Updates on Winter Vegetable Diseases

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UC Coop Ext Riverside Vegetable Growers
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University of California
Agriculture and Natural Resources

Downy mildew pathogens

- Water molds
  - Like *Pythium*, *Phytophthora*
  - Fungicides used are typically specific to this group
- Obligate biotroph (obligate parasite)
  - Requires living host to grow and reproduce
- Over 700 species, generally host-specific

Downy mildews are host-specific

Bremia lactucae

Lettuce

Prickly lettuce

Downy mildew spores from lettuce can infect prickly lettuce

Peronospora destructor

Onion

Garlic

…And Others ?

= NO cross-infection

Downy mildew spores from lettuce will not infect or cause disease on onion, and vice versa

Downy mildews are host-specific

Bremia lactucae

Lettuce

Prickly lettuce

Peronospora effusa

Spinach

Peronospora destructor

Onion

Garlic

…And Others ?

= NO cross-infection

Amaranth family

Peronospora effusa

Spinach

Downy mildews are host-specific

Peronospora variabilis

Nettleleaf goosefoot, Lambsquarters, Quinoa

Peronospora schachtii

Sugar beet (+ others)

Prob. NOT

= NO cross-infection

Correll and Koike, 2012 CLGRP

D. Etchison, Calflora.org

H. Schwartz, Colorado St. Univ.

When are spores present?

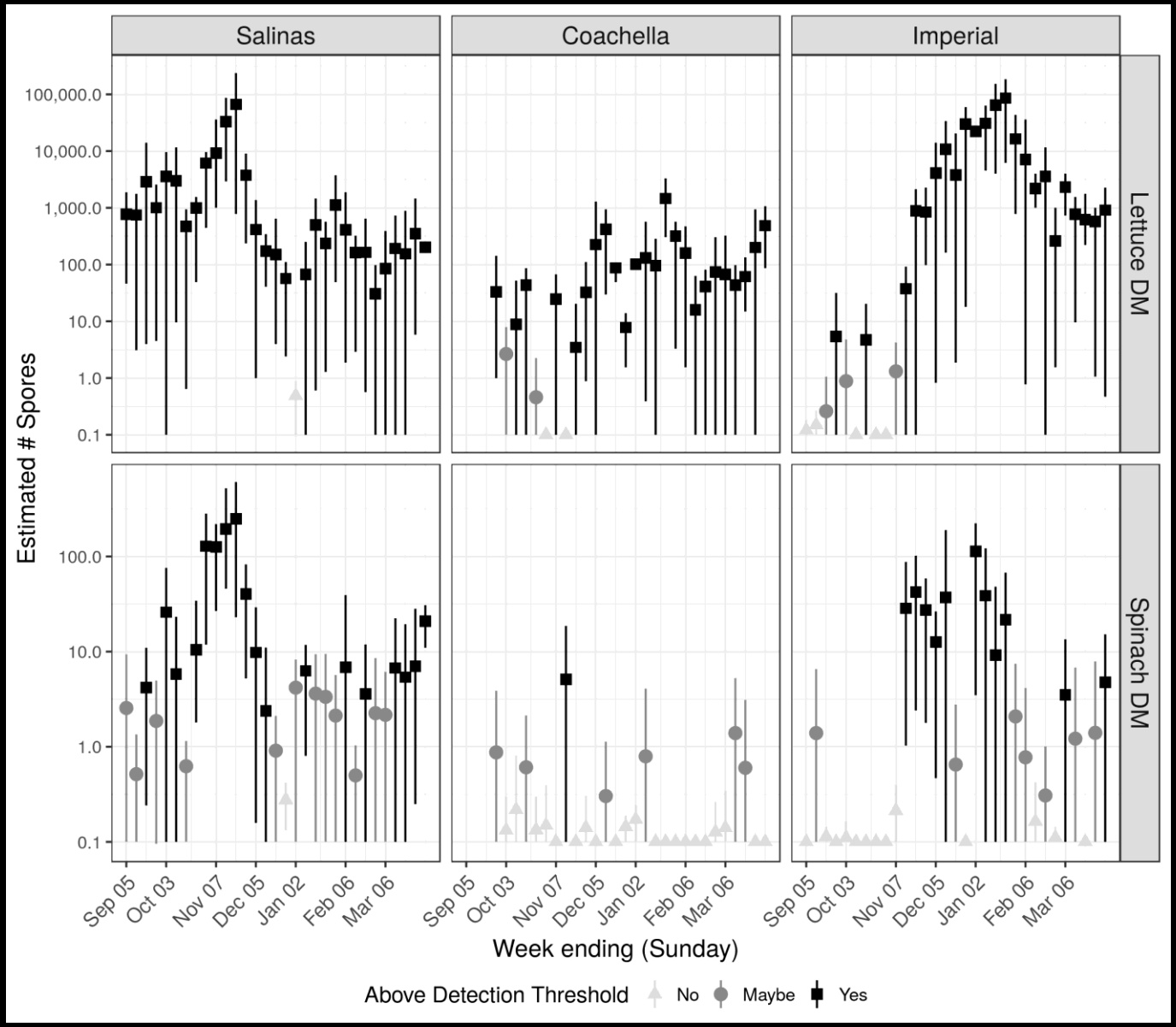
- Spore trapping project in <u>both</u> spinach and lettuce

