# Soilborne Vegetable Diseases: Best Management Practices

Lindsey du Toit, Washington State University

Pacific Northwest Vegetable Association Annual Convention & Trade Show
16-17 November 2022, Kennewick, WA

Photo courtesy of Lyndon Porter

# Accurate diagnosis of the problem

## Plant problem

**biotic**

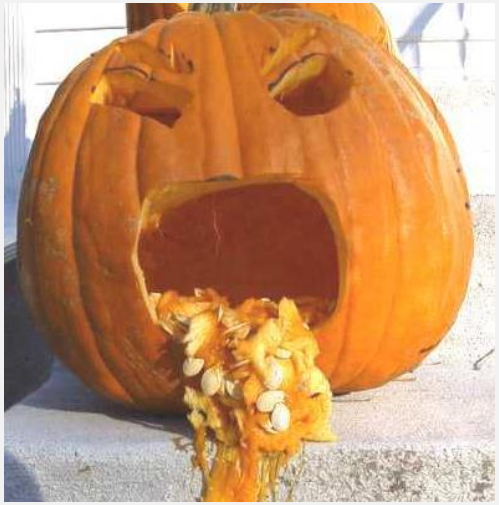
pathogenic:
1. fungal
2. bacterial
3. viral
4. nematode

"macro" organisms

insect/mite:
1. feeding habit
2. life "cycle"

**abiotic**

physical
chemical
mechanical



# PNW University Plant 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/

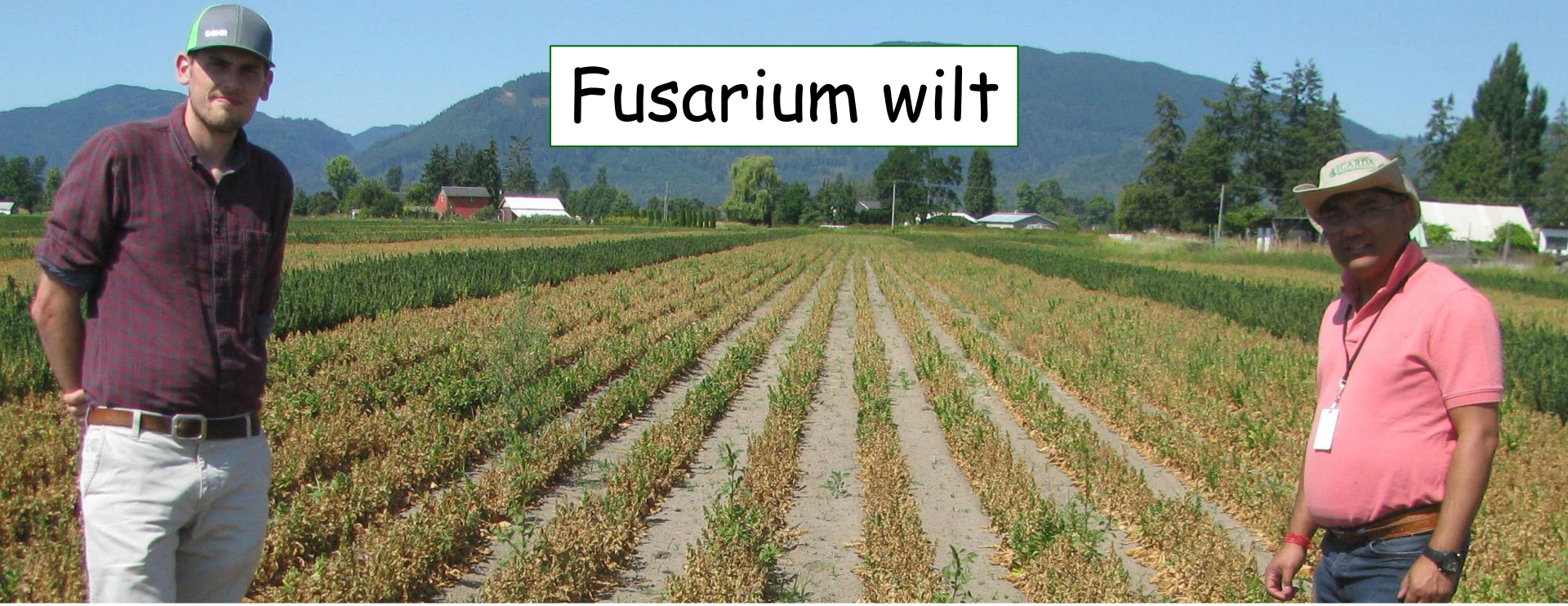
**University of Idaho Parma REC**
**James Woodhall**
uidaho.edu/cals/parma

## Complexity of diagnosing soilborne diseases

- Above-ground symptoms of below-ground problems
- Primary vs. secondary or saprophytic microorganisms
- Disease complexes (e.g., early dying in potato)
- Abiotic problems pre-dispose plants to colonization
- Communicate directly with diagnostician

## Testing for soilborne pathogens

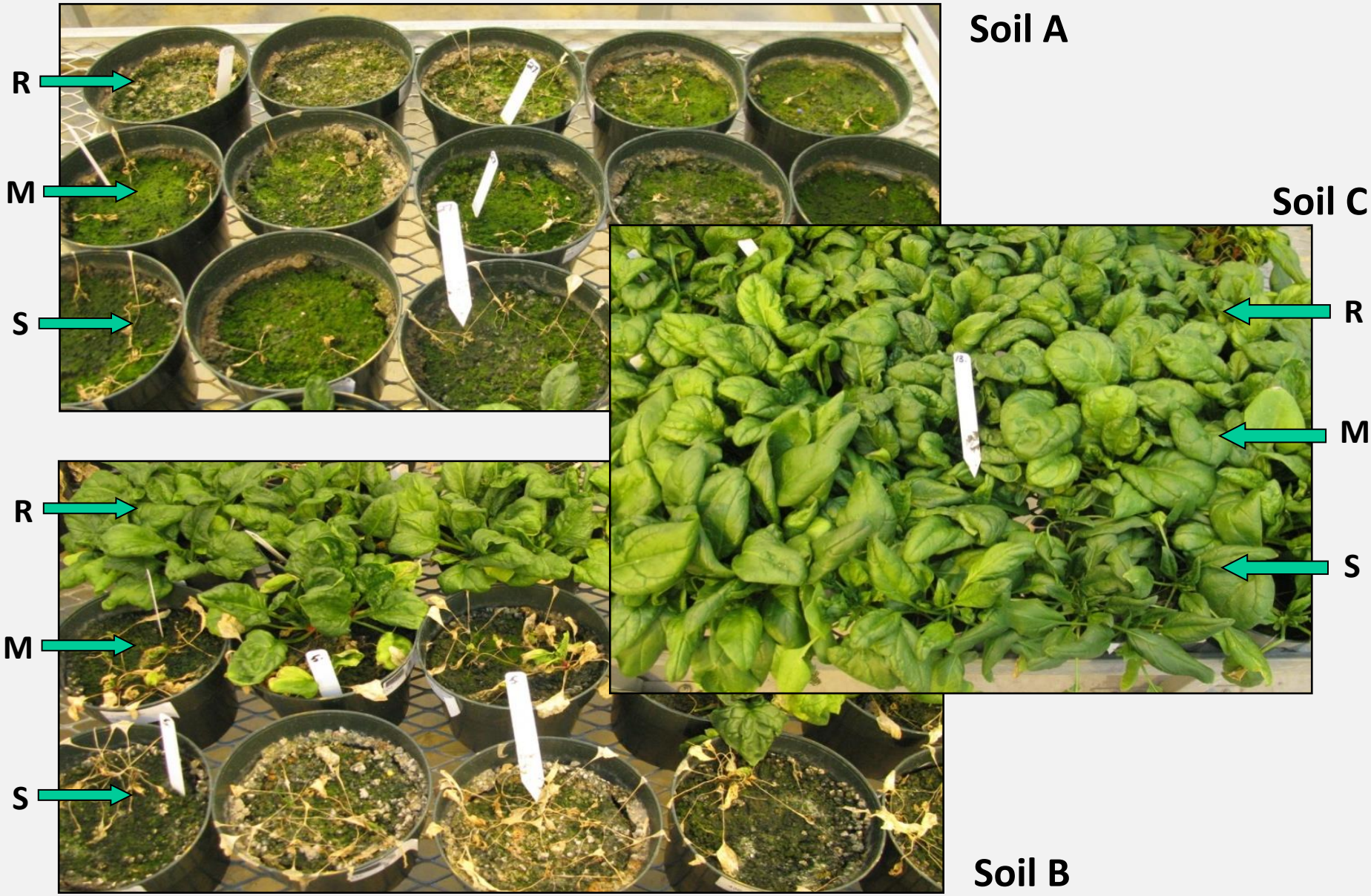
- Pathogenic vs. non-pathogenic strains or species
  - *Fusarium* spp. and subspecies, *Pythium*, *Rhizoctonia*
  - *Verticillium* spp. (*V. dahliae* & *V. albo-atrum*)
  - Specific plant parasitic nematodes
- Distribution in fields – sample representatively
- Appropriate time of year to sample soil
  - Stubby root nematodes go 2-3' deep in hot or cold soils
- Disease risk is not just a function of inoculum density
- Communicate with diagnostic lab
  - What, when, and how to sample (& ship samples)
  - Interpret results: Quantify risk, management



