‘Stop the Rot’

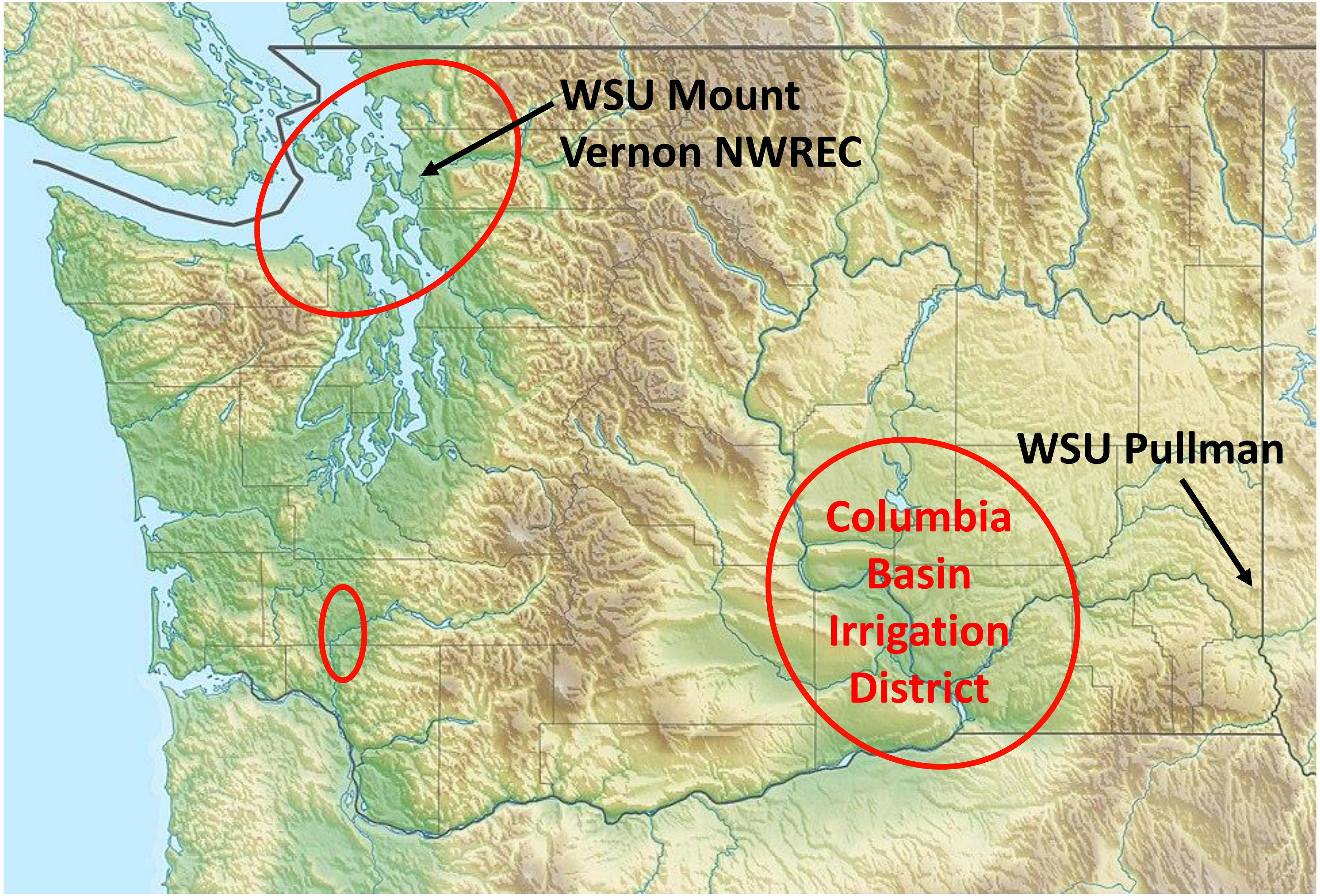
and Other Select Onion Research Projects at WSU

Lindsey du Toit
Washington State University

AUSVEG, HortInnovation, & SARDI Onion Growers’ Meeting
27 November 2023
Murray Bridge, South Australia