- Timing
  - September through April
  - 2-3 days per week

- Led by Steve Klosterman (USDA Salinas)
  - Includes Ali Montazar (UCCE Imperial)

- Funding:
  - CA Leafy Greens Research Program
  - CA Dept. of Food and Agriculture Spec. Crop Block Grant #20-001-047-SF

Downy Mildew Spores



In desert, spores were not detected in significant numbers before mature crops or significant acreage

Suggests spores were not being carried long-distance from another region

Detection range

2 locations

3x/week

Maximum

Average

Minimum

Plant Disease

Susceptible host

Favorable environment

Virulent pathogen

Favorable Conditions*

*in canopy

Time

Spores

Morning

Infection

Symptoms

Night

Sporulation

LETTUCE

Leaf wetness beginning at sunrise

Low as 3 hrs (<59°F)

Up to 4 hrs

Temp. optimum: 50°F to 59°F
(range 41°F to 70°F)

High relative humidity (>90%) or leaf wetness

No to light winds

Lettuce data from California Central Coast

ONION

Previous day air temp.:
optimal <80°F

Low as 2 hrs (<70°F)

Up to 5 hrs

No rain after midnight

Onion data from Ontario, Canada

Spinach Under Drip Irrigation

3 lines, surface, strip planting

Organic field at UC ANR Desert REC in Holtville

Cultivar Viroflay (susceptible to all downy mildew races)

Four trials over three years

3-4 beds per plot

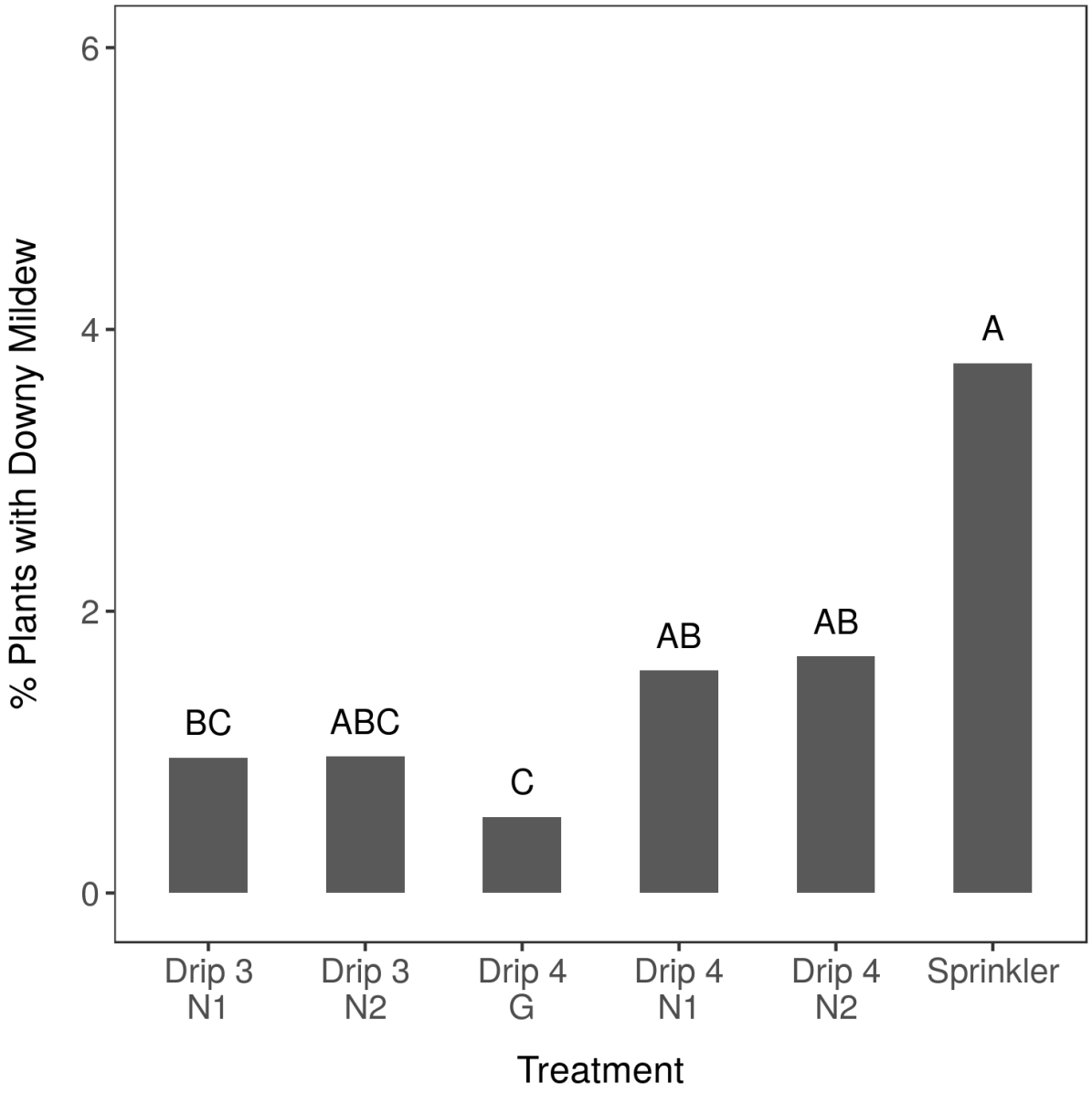
Ali Montazar (UCCE Imperial)