Verticillium wilt

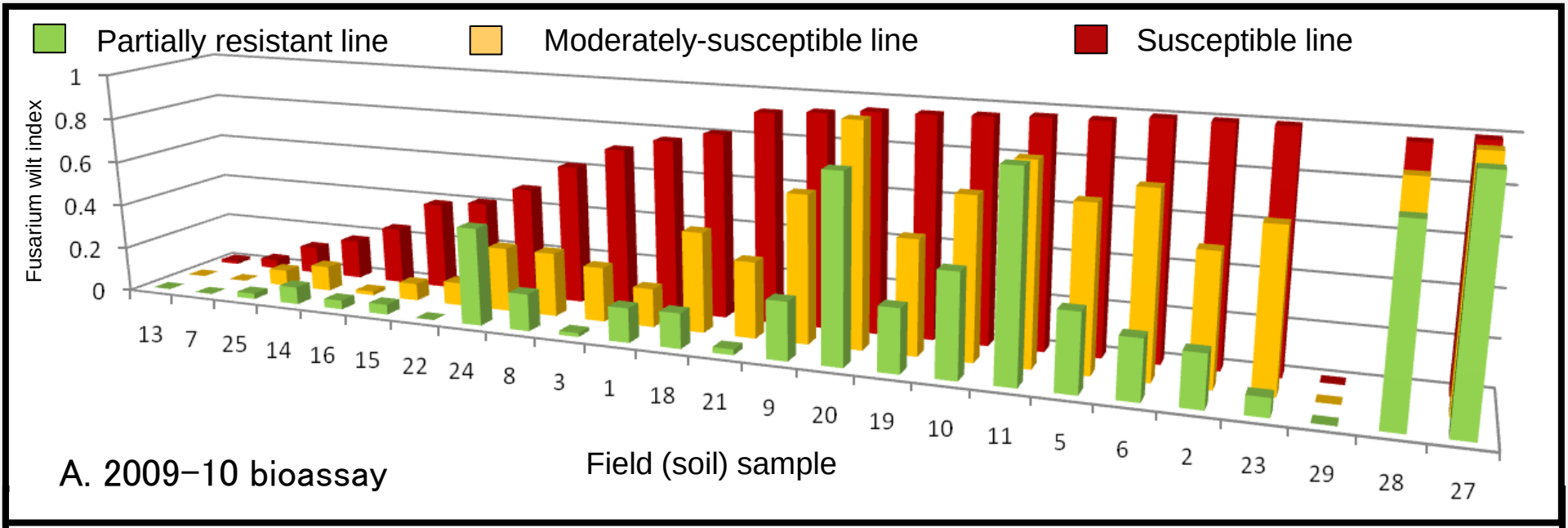
# Soil bioassay for spinach Fusarium wilt

Gatch and du Toit 2015. Plant Dis. 99:512-526
Gyawali et al. 2021. Plant Pathology 70:778-792

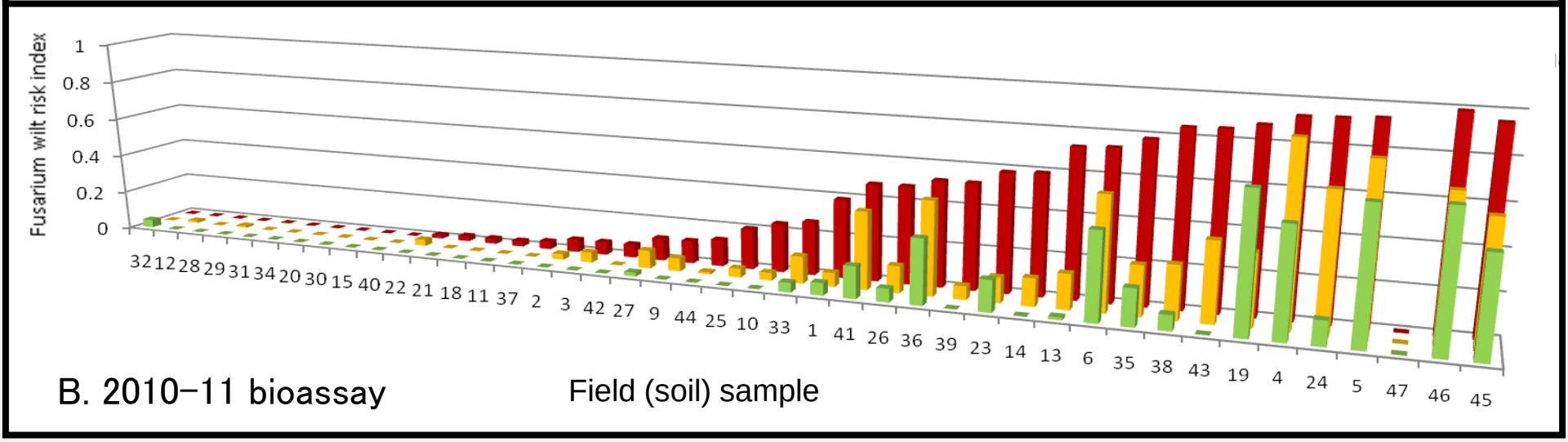

Soil A
R
M
S
Soil C
R
M
S
R
M
S
Soil B

# Risk assessment: Spinach Fusarium wilt soil bioassay

Gatch and du Toit 2015. Plant Dis. 99:512-526




A. 2009–10 bioassay




B. 2010–11 bioassay

# Multiple regression analyses (121 fields, 2010-2014)

pH
Buffer pH
$NO_3$
$NH_4$
P
K
Ca
Mg
S
B
Fe
Mn
Zn
Cu
CEC
OM
EC
Spinach rotation duration
% sand, silt, and clay
*F. oxysporum*, *V. dahliae*

**Susceptible inbred:**

Y = -0.4556 – 0.0172(rotation) + 0.0854($NH_4^+$-N) – 0.3875(soil pH) + 0.4037(buffer pH) + 0.0056(sand) + 0.0245(clay)

**$R^2$ = 0.3396 at *P* <0.0001**

**Moderate inbred:**

Y = 1.0777 – 0.0136(rotation) + 0.0005(*V. dahliae*) + 0.0563($NH_4^+$-N) – 0.1528(soil pH) + 0.0045(clay)