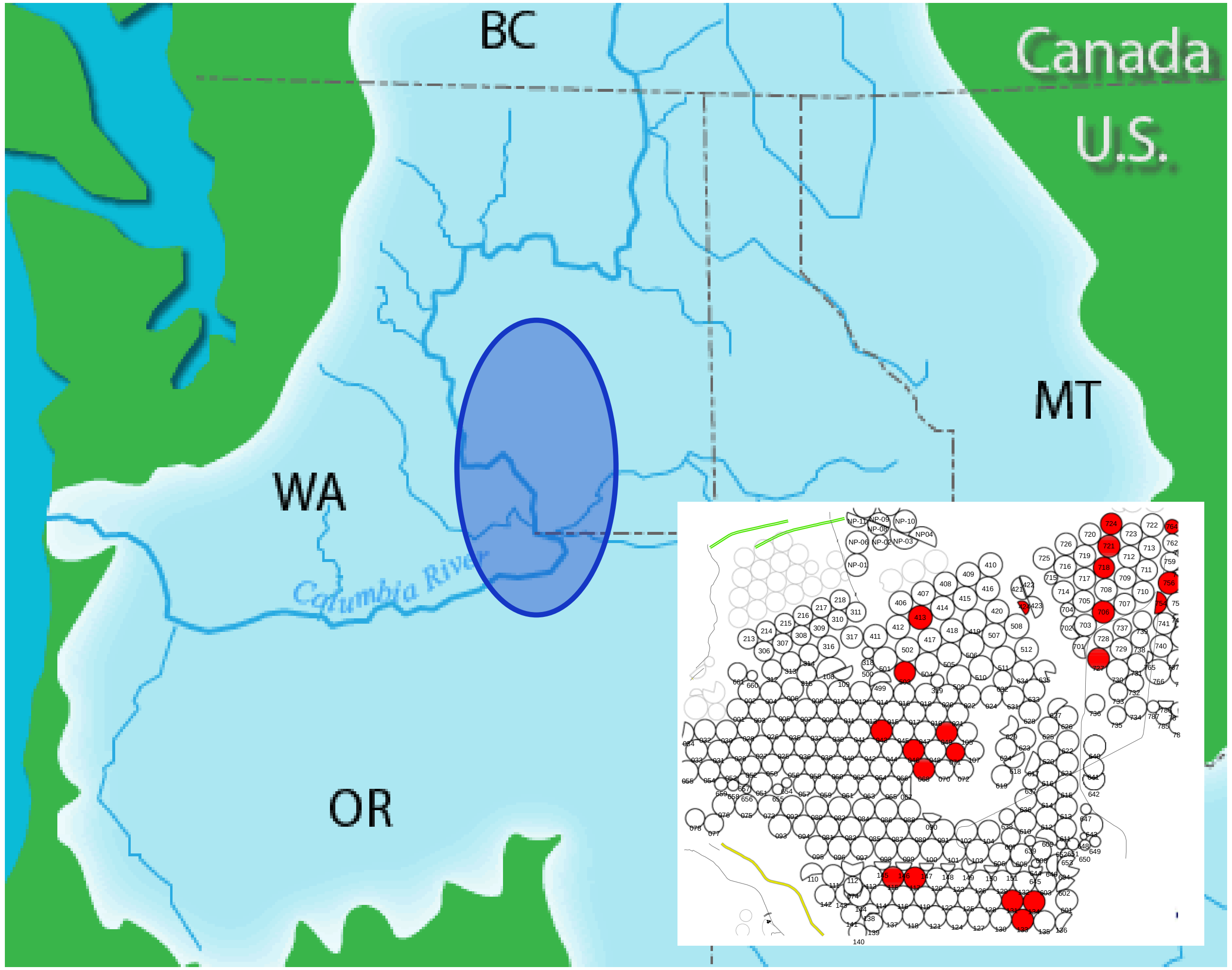

ILLINOIS

Vegetable Seed Production in Washington State

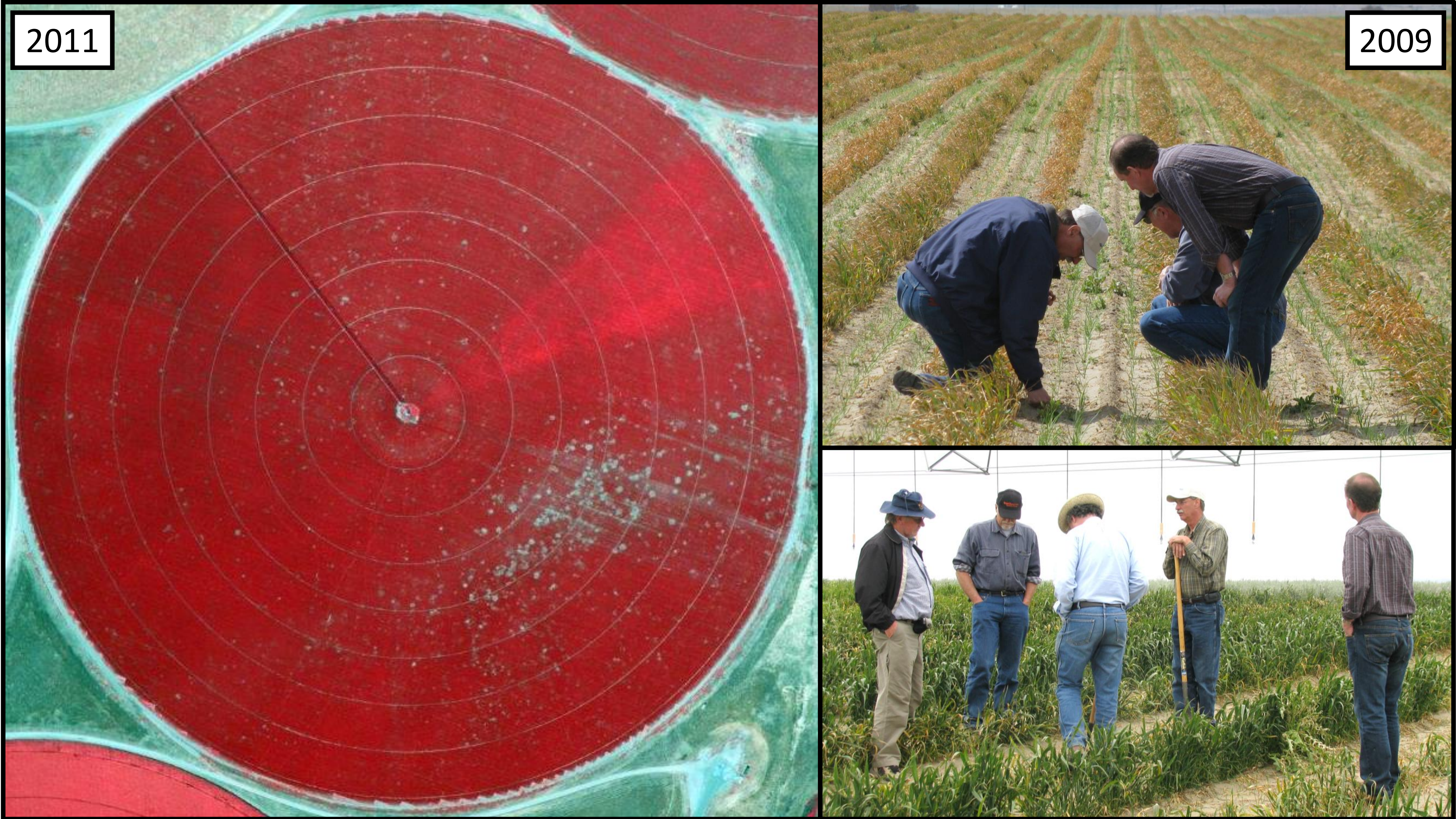


Onion Production in the Columbia Basin of Washington and Oregon

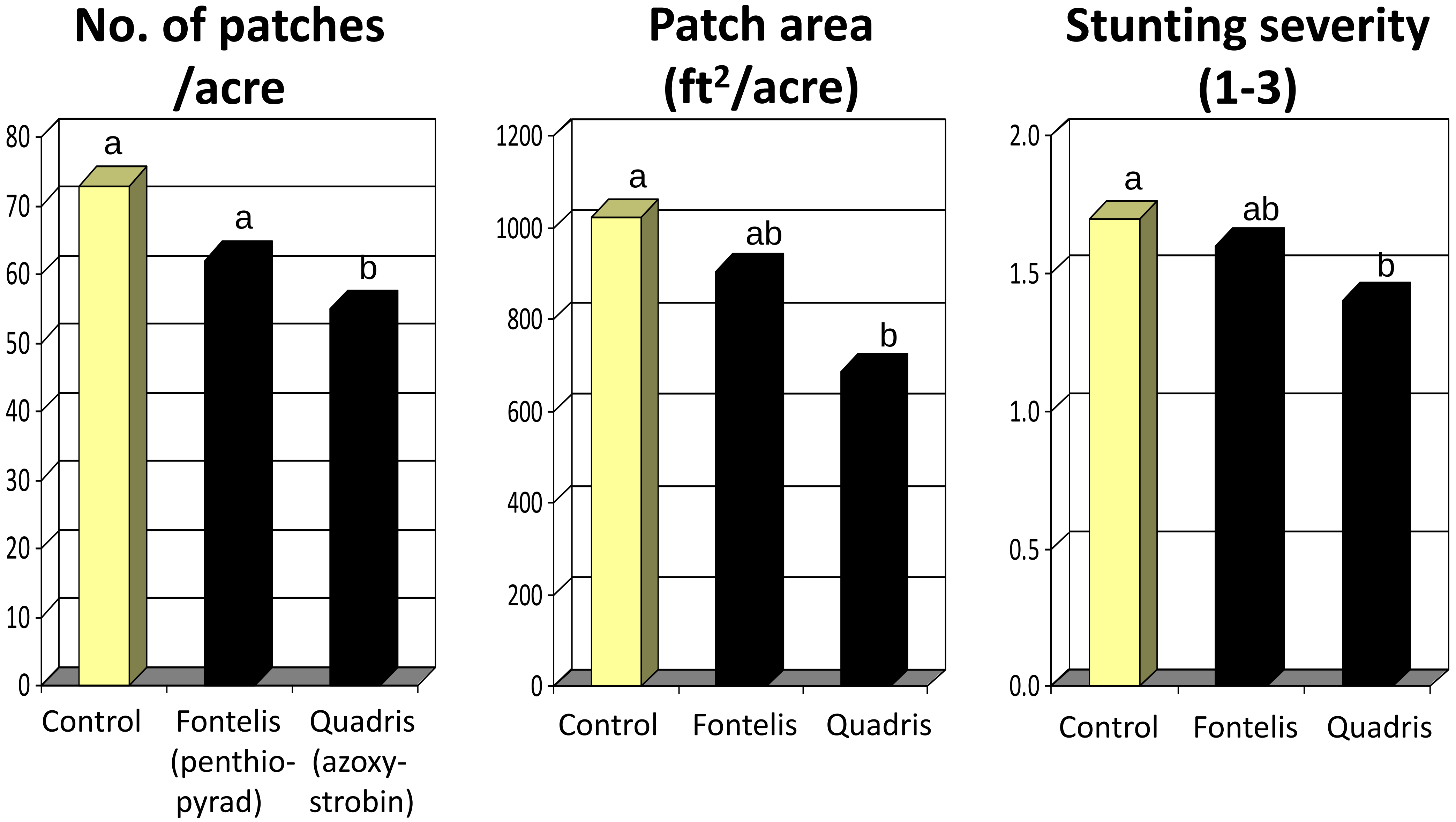
- Central Washington & northcentral Oregon
- ~10,000 ha storage onions
- ~500 ha certified organic
- ~27% of USA onion production
- >95% direct-seeded, spring-planted
- Semi-arid (120-200 mm/year)
- 75% center-pivot, 25% drip-irrigated
- ~90% fumigated or bio-fumigated prior to planting



Rhizoctonia stunting in onion crops grown on coarse, sandy soils following cereal cover crops


