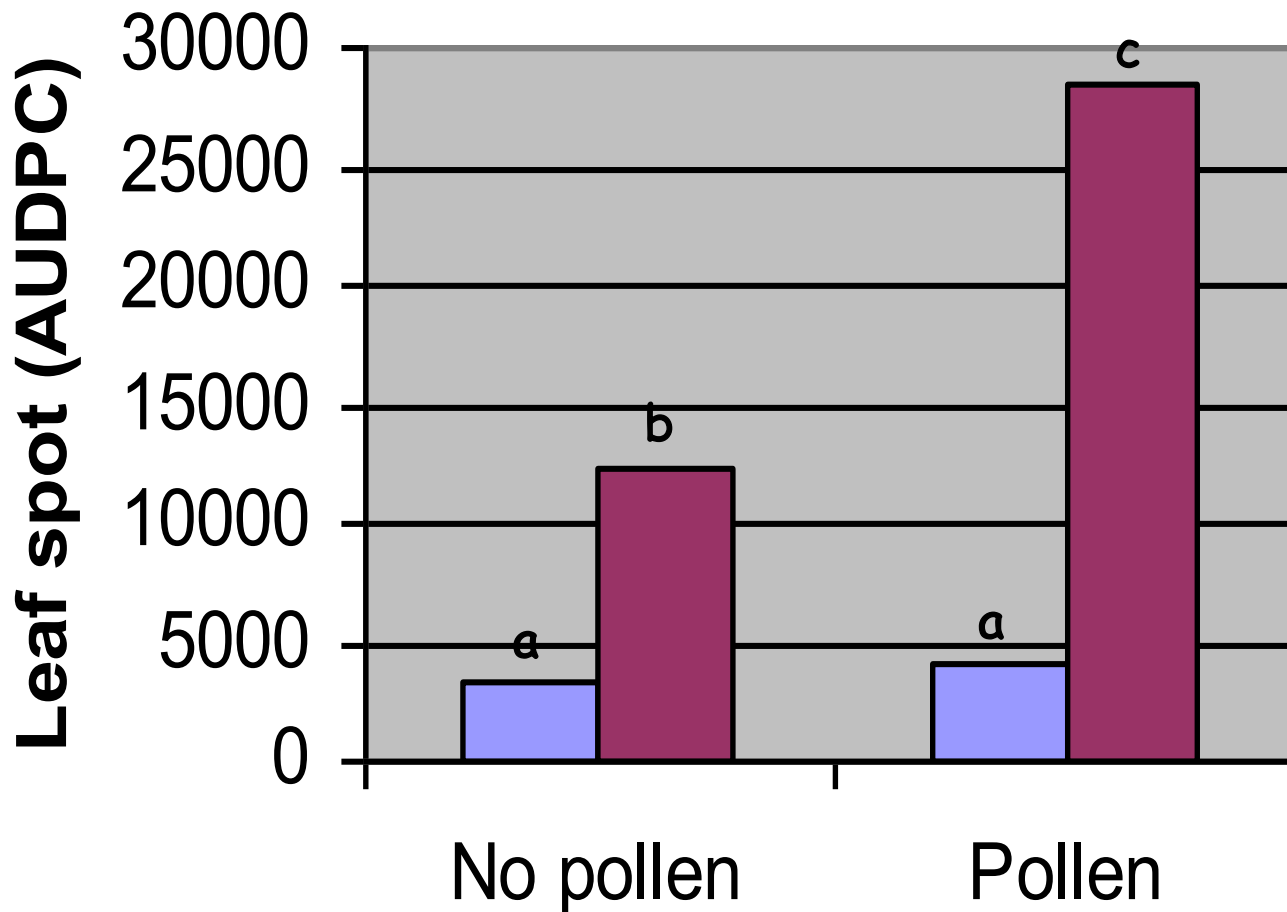
du Toit & Derie, 2008



Timing of Pesticide Applications

Influence of pollen on spinach leaf spot

du Toit & Derie, 2002.