**$R^2$ = 0.3213 at *P* <0.0001**

**Resistant inbred:**

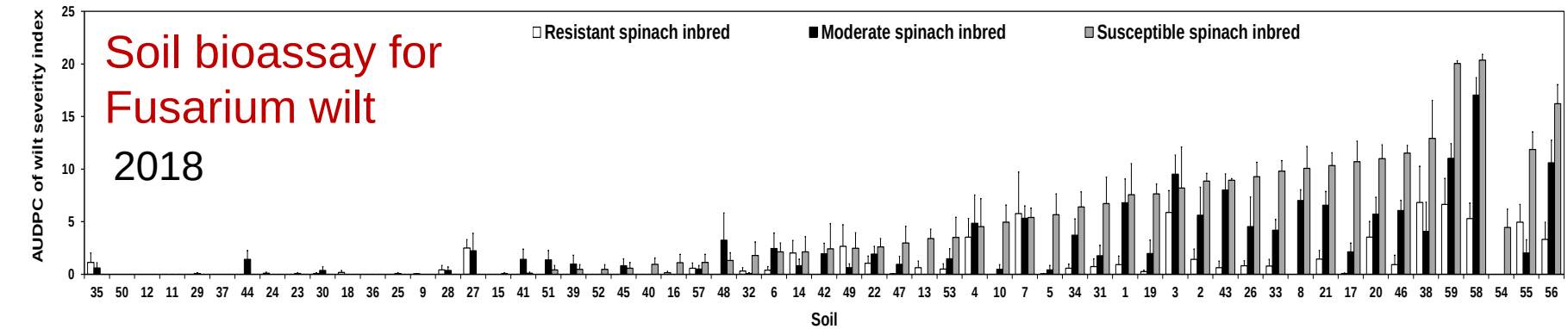
Y = 0.6161 – 0.0094(rotation) + 0.0498($NH_4^+$-N) + 0.0003(K) – 0.0947(soil pH)

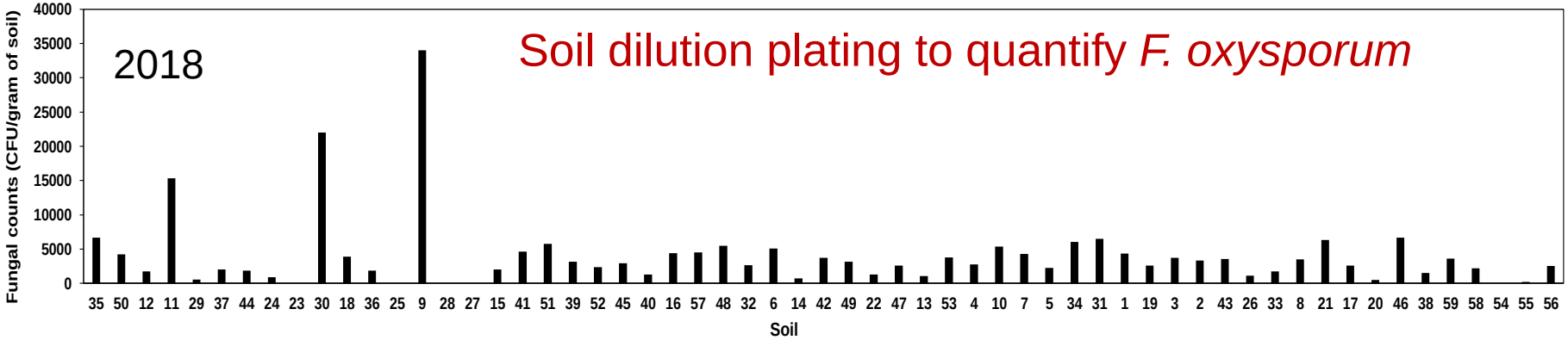
**$R^2$ = 0.2415 at *P* <0.0001**

# Spinach Fusarium wilt risk assessment

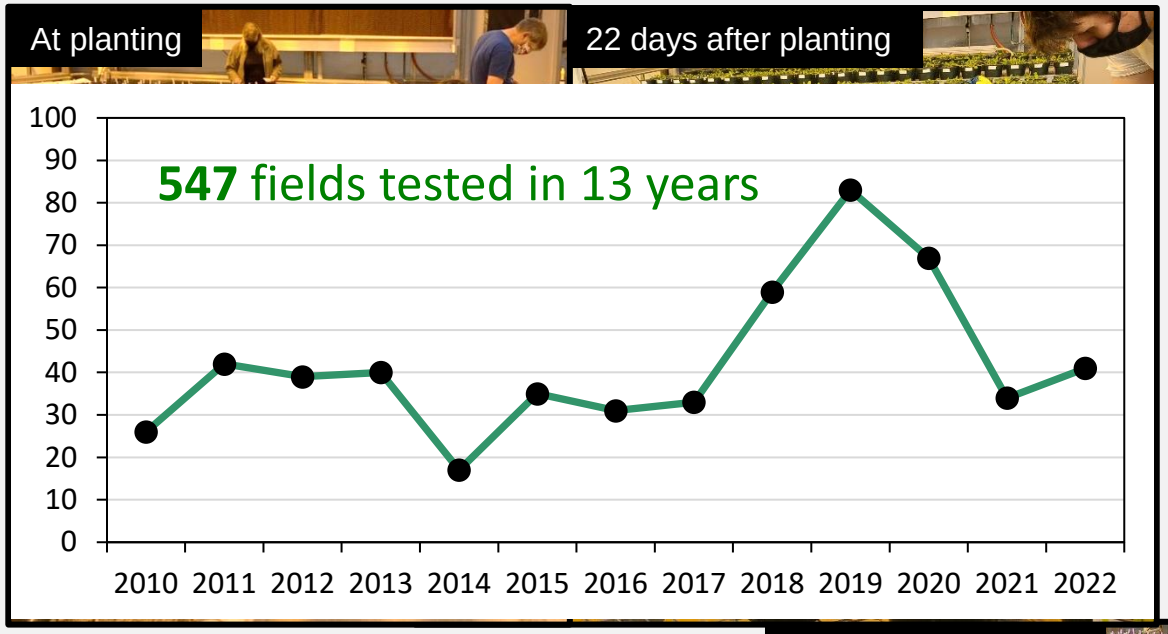
Spinach Fusarium wilt soil bioassay compared to:

1) Quantifying *Fusarium oxysporum* in soil by dilution-plating
2) Quantifying *F. oxysporum* f. sp. *spinaciae* with a real-time PCR assay (Okubara et al. 2013. Plant Dis. 97:927-937)
3) Quantifying *F. oxysporum* f. sp. *spinaciae* with a real-time PCR assay for genes associated with pathogenicity to spinach (Batson et al. *in review*)