- With Alex Putman (UC Riverside), Mike Cahn (UCCE Monterey)

<u>Factors Examined</u>

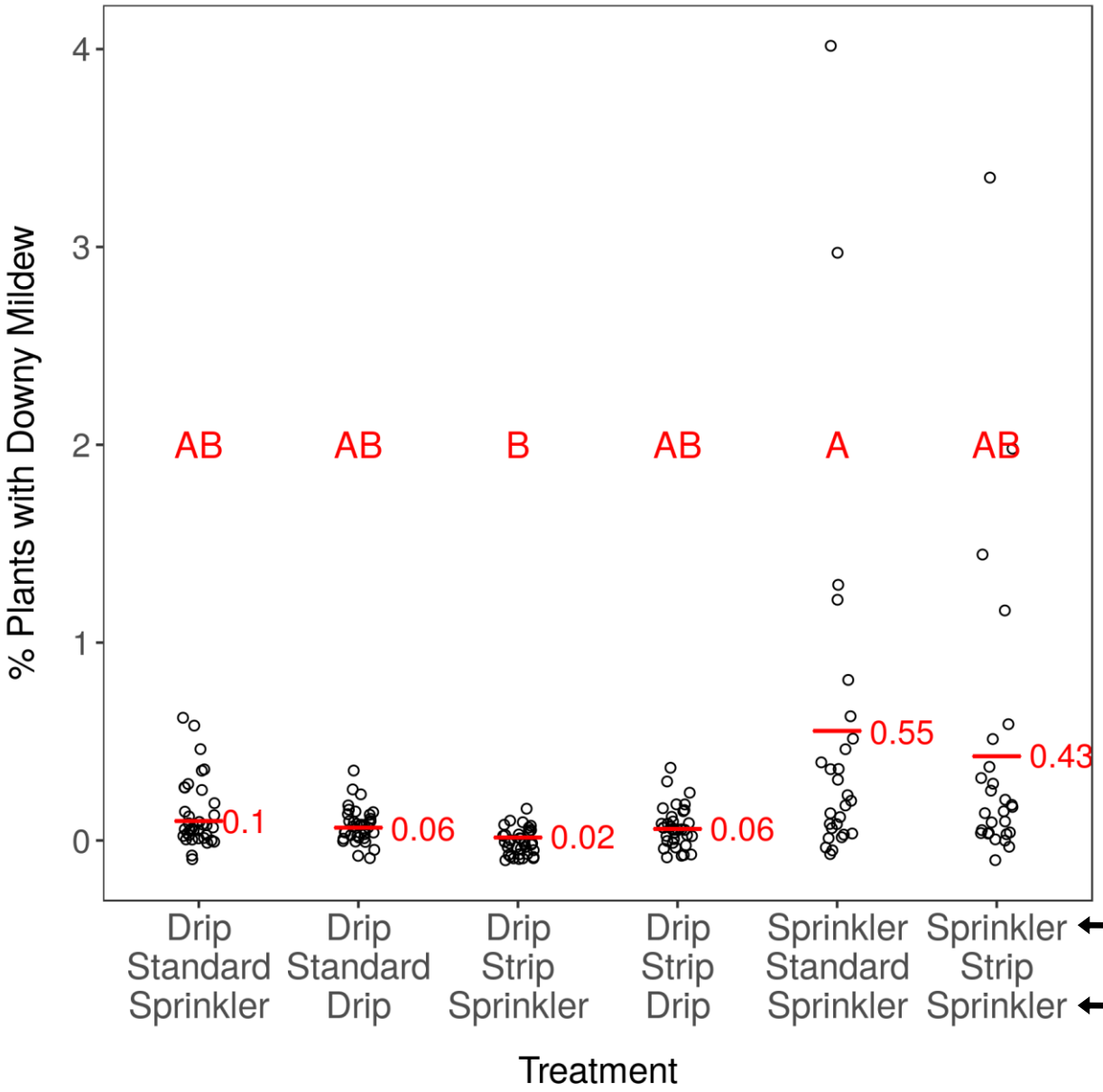
- Number of drip lines (3 or 4)
- Surface or buried
- Nitrogen regime
- Germinate with sprinkler or drip
- Planting scheme (standard or strip)

Spinach drip – Downy mildew 2020



- Downy mildew 2 to 7 times lower in drip vs. sprinkler

Spinach drip – Downy mildew 2021



- Few significant differences among treatments
- Strong numeric trend for less downy mildew in drip, driven by a few hot spots in sprinkler