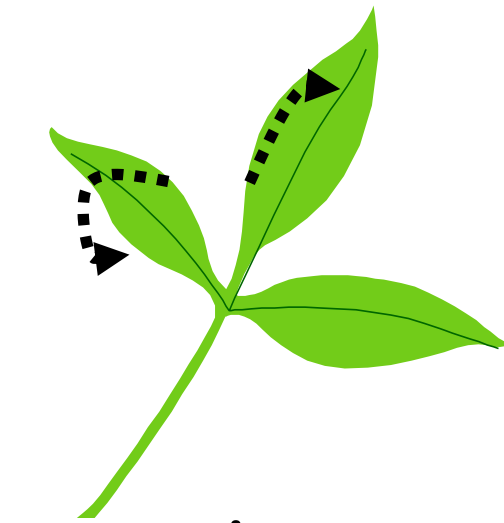


Same effect with
immature &
flowering (female)
plants

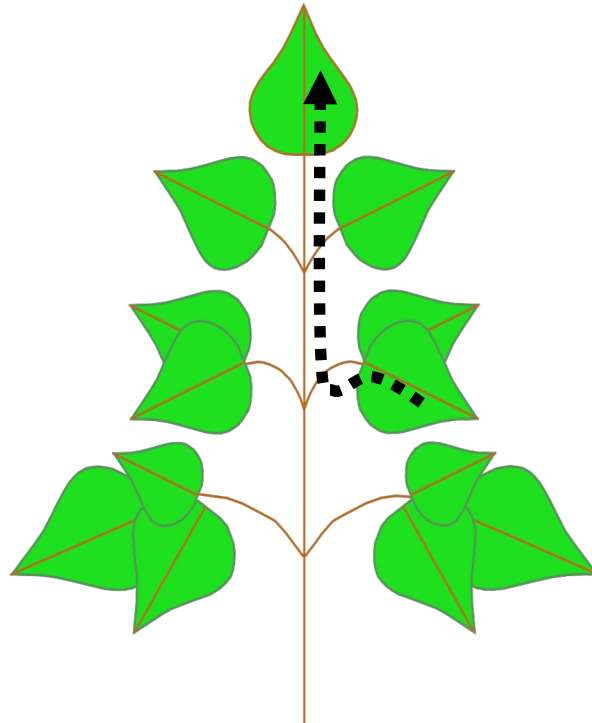


Impact: Time
fungicide applications
at start of anthesis
(pollen shed)

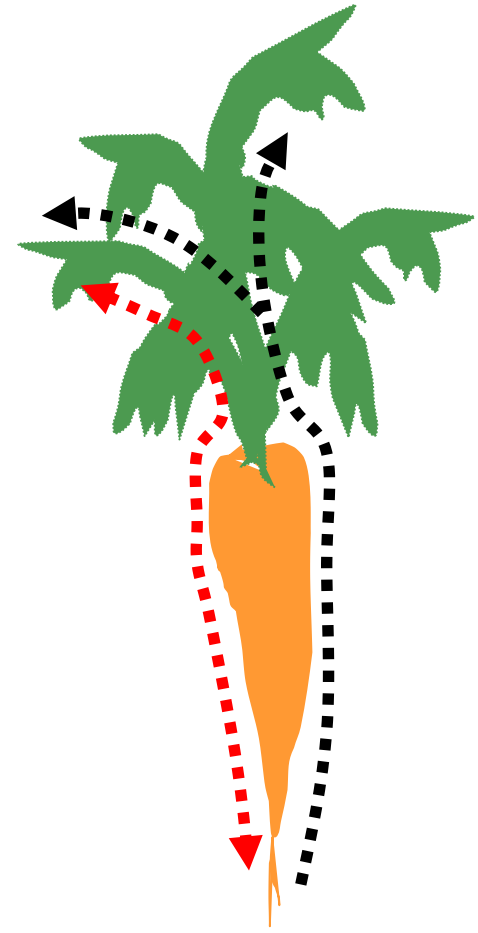
"Systemic" fungicides



Translaminar



Locally systemic



Systemic

Xylem-mobile = move UP the plant (e.g., Ridomil, FRAC Grp 4)

Amphimobile = phloem-mobile = UP & DOWN (e.g., Aliette, FRAC Grp 33)

<https://pnwhandbooks.org/plantdisease/pesticide-articles>

Application of a pesticide to a crop or site that is not on the label is a violation of pesticide law and may subject the applicator to civil penalties.

In addition, such an application may also result in illegal residues that could subject the crop to seizure or embargo action.

It is your responsibility to check the label before using the product to ensure lawful use and obtain all necessary permits in advance.