# Annual Kirby Johnson Spinach Fusarium Wilt Soil Bioassay & Parent Line Screening



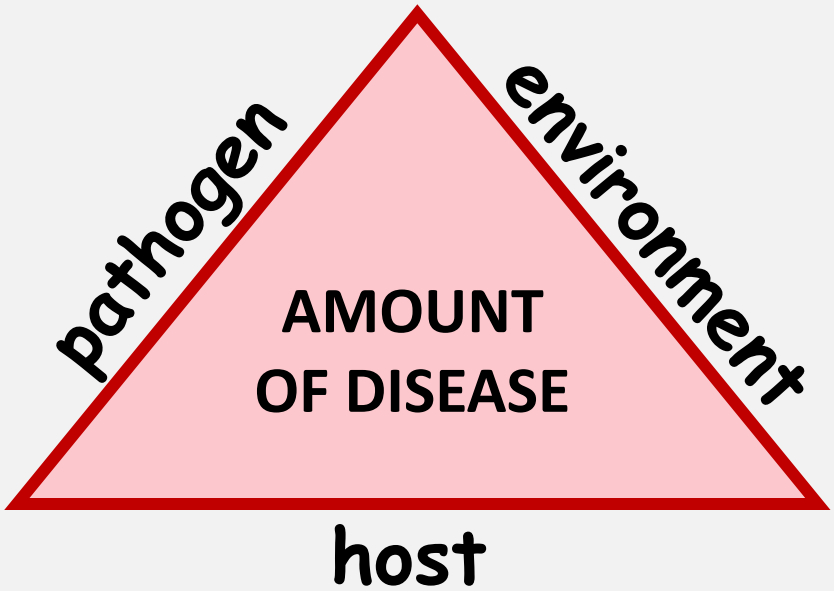

## Soil bioassay

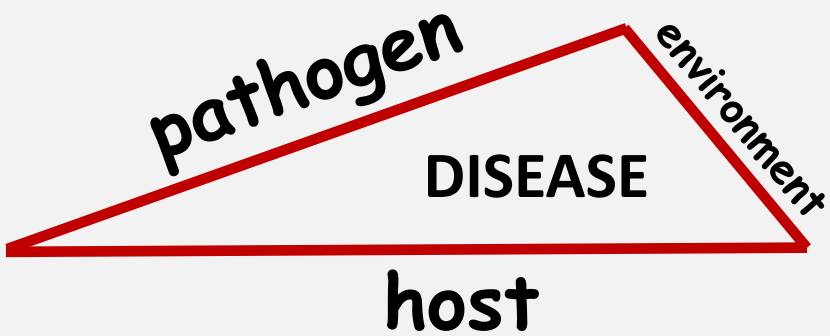
- Growers' soil samples
- 3 control soils
- Plant in Dec.
- Open House in Jan.
- Complete soil nutrient analysis
- *Verticillium dahliae* soil results
- $200/soil sample

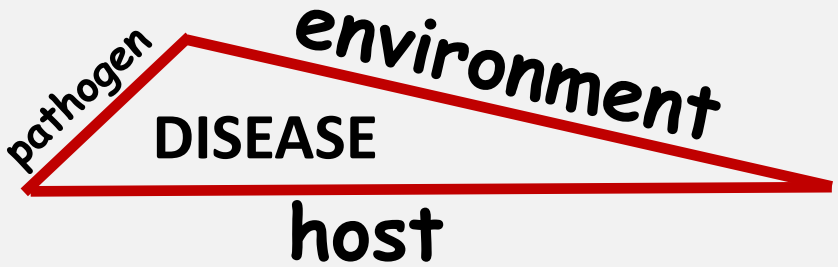
## Spinach parent line trial

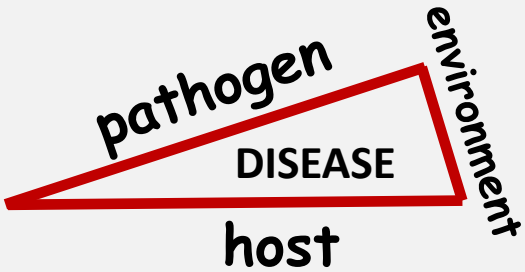
- Seed company inbred lines
- 3 control inbreds
- Plant Dec.
- Test with races 1 & 2 separately
- Open House in Jan.
- $100/parent line

# What can you control?



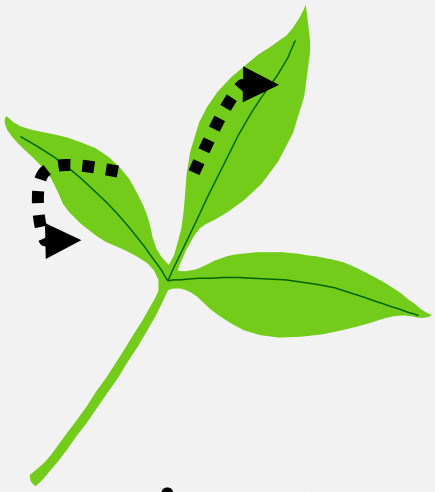





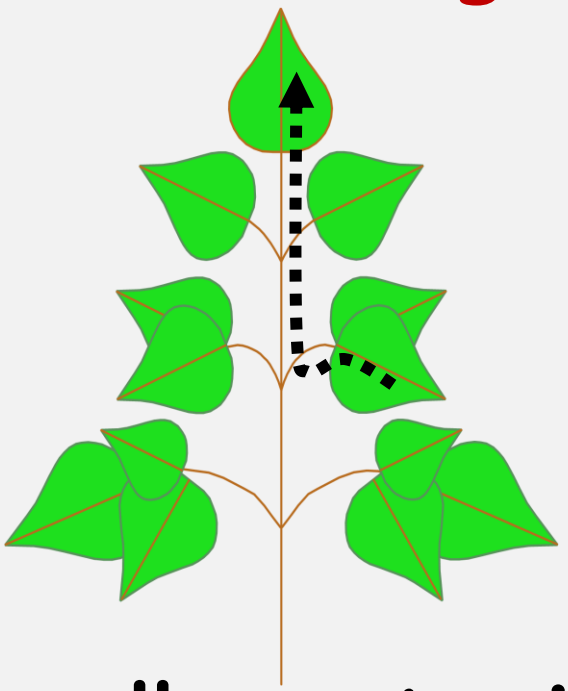
# Principles of soilborne disease management

1. Eradicate inoculum:
   - Destroy inoculum (e.g., fumigation, burial in soil)
   - Soil solarization, anaerobic soil disinfestation
   - Sanitation (soil on equipment, tires, shoes, …)
2. Avoid the pathogen, reduce inoculum amount or virulence:
   - Select low-risk fields
   - Crop rotation = longer-term for soilborne pathogens
     - Host range (symptomatic vs. asymptomatic crops and weeds, narrow vs. broad host range)
     - Persistence of pathogen
   - Soil preparation – good structure, tilth, drainage
   - Soil amendments (e.g., limestone, compost, …)
   - Optimum fertility and irrigation, choice of fertilizer
   - 'Clean' or treated seed or seedlings
   - Time of planting (e.g., sweet corn seedling blight)
   - Plant more resistant cultivars, if available
3. Protect plants from infection
   - Fungicides: What, when, where, and how to apply?
   - Fungicide resistance (e.g., *Pythium* spp. and mefenoxam)

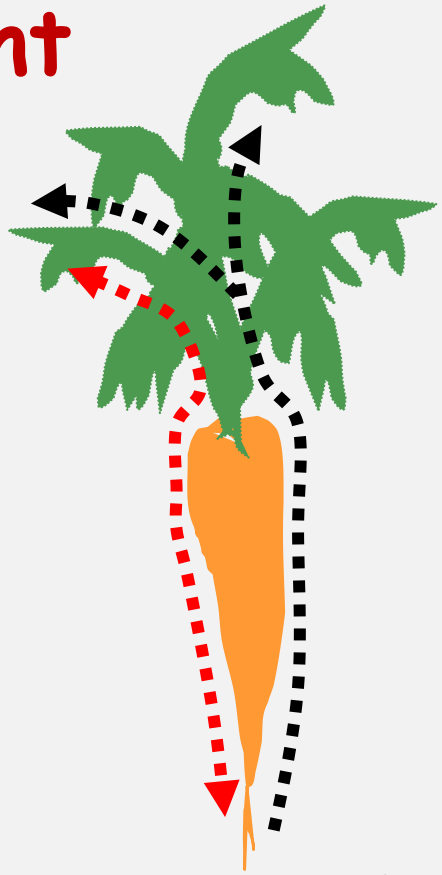
# "Systemic" fungicides and soilborne disease management



translaminar



locally systemic



systemic

**Apoplastic** = xylem translocated up only (e.g., Ridomil, FRAC Group 4)

**Symplastic** = phloem translocated UP & DOWN (e.g., Aliette, FRAC Group 33)

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

# Fungicide Mobility in Soil

- Ability of a fungicide to move in the soil
- Determines relevant methods of fungicide application to soil
- **Pesticides Properties Database** (IUPAC: International Union of Pure & Applied Chemistry): http://sitem.herts.ac.uk/aeru/iupac/index.htm
  - Search by active ingredient
  - Various properties, including "soil adsorption & mobility" = "Freundlich equation" (Kf):
    - Azoxystrobin = slightly to moderately mobile (Kf = 7.35)
    - Mefenoxam or metalaxyl = moderately mobile (Kf = 1.63)
    - Prothioconazole (Proline) = slightly mobile (Kf = 44.2)
    - Penthiopyrad (Fontelis) = slightly mobile (Kf = 12.52)