2011
2009

2012 Fungicide field trial (Sharma-Poudyal et al. 2013. PDMR 7:V047)



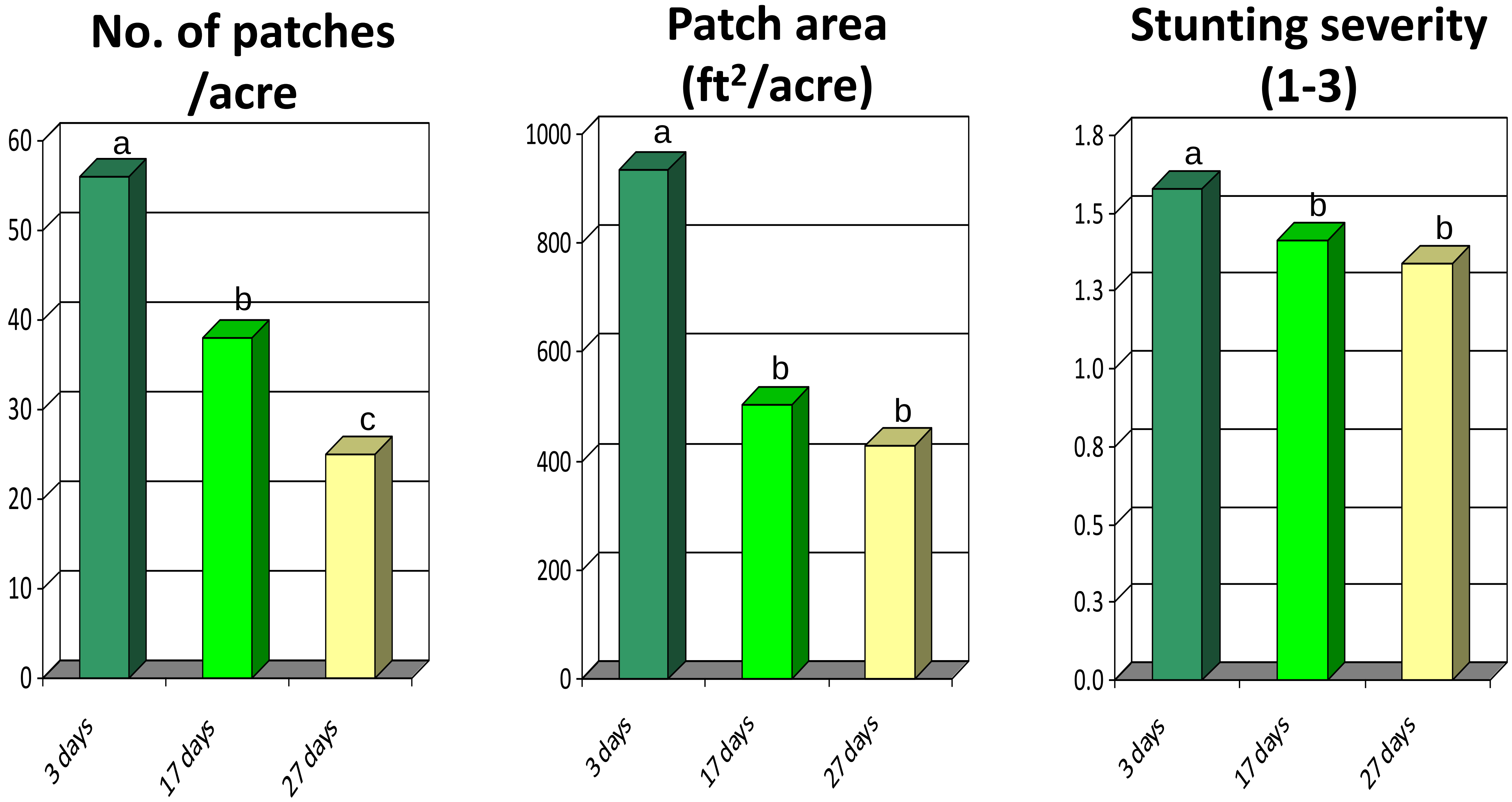
Rated on 5 June 2012

Green bridge field trials

Sharma-Poudyal et al. 2016. Plant Disease 100:1474-1481

Green bridge field trials

Sharma-Poudyal et al. 2016. Plant Disease 100:1474-1481



Rated on 18 June 2012

Rhizoctonia stunting: Summary

- Pre-plant, banded, & incorporated application of Quadris (azoxystrobin) consistently reduced stunting; Fontelis (penthiopyra) had minimal effect (better for pink root control).
- Duration between herbicide application to cover crop & planting onion seed affected stunting. Delay onion planting for >2 weeks after killing cover crop = green bridge management tool for high risk fields.
- Risk assessment: spring testing of soil samples from fields was ineffective at assessing risk; crop history & coarse, sandy soils = best predictor of risk.
- Funding: WSDA Specialty Crop Block Grant, WA State Commission for Pesticide Registration, Pacific Northwest Vegetable Association

Can Onion Growers Benefit from Using Mycorrhizal Inoculants?

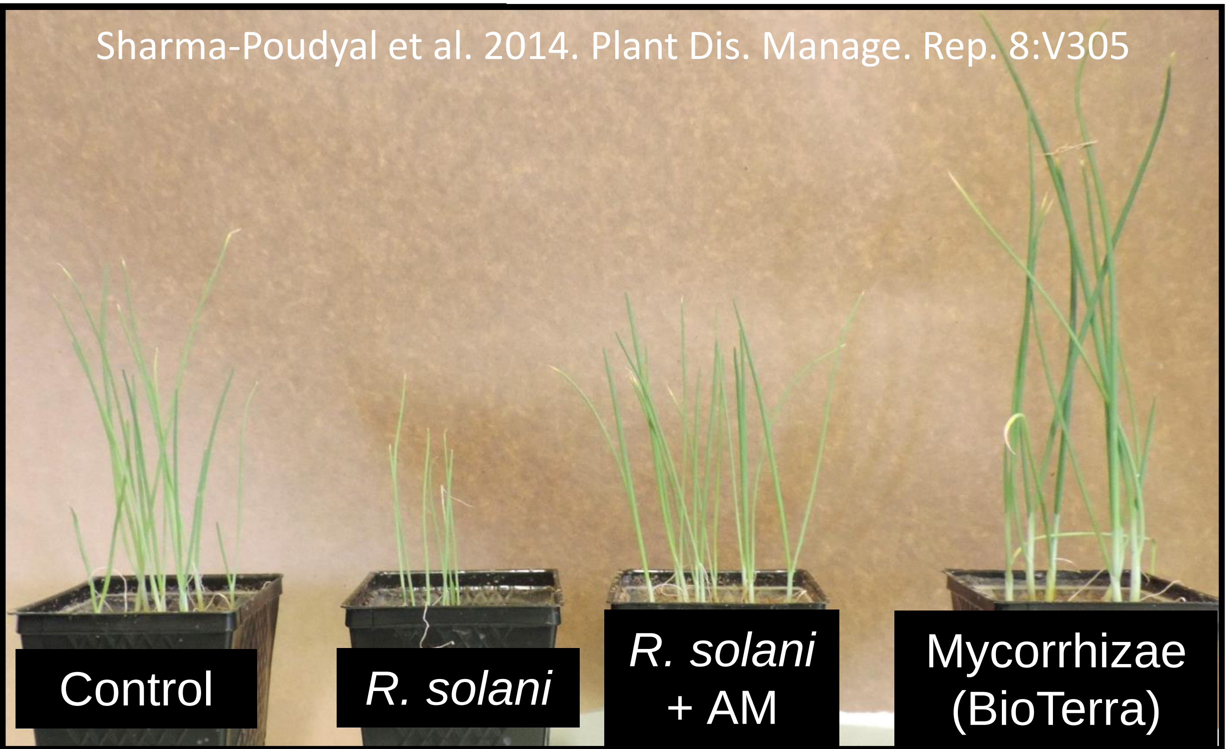
Lindsey du Toit, Tim Waters, Louisa Winkler,
Mike Derie, Jenny Knerr, Brian Henrichs, & Barbara Holmes
Washington State University