Disease Management with Plant Resistance

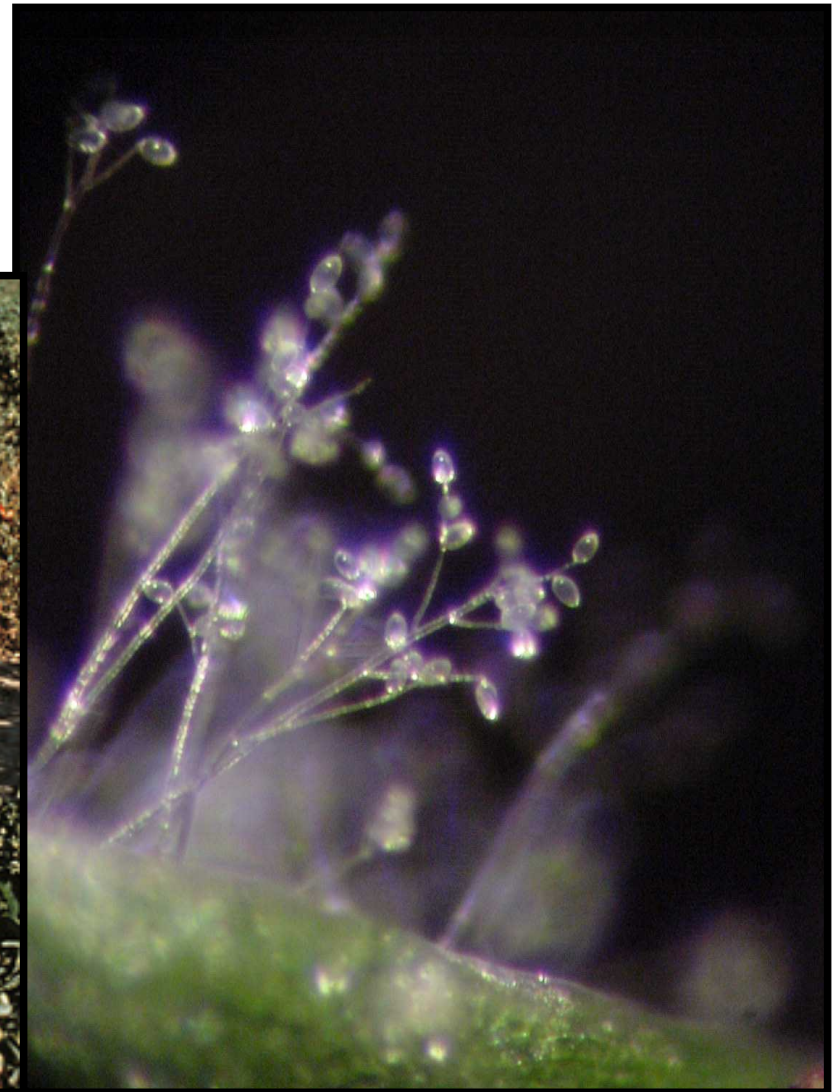
- Can be very effective
- May not be available
- Understand susceptibility of cultivars