**Application of Fontelis (penthiopyrad = FRAC Group 7) for control of pink root of onion**

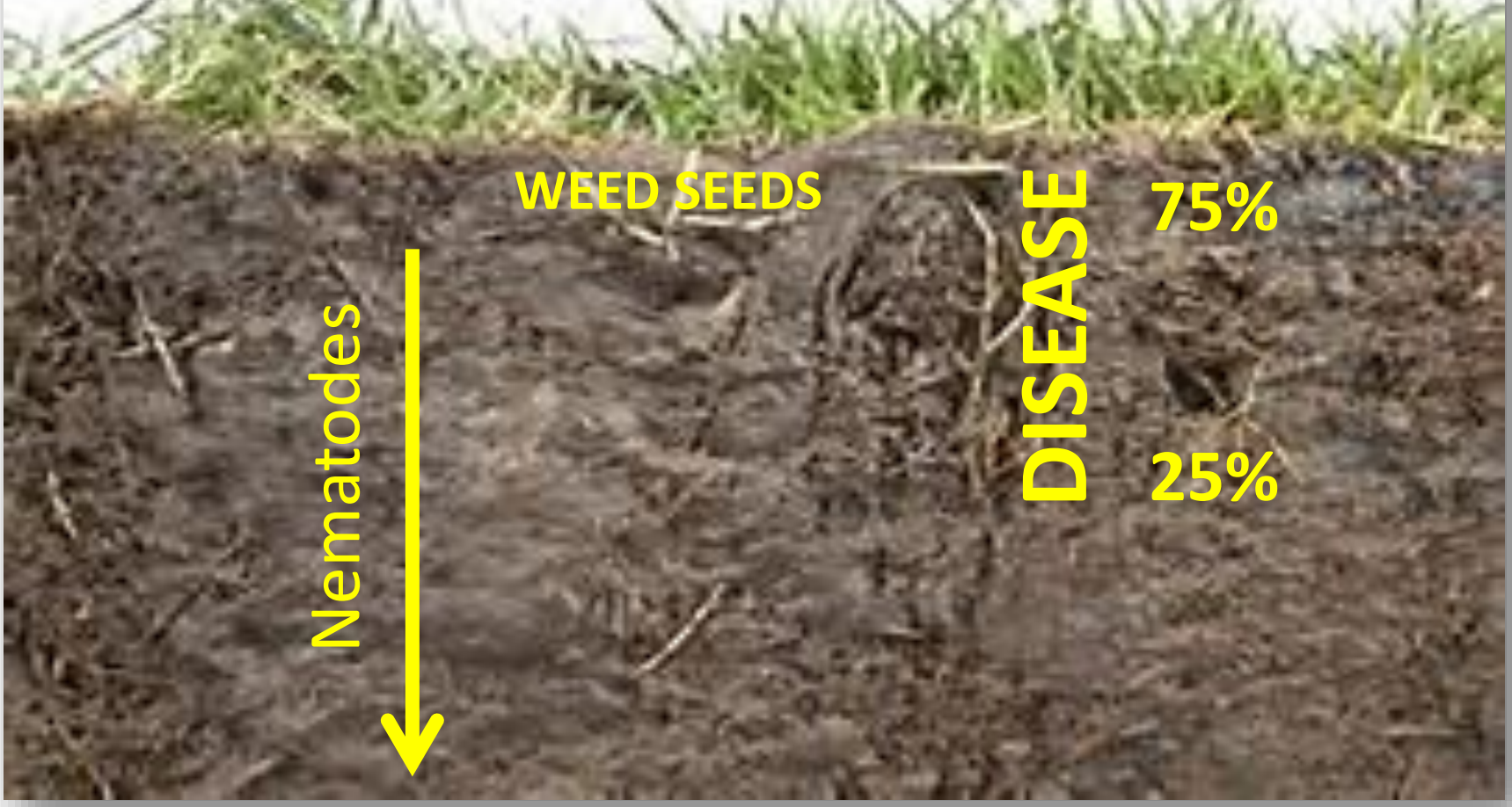
Application of a pesticide to a crop or site that is not on the label is a violation of pesticide law and may subject the applicator to civil penalties.

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 any product to ensure lawful use, and obtain all necessary permits in advance.**

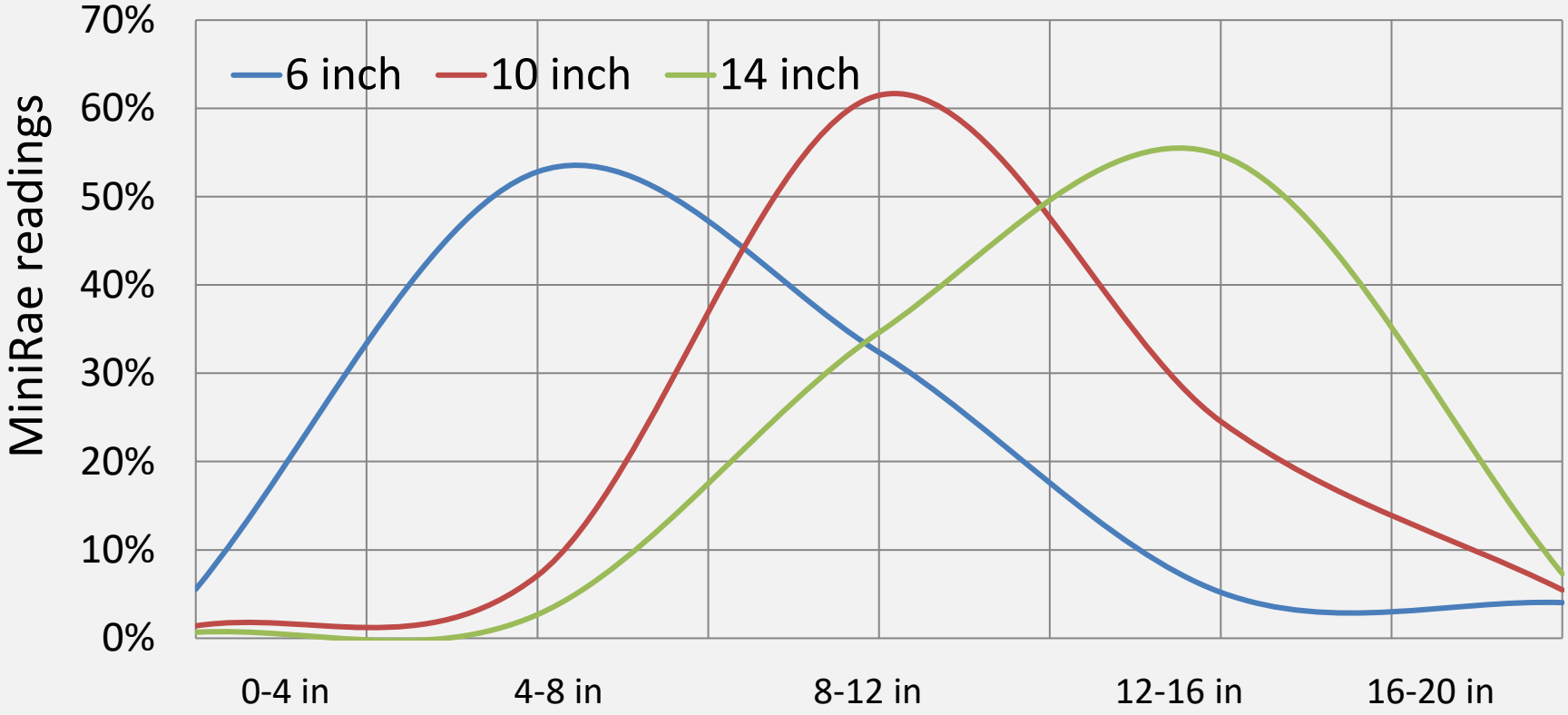
# Soil fumigation: Metam sodium

**Historically, metam sodium has never effectively reached all three pests (weed seed, nematodes, soilborne pathogens) in a single application (Kyle Coleman, NovaSource)**