← After establishment

← Germination

LETTUCE Fungicides

control = disease was lower than untreated check

Product	AI	FRAC	Avg % OF Control	# control /# trials
VERY GOOD				
Orondis Ultra	oxathiapiprolin + mandipropamid	49 + 40	12.3	1/1
Zampro	dimethomorph + ametoctradin	40 + 45	36.1	10/11
Forum	dimethomorph	40	33.4	3/3
Revus	mandipropamid	40	39.1	8/9
Reason	fenamidone	11	31.6	5/5
GOOD				
Quadris	azoxystrobin	11	35.0	1/1
Cabrio	pyraclastrobin	11	38.8	2/2
Curzate	cymoxanil	27	43.4	2/2
Gavel	mancozeb + zoxamide	M3 + 22	39.8	1/1
Aliette	fosetyl-Al	P07	37.5	1/1
containing phosphite	phosphorous acid	P07	40.8	8/8

Mike Matheron, Univ. of Arizona, Yuma (Plant Disease Management Reports, 2012, 2014, 2016-2019)
Tom Turini, UC Cooperative Extension (PDMR 2012)
Richard Raid, Univ. of Florida (PDMR 2014, 2017, 2018, 2020)

LETTUCE Fungicides

control = disease was lower than untreated check

Product	AI	FRAC	Avg % OF Control	# control /# trials
MODERATE TO GOOD				
Presidio	fluopicolide	43	46.5	7/8
containing mancozeb	mancozeb	M3	44.6	8/9
Actigard 50WG	acibenzolar-S-methyl	P01	44.1	4/4
MODERATE				
Bravo Ultrex WDG	chlorothalonil	M5	55.2	1/1
Ranman (+NIS)	cyazofamid	21	55.6	3/4
Previcur Flex	propamocarb HCl	28	48.5	5/5
Tanos 50WG	Cymoxanil + femoxadone	27 + 11	42.5	1/1

Mike Matheron, Univ. of Arizona, Yuma (Plant Disease Management Reports, 2012, 2014, 2016-2019)
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Fungicide mobility and timing

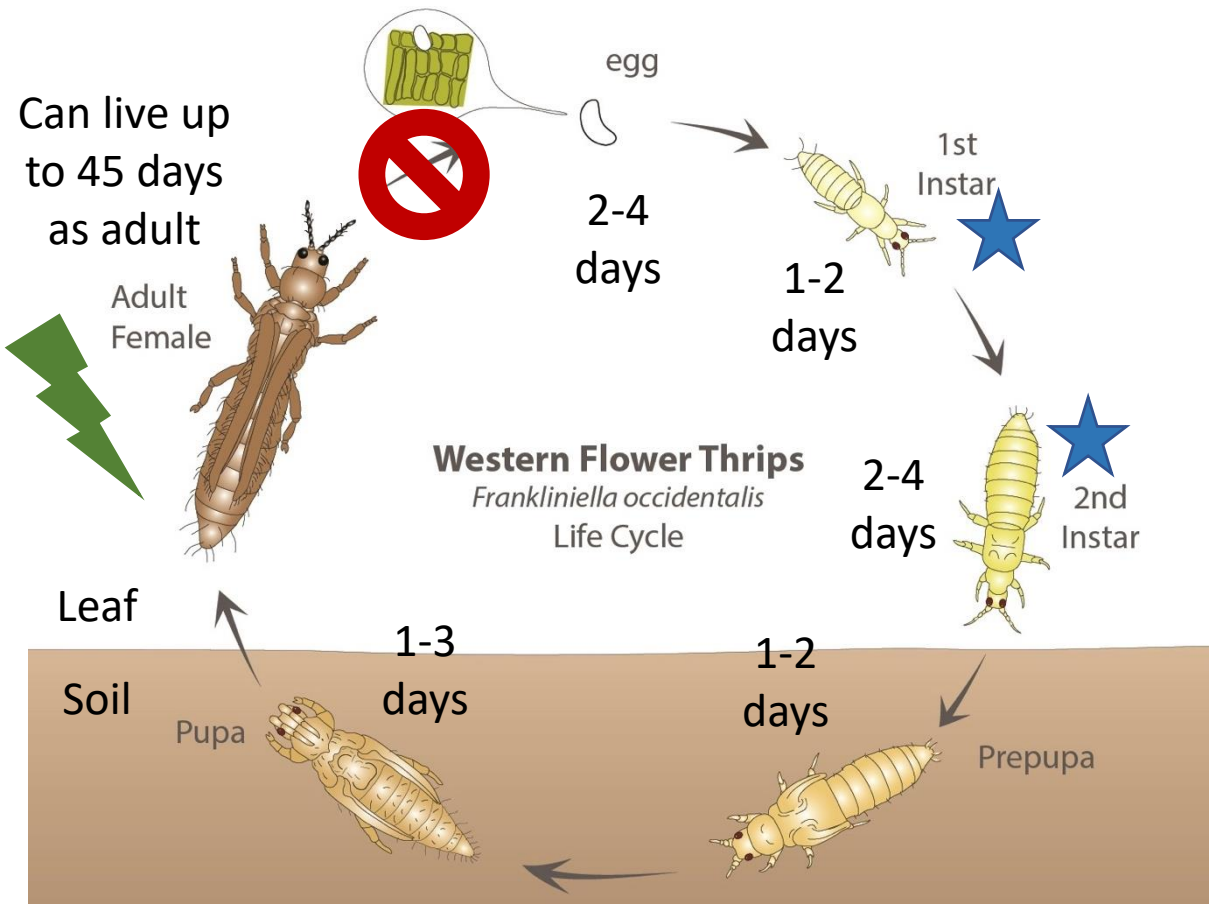
- Fungicides are most effective when applied before infection, regardless of mobility
  - Protectant (contact): must be applied before spores germinate
- Infections in an advanced state cannot be stopped
- Penetrant fungicides can slow infections that began before application (curative activity)
  - BUT window is narrow and curative activity is less effective
- Post-infection (curative) activity in comparison to preventative:
  - Lettuce (*B. lactucae*) lab study: dimethomorph > mandipropamid at 18 hr after infection; neither at 45 hr
  - Hop downy mildew greenhouse, field
    - Trifloxystrobin: <6 hr
    - Fosetyl-Al: <24 hr
    - Cymoxanil: <48 hr
    - Dimethomorph: <72 hr