Beet curly top virus
(BCTV)
= leafhopper vector



Late Blight of Potato & Tomato

Phytophthora infestans

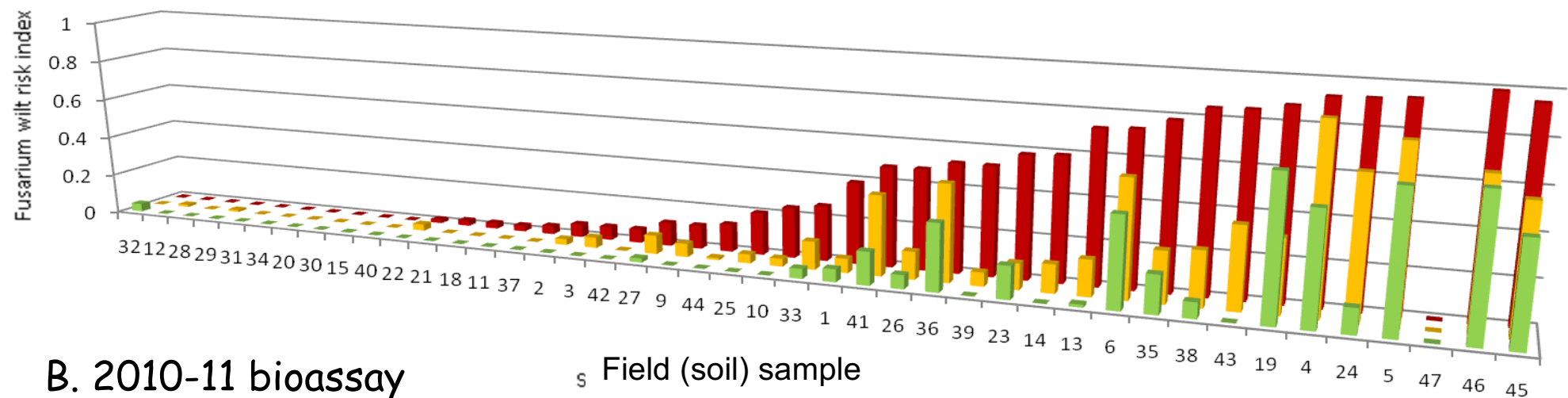
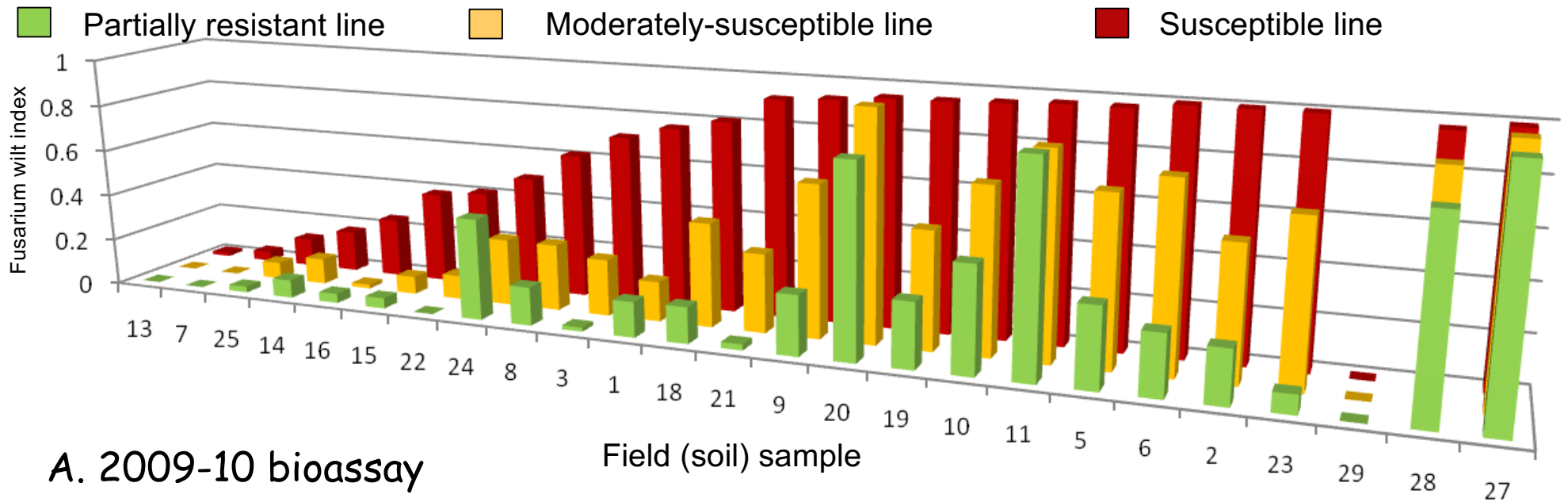