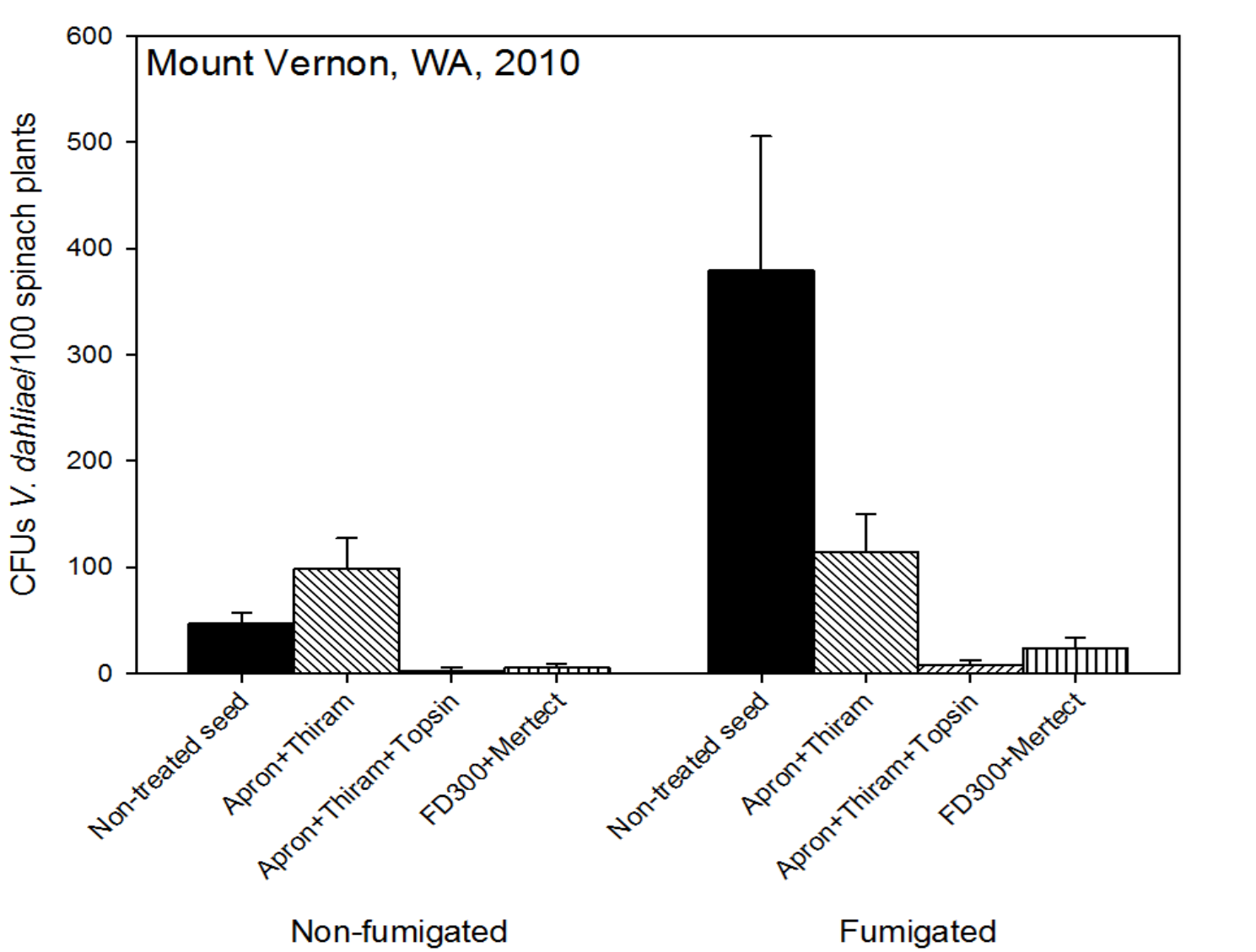


# Influence of placement on efficacy of soil fumigation with metam sodium

**Readings by single shank injection at 6, 10, and 14 inches after 18 hours, 180 readings, Paterson, WA (Kyle Coleman, NovaSource)**