Cohen et al. 2008 10.1007/s10658-008-9327-9
Gent et al. 2015 10.1094/PDIS-10-14-1004-RE

Fungicide Resistance

	LETTUCE (*B. lactucae*)	ONION (*P. destructor*)
Mefenoxam (Group 4)	• First reported in late 1980s • Survey CA+AZ 2019 (R. Michelmore, UC Davis) - Sensitive: 47 samples - Intermediate sensitivity: 19 - Insensitive: 86	• Australia (O'Brien, 1992): poor performance since 1987 - Resistance confirmed in field study • New Zealand (Wright, 2004) - Greenhouse study • Georgia: anecdotal report of decline in performance, resistance not documented
Phosphonates (Group P07)	• fosetyl-Al, phosphite-containing • Reported in California in early 2000s (Brown et al. 2004)	
Future resistance risk: Oxathiapiprolin (Group 49)	Considered moderate to high risk of resistance development • *Phytophthora nicotianae* in lab (Bittner and Mila, 2016)	

Impatiens necrotic spot virus (INSV)



BioBee Biological Systems

Virus NOT passed from adult to egg

ONLY larvae can acquire virus

ONLY adults can transmit virus
Transmits for LIFE

D. Hasegawa, USDA-ARS Salinas

INSV Transmission Dynamics

In a field, there are two stages to disease spread

- Primary infection:
  - Thrips with INSV are blown into field
  - Infect lettuce plant
  - Egg hatches and larvae acquires virus from infected plant
- Secondary infection:
  - Adults derived from the first infected plant move to nearby plants to begin another cycle
- Adults can transmit the virus in a matter of minutes
- Time between plant infection and symptom appearance (incubation period) = 10 to 14 days