Fusarium Wilt of Spinach

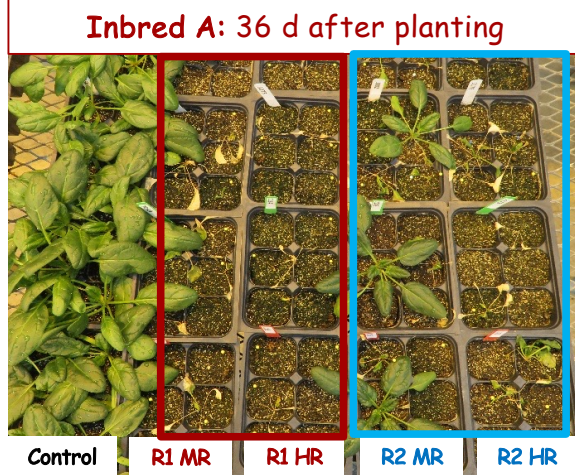
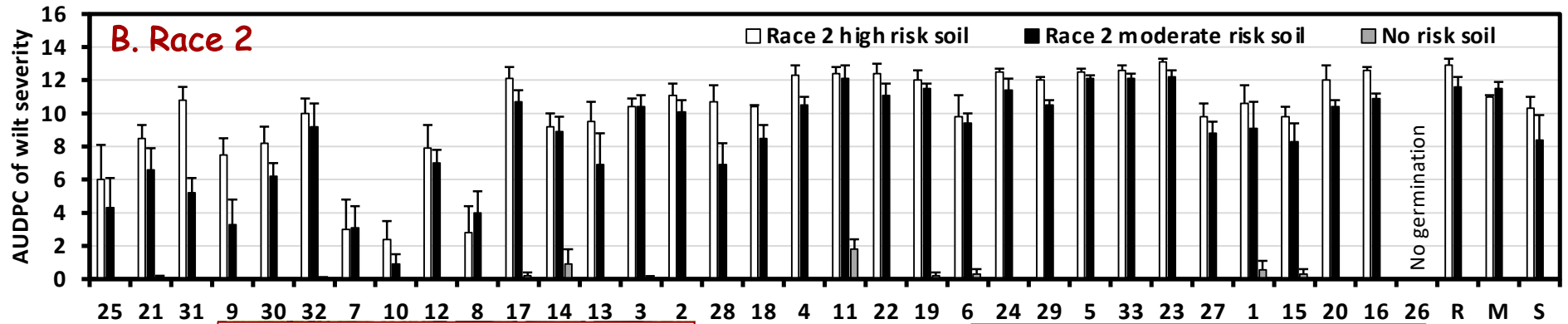
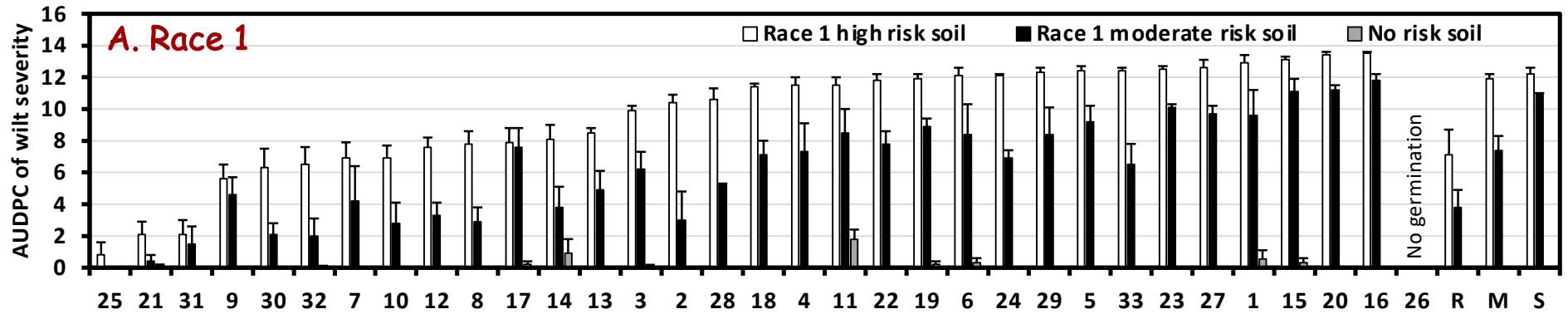
Fusarium oxysporum f. sp. *spinaciae*



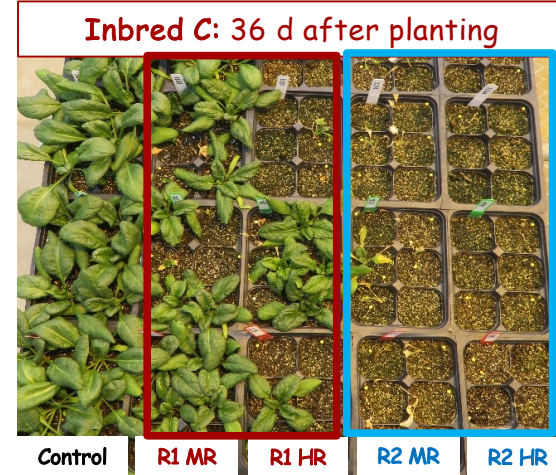
Risk assessment: Spinach Fusarium wilt soil bioassay



Spinach Parent Line Screening for Susceptibility to Fusarium wilt



Spinach genotype



Monitoring plant diseases

- Accurate identification
- Appearance/development
- Threshold populations
- Rogue symptomatic plants
- Assess the need for control
- Effectiveness of actions
- Use integrated disease management practices