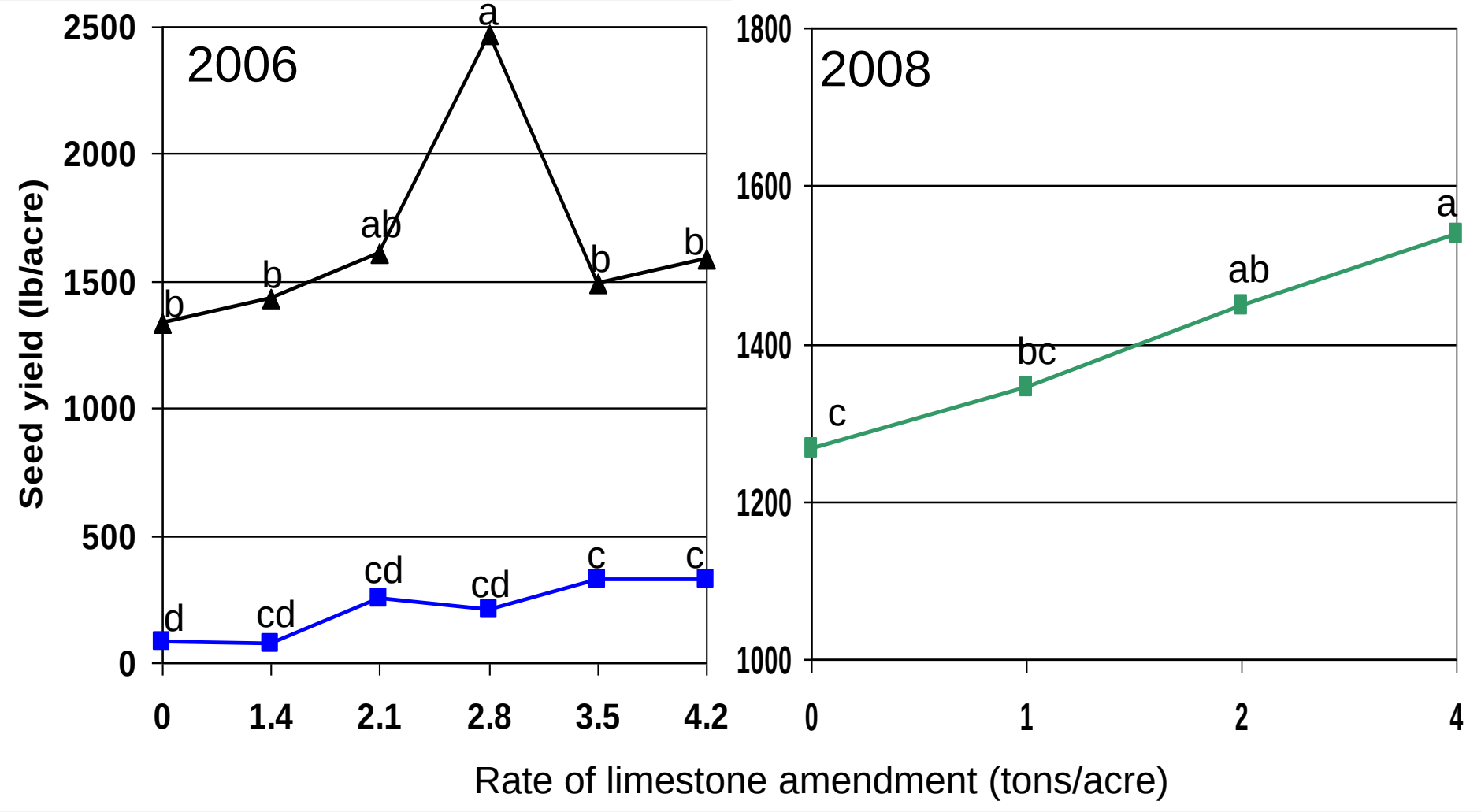


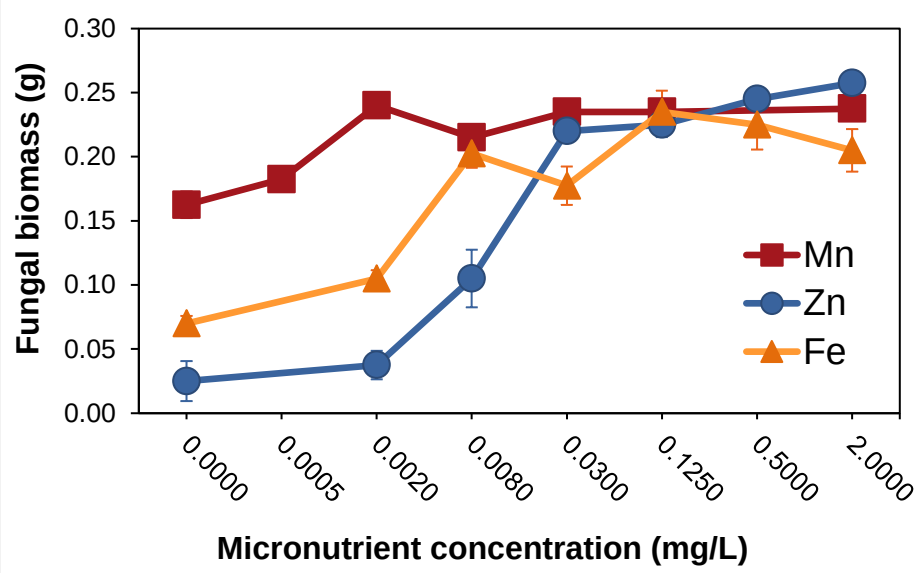
# Effects of fungicide seed treatments & soil fumigation with methyl bromide & chloropicrin on seed transmission of *Verticillium dahliae*

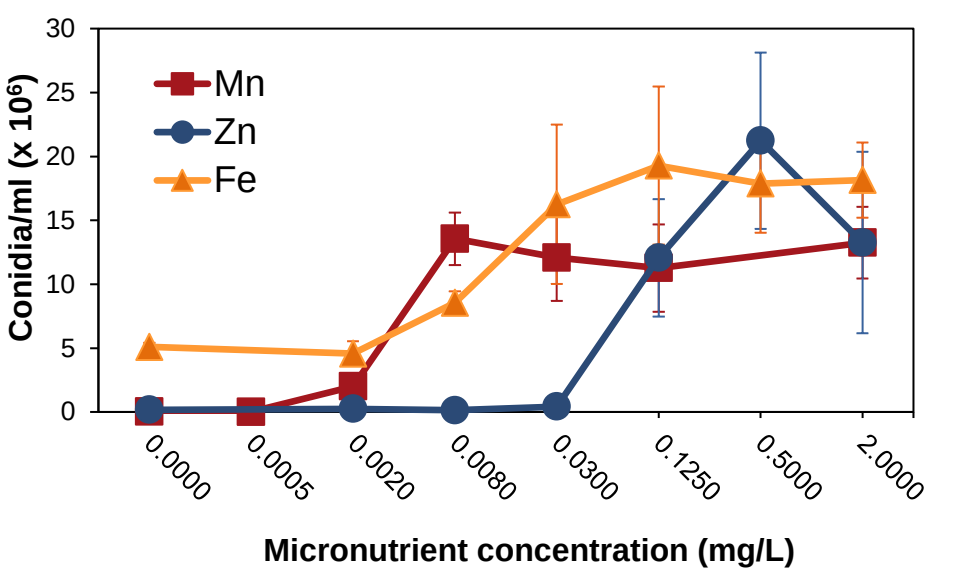


# Agricultural limestone amendment for suppression of spinach Fusarium wilt

du Toit et al. 2007, 2008, 2011; Gatch 2013; Gatch & du Toit 2017





Emily Gatch 2013

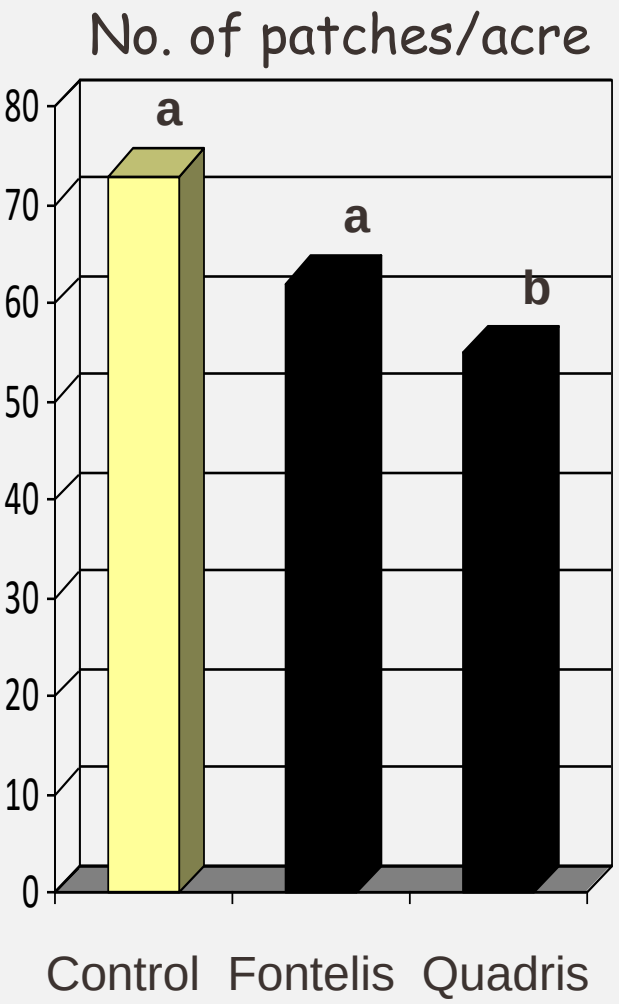
# Fusarium wilt of radish in central Washington

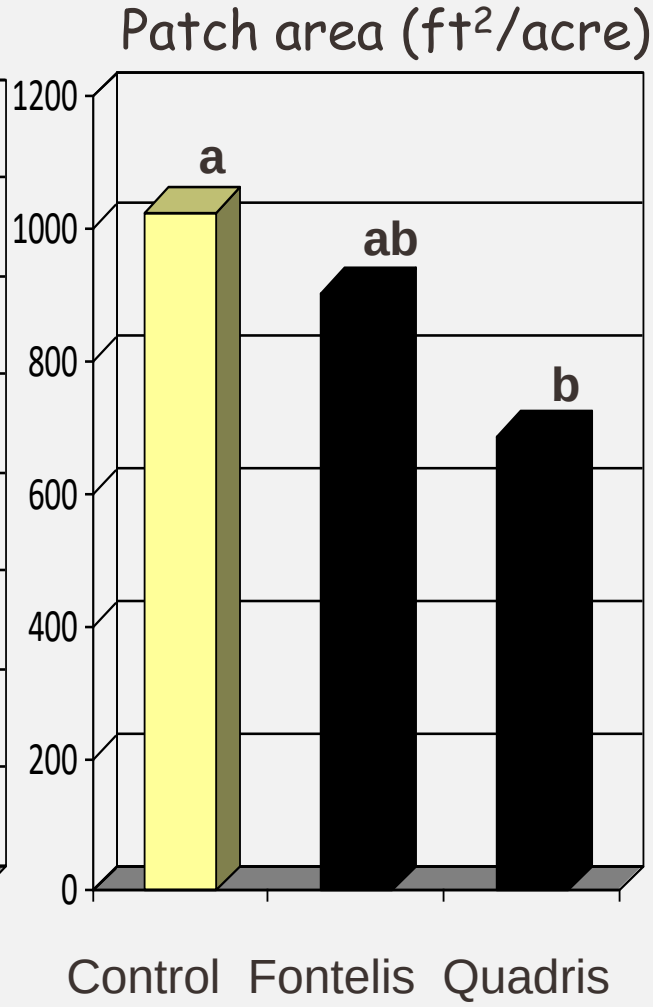
***Fusarium oxysporum* f. sp. *raphani*** (du Toit & Pelter, 2003)