WSDA Specialty Crop Block Grant
Pacific Northwest Vegetable Association
Washington State University BIOAg Program

AMF inoculants in Columbia Basin onion production

Winkler et al. Onion World, Feb. 2019

1. Prevalence/diversity of AMF in organic & conventional crops
2. Influence of soil fumigation on AMF in onion crops
3. Effect of AMF inoculants on onion growth & P use efficiency
4. Influence of fungicides & fertilizers on AMF
5. Potential for AMF inoculants to suppress soilborne onion diseases




GANDY
GANDY
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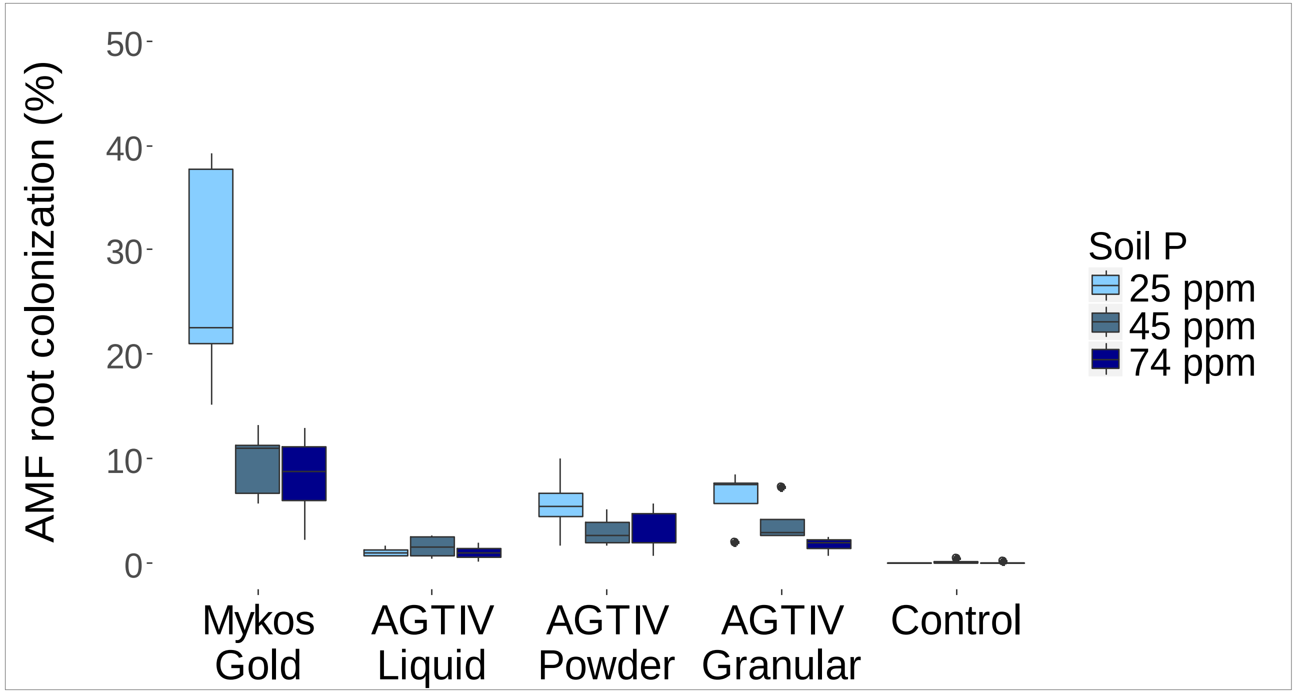
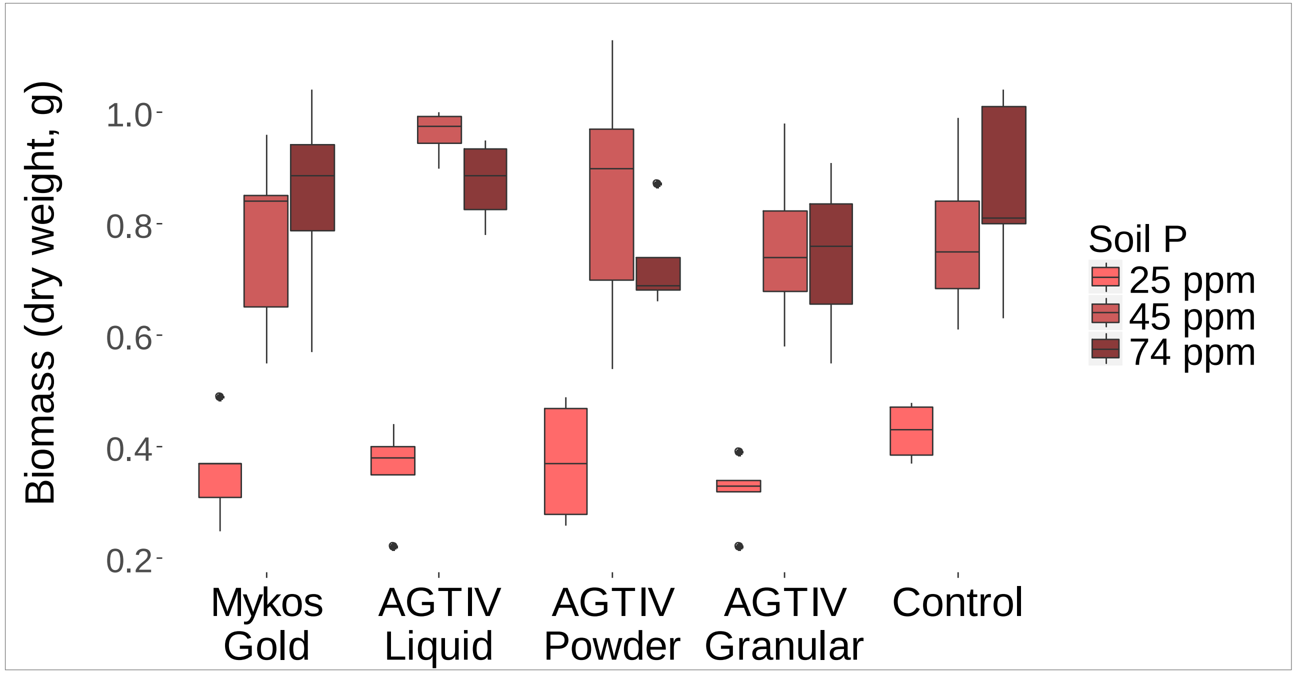




Effects of soil P on AMF and onion growth

(growth chamber trials)

Can onion growers benefit from using mycorrhizal inoculants?