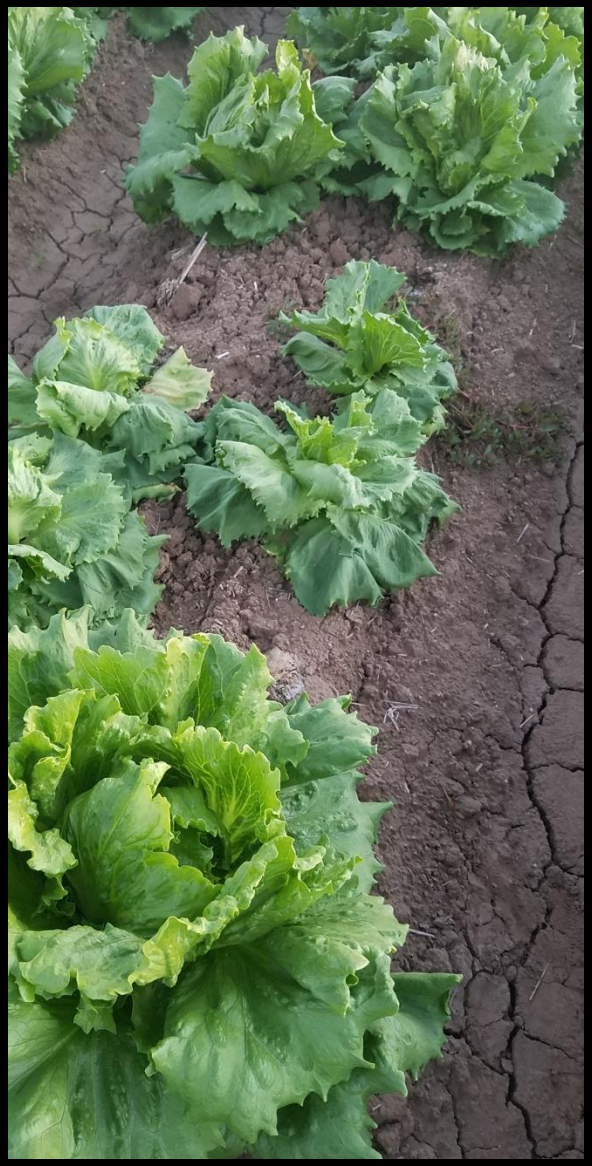
INSV Host Range – Crops

Family	Examples
Apiaceae (carrot)	Celery
Solanaceae (nightshade)	Pepper, tomato, eggplant, potato
Fabaceae (pea or bean)#	Peanut, fava bean
Asteraceae (aster or daisy)	Chicory, lettuce
Cucurbitaceae (cucurbit)	Cucumber
Lamiaceae (mint)	Basil, peppermint
Chenopodiaceae (goosefoot)	Spinach

*Not known to be hosts: Brassicaceae (mustard), Poaceae (grasses)

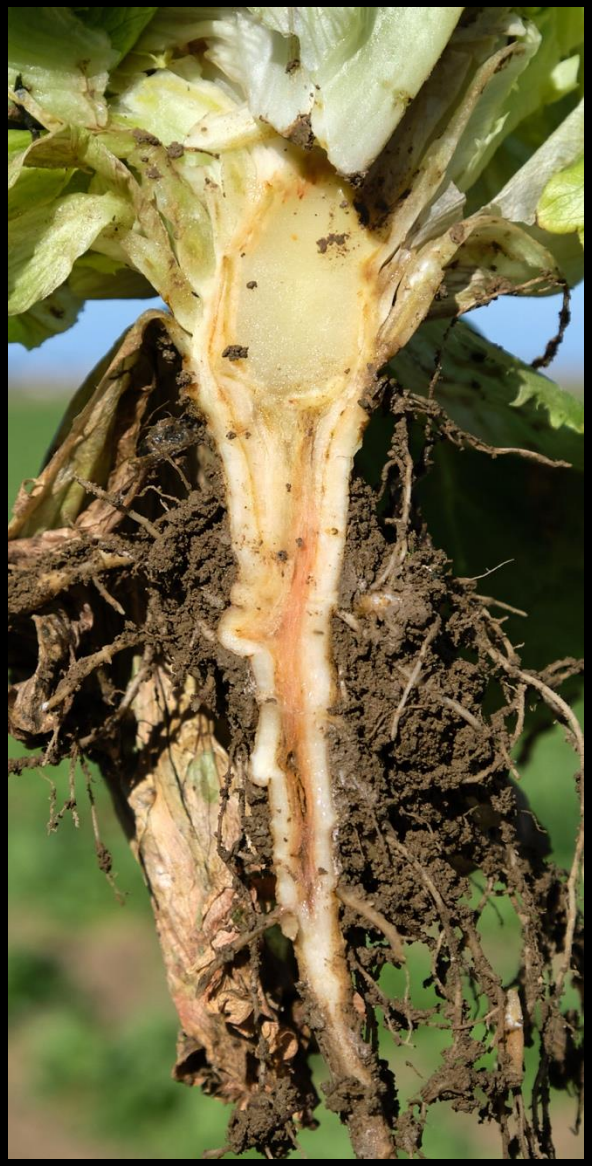
Alfalfa samples have been tested but none have been positive for INSV

Non-hosts for virus can still support virus-carrying thrips



Stunting, wilting

Yellowing/death of outer leaves



Collapse; Interior rot, reddish discoloration

Fusarium oxysporum f. sp. *lactucae*

- Disease-causing ability is host specific
  - *F. oxysporum* f. sp. *lactucae* will only cause disease of lettuce
  - f. sp. = “special form”
- There are many *F. oxysporum* f. sp. ____ of other hosts
  - Also, non-pathogenic *F. oxysporum* are probably widespread

You have…	Can it cause disease on…?		Can it grow on roots of…?	
	Lettuce	Strawberry	Lettuce	Strawberry
 Lettuce Fusarium wilt	YES	no	YES	? (probably)
	Fusarium oxysporum f. sp. *lactucae*			
 Strawberry Fusarium wilt	no	YES	YES	YES
	Fusarium oxysporum f. sp. *fragariae*			

Henry et al. 2019 10.1094/PHYTO-11-18-0418-R

Fusarium thrives in soil

Maryani et al. 2019 Studies in Mycology

G. Holmes, Cal Poly SLO, Bugwood.org

Structures are produced in abundance in diseased tissue and are added to the soil

Fusarium is spread via infested soil

Acknowledgements

SPORE TRAPPING

- Funding: CA Leafy Greens Research Program, CA Department of Food and Agriculture
- USDA Salinas: Amy Anchieta; UC Riverside: Hannah Ayala

SPINACH DRIP IRRIGATION

- Funding: CA Leafy Greens Research Program
- UC Riverside: Hannah Ayala

ONION

- Funding: CA Garlic and Onion Research Advisory Board
  - Also UC Riverside College of Nat. Ag. Sci/USDA Hatch Multistate W3008
- Olam (Larry Hanson, Mary Campbell), Sensient (Dan Brotslaw, Theo Hudson, Paul Leimgruber) for seed, planting
- UC ANR Desert REC staff; UC Riverside: Jacob Goldberg, Anita Behari, Sonali Singh

Got bacterial diseases of onion?