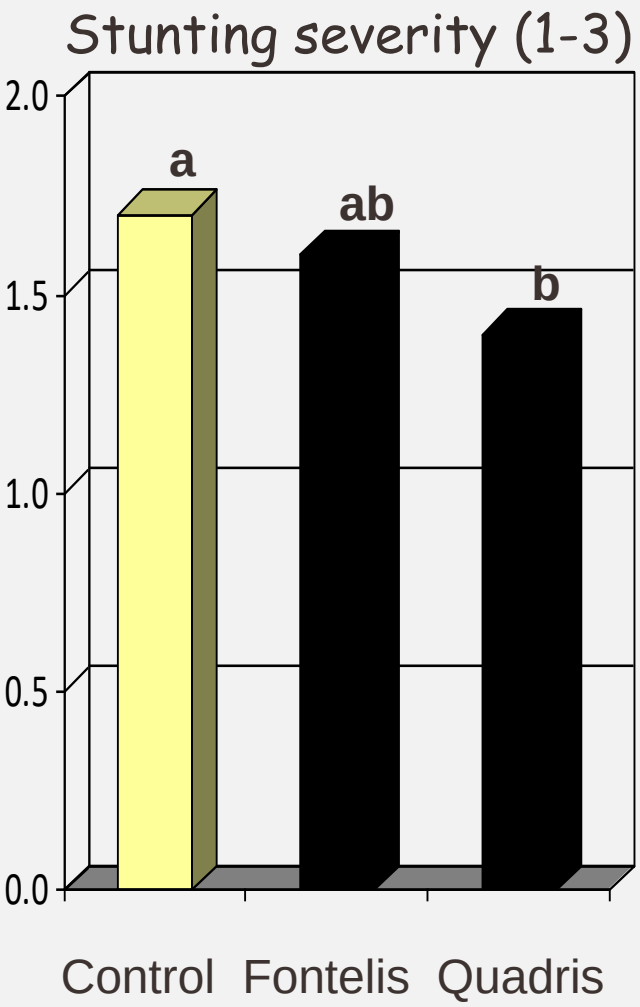
- 40-acre seed crop
- 7-year rotation
- Same seed lot in an adjacent, 10-acre field was healthy
- No history of radish
- Soil pH 5.8

# Onion stunting from *Rhizoctonia* spp. on coarse soils with cereal cover crops

# Evaluation of PPI application of Quadris (FRAC group 11) & Fontelis (FRAC group 7) for Rhizoctonia stunting of onion

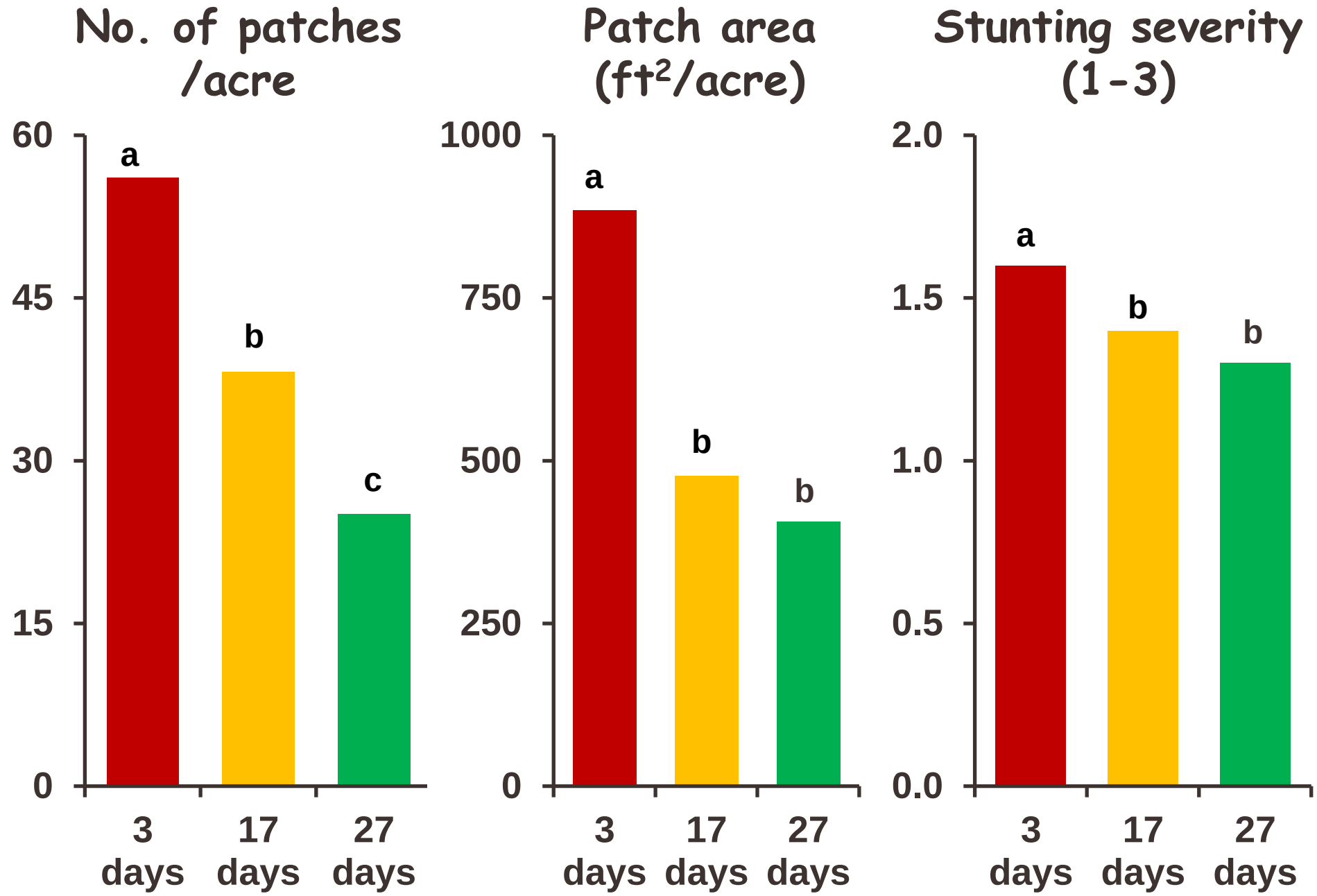


# Onion-cereal 'green bridge' for Rhizoctonia

# Onion Rhizoctonia 'green bridge' trial



https://csanr.wsu.edu/fine-tuning-soilborne-disease/

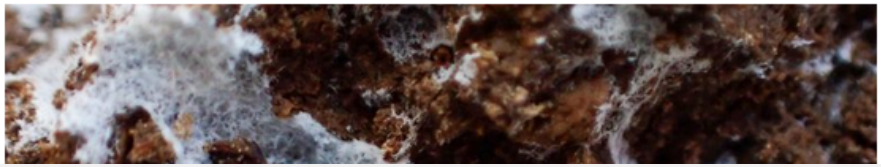


# Fine-Tuning with Soil Health; Soilborne Disease?

Posted by Andrew McGuire | October 5, 2022

Healthy soils produce healthy crops, right? Nope. Although it would seem the very definition of soil health, this popular thinking does not match what plant pathologists find (Janvier et al., 2007). It's not true.

You can have a soil that is healthy in all other ways and still have problems with soilborne disease. But then, one may ask, is it really healthy? We can define away the dilemma – if you have soilborne disease problems, you don't have a healthy soil—but then we may never have healthy soil. Instead of the soft thinking of catch phrases, let's look at the hard reality.



# Best management practices for soilborne diseases of vegetables

- Learn about regionally prevalent soilborne pathogens of your vegetable crops
- Read about disease cycles to identify the Achilles' heels
- Determine what you can control to reduce the size of the disease triangle (environment, host, pathogen)
- Integrate all available disease management tools
  - Timely and appropriate implementation