- AMF are prevalent in onion crops in the Columbia Basin
- No benefit of AMF inoculants in direct-seeded onion crops with adequate fertility & minimal stress
- Potential value in poor soils & other stress situations, e.g., transplanting (Jaime et al. 2008)?
- Medium to high soil P in growers’ fields had a negative effect on onion root colonization by AMF

Stop the Rot

Combating onion bacterial diseases with pathogenomic tools & enhanced management strategies

https://alliumnet.com/projects/stop-the-rot/

USDA NIFA SCRI Project No. 2019-51181-30013

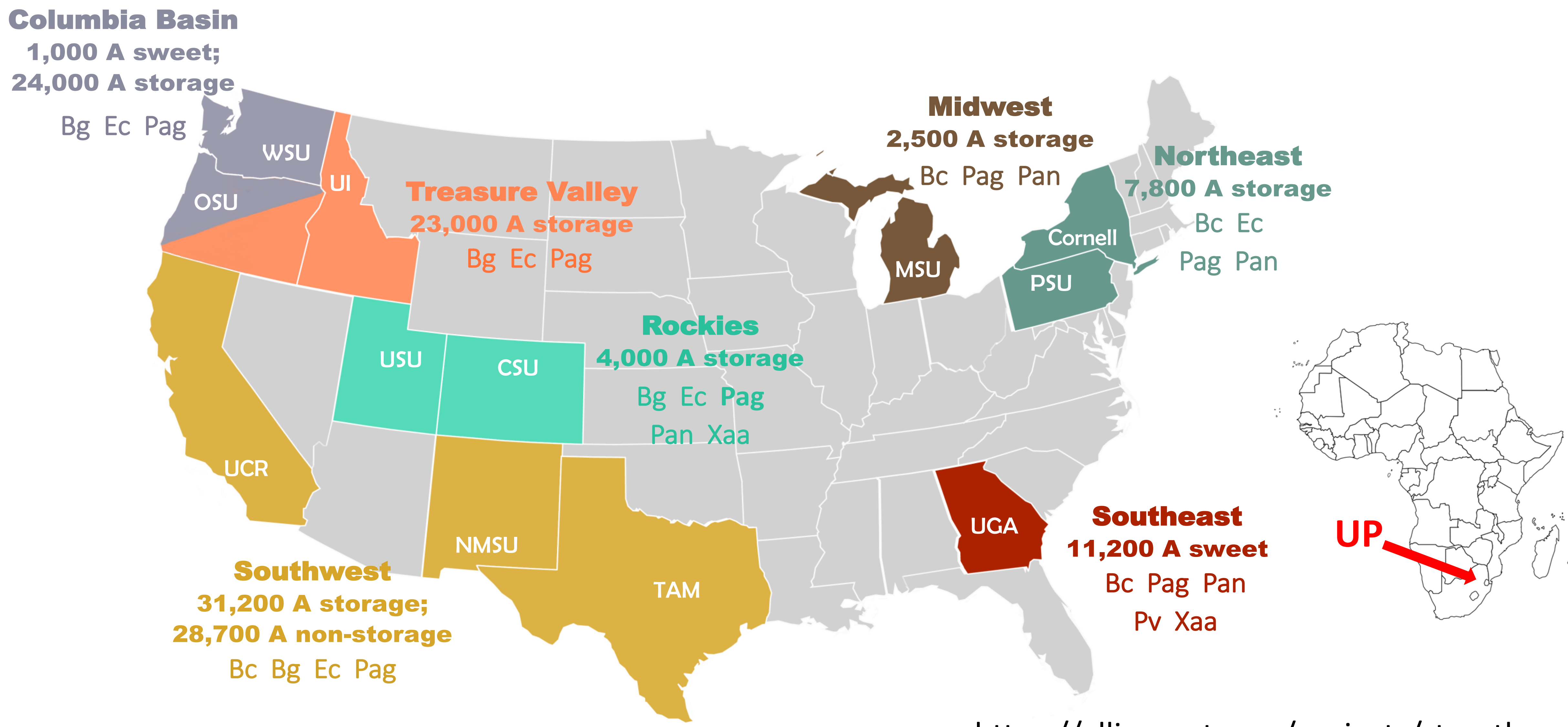
USDA United States Department of Agriculture National Institute of Food and Agriculture

Nature's Ninja graphic courtesy of U.S. National Onion Association

Onion bacterial diseases

- Ubiquitous
- Difficult to manage:
  - Lack effective, rapid detection methods
  - Poor understanding of the genetic basis of pathogenicity, and epidemiology of complex of bacteria associated with onions
  - Few/no resistant onion cultivars
  - No systemic, curative, highly effective bactericides