Help us "**STOP THE ROT**"

WHO We Are: A team of researchers from across the country, working on tools to combat bacterial diseases of onions

WHAT We Are Looking For: Samples of onion plants affected by any of the bacteria known or suspected to cause diseases in onions

HOW You Can Help: If you are a grower and you have a suspected bacterial disease in your onion crop, contact us to survey your field and/or sample the bulbs in storage

California contacts:

Brenna Aegerter, UCCE San Joaquin (209-953-6114, bjaegerter@ucanr.edu)
Jaspreet Sidhu, UCCE Kern (661-868-6222, jaksidhu@ucanr.edu)
Alex Putman, UC Riverside (951-522-9556, aiputman@ucr.edu)
Rob Wilson, UCCE Tulelake (530-667-2719, rgwilson@ucanr.edu)

Nature's NINJA

Nature's Ninja graphic courtesy of the National Onion Association

Project Director:
Lindsey du Toit, Washington State Univ.
Regional lead for California:
Brenna Aegerter, Univ. of Calif. Coop. Ext.

USDA United States Department of Agriculture National Institute of Food and Agriculture

'Stop the Rot' Onion Bacterial Project 2019-51181-30013

We Are Looking for Samples

Downy mildew
Onion
Lettuce
Spinach
…and others

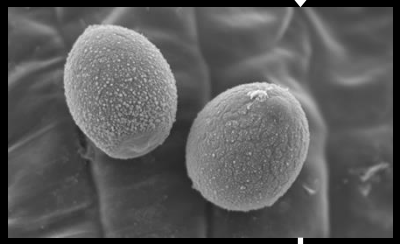
Also: Fusarium wilt of lettuce

951-827-4212
aiputman@ucr.edu

LETTUCE Disease Cycle

In-season: Potential for multiple cycles

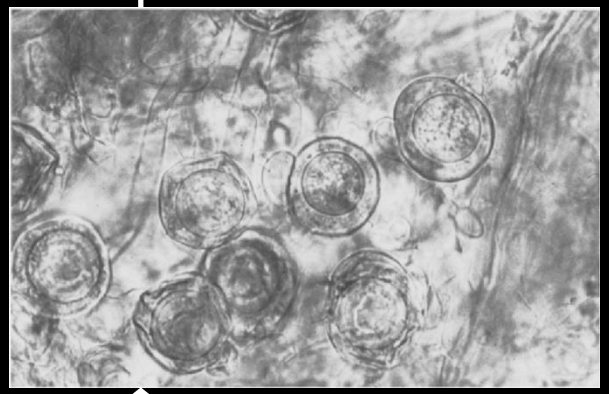
Spores



Infection

Symptoms

Sporulation



Blok 1981. 10.1007/BF01980412

Survival
*Between seasons, as oospore in soil (suspected)

Latent Period

7 to 9 days

Potential sources of pathogen for first Infection (*Theoretical)