Stop the Rot: Combating onion bacterial diseases with pathogenomic tools & enhanced management strategies: 2019-2024



https://alliumnet.com/projects/stop-the-rot/

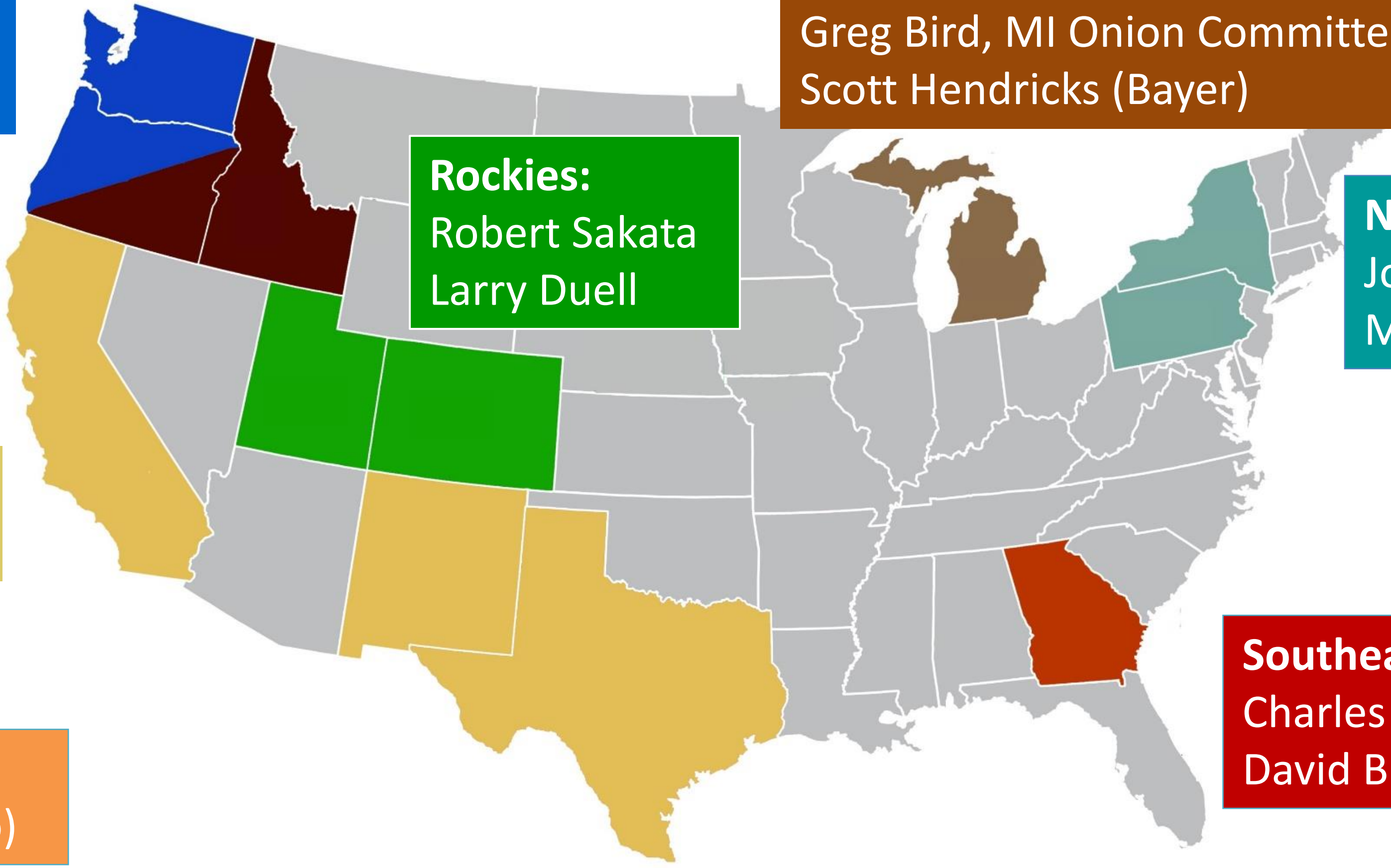
Stop the Rot – Stakeholder Advisory Panel

Pacific Northwest:
Michael Locati
Peter Rogers (BASF)
Juan Carlos Brevis (BASF)

Midwest:
Gumz Farms, WI
Greg Bird, MI Onion Committee
Scott Hendricks (Bayer)

Rockies:
Robert Sakata
Larry Duell

Northeast:
Joe DiSalvo
Maxwell Torrey



Southwest:
Bob Ehn, CGORAB

Southeast:
Charles Hall, GFVGA
David Burrell

International:
Margreet Asma (Bejo)

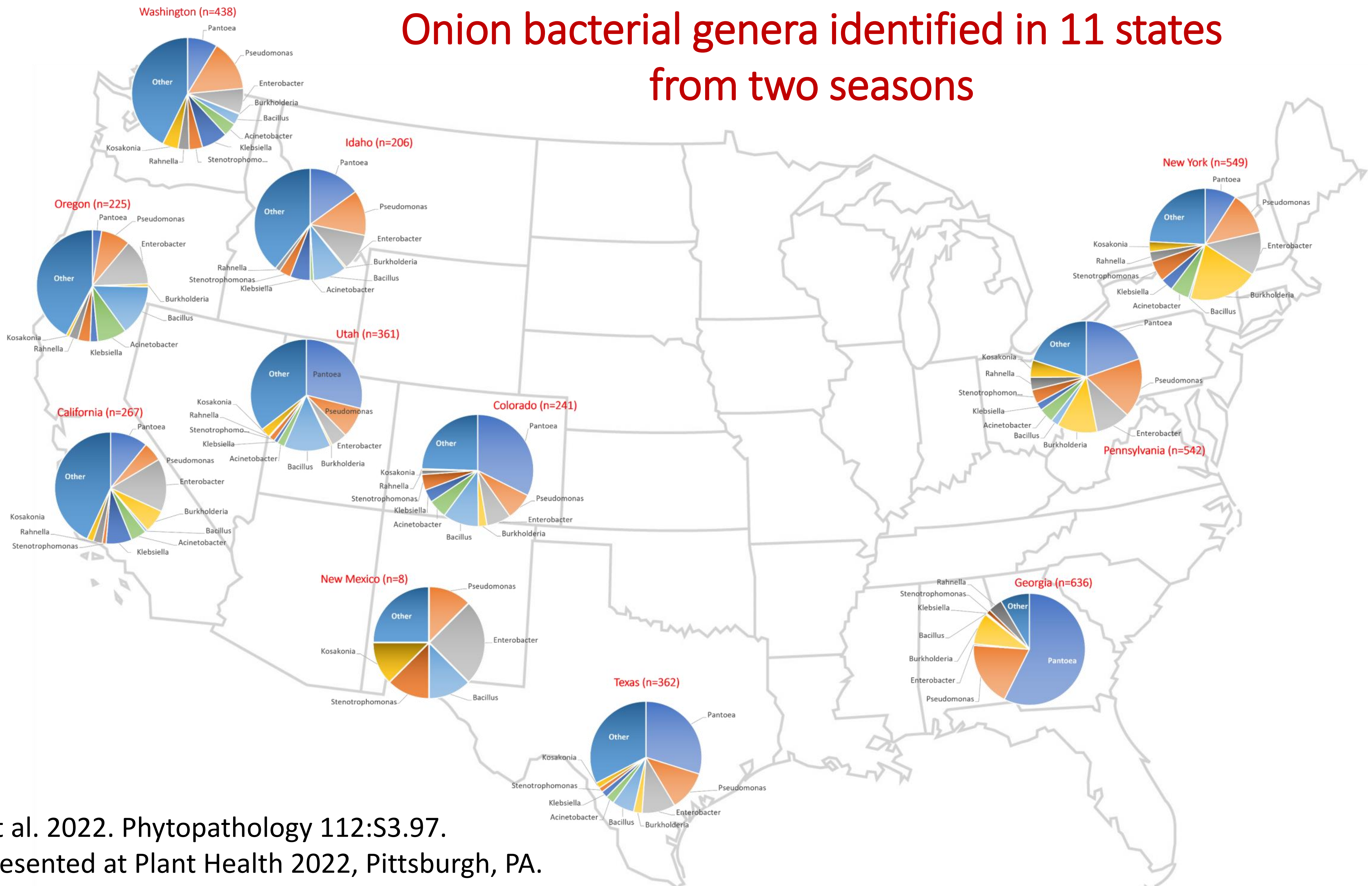
Stop the Rot

https://alliumnet.com/projects/stop-the-rot/

- Objective A: Onion bacterial disease characterization
  - A1 – Survey onion crops nationally for bacterial pathogens
  - A2 – Genetic analyses, virulence factors, bacterial communities
  - A3 – Develop molecular diagnostic tools
  - A4 – Develop methods to screen for resistance to bacterial diseases
- Objective B: Onion bacterial disease management
  - B1 – Irrigation practices
  - B2 – Fertility practices
  - B3 – Pesticide programs
  - B4 – Cultural practices
  - B5 – Postharvest practices (application of disinfectants to bulbs)
  - B6 – Bacterial disease modeling/risk prediction
  - B7 – Extension/outreach
  - B8 – Economic assessments

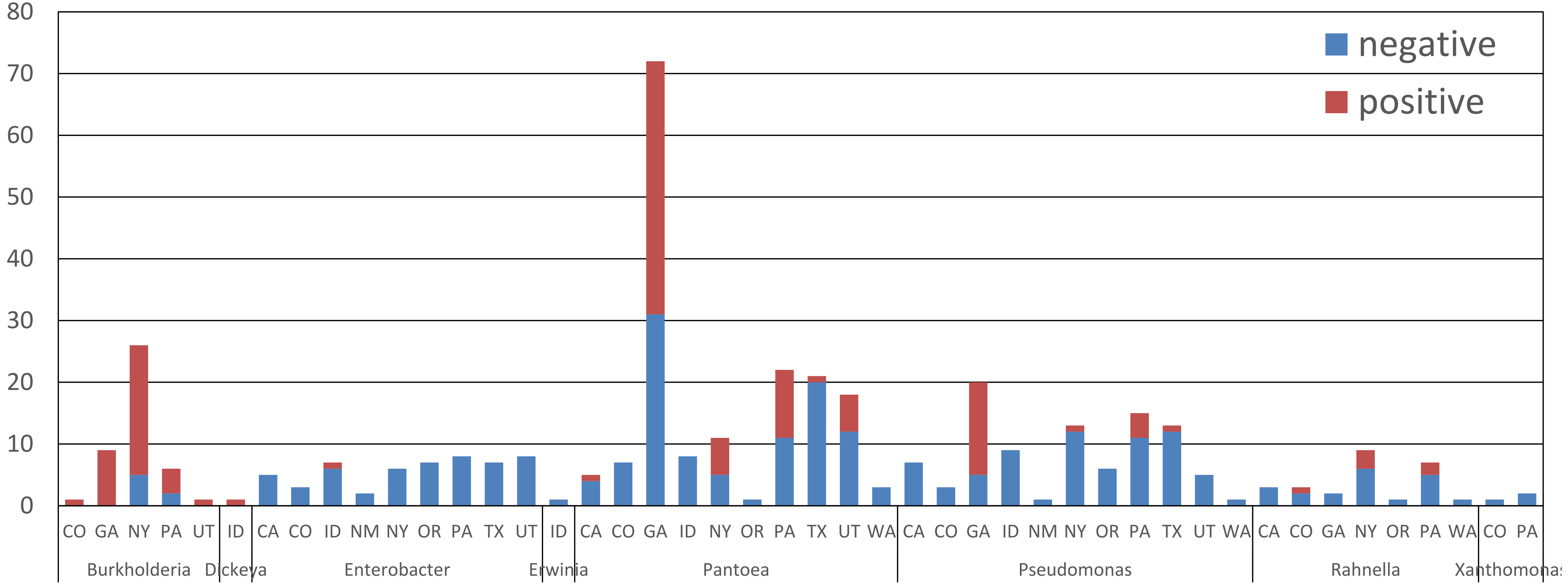
MacKay, H., du Toit, L., and Hoepting, C. 2023. Onion World July/August 2023:6-7.
https://issuu.com/columbiamediagroup/docs/ow_july-august_2023?fr=sYmUxNzQ5MDQ1MjQ

Onion bacterial genera identified in 11 states from two seasons