Outside the Field

Airborne spores by wind

Far

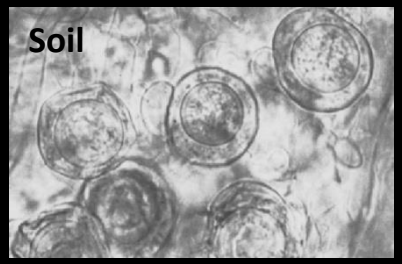
Near

In or Next to the Field

Previously infested residue

Volunteer plants

Soil

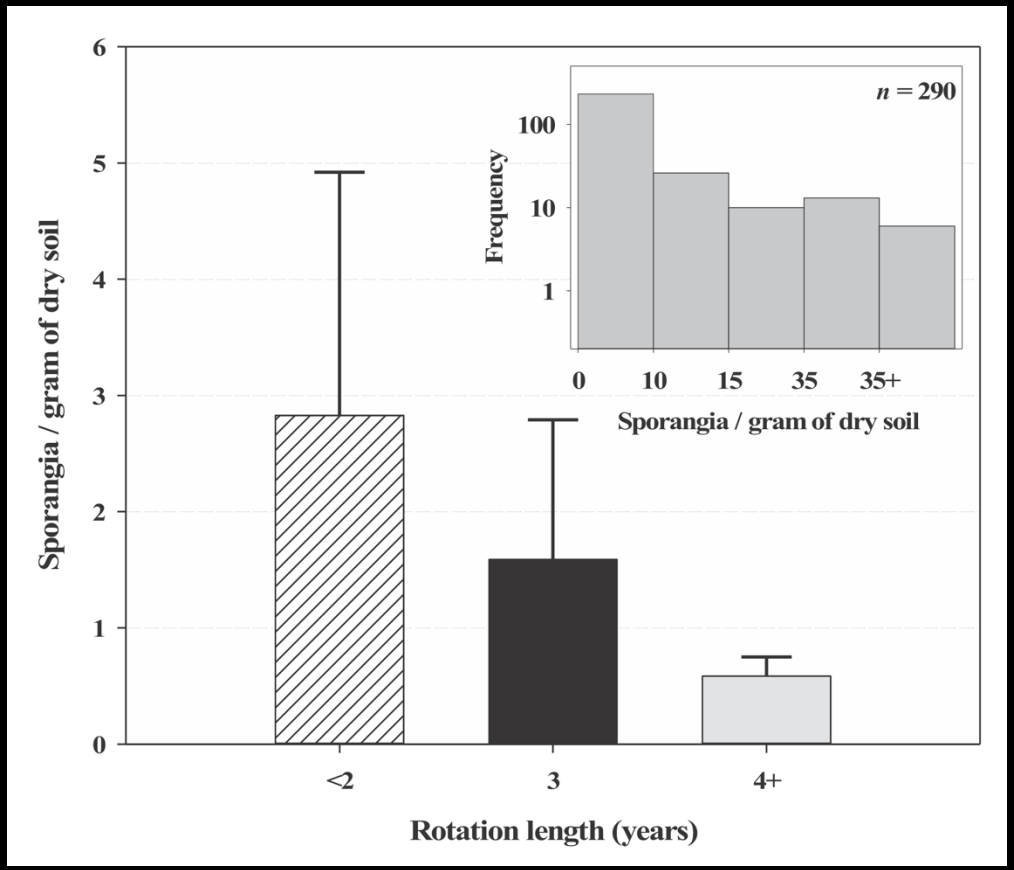


Seed

As oospores

Potential sources of *Peronospora destructor* for first infection

<u>In or Next to the Field</u>
Previously infested residue
Volunteer plants
***Soil in Quebec, Canada in Spring**



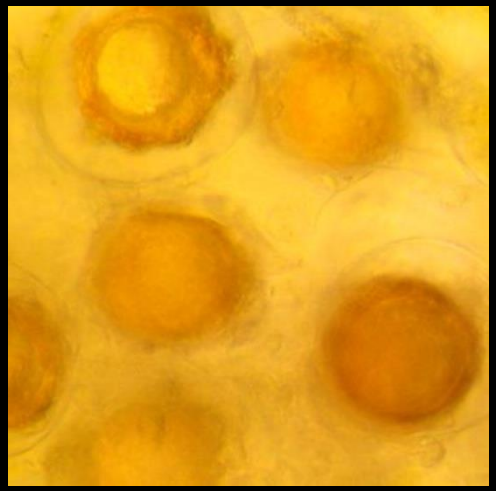
P. destructor frequently found in fields with history of onion in Quebec, Canada

<u>Unknown</u> if can survive summer in the CA desert

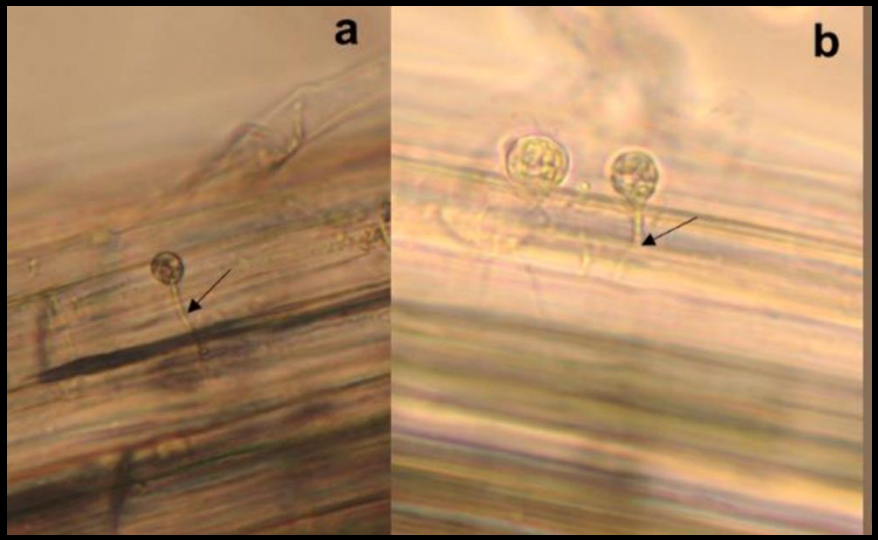
Van der Heyden et al. 2020 10.1094/PDIS-03-20-0687-RE

Seed as a potential source for first infection of *Peronospora effusa*

P. effusa oospores can be abundant in spinach seed (52 of 299 seed lot samples that have been tested since 2014)



Oospores can germinate and infect roots



*Not yet proven that oospores are causing epidemics in the field

Kandel et al. 10.1094/PDIS-10-18-1720-FE; Klosterman et al. (USDA Salinas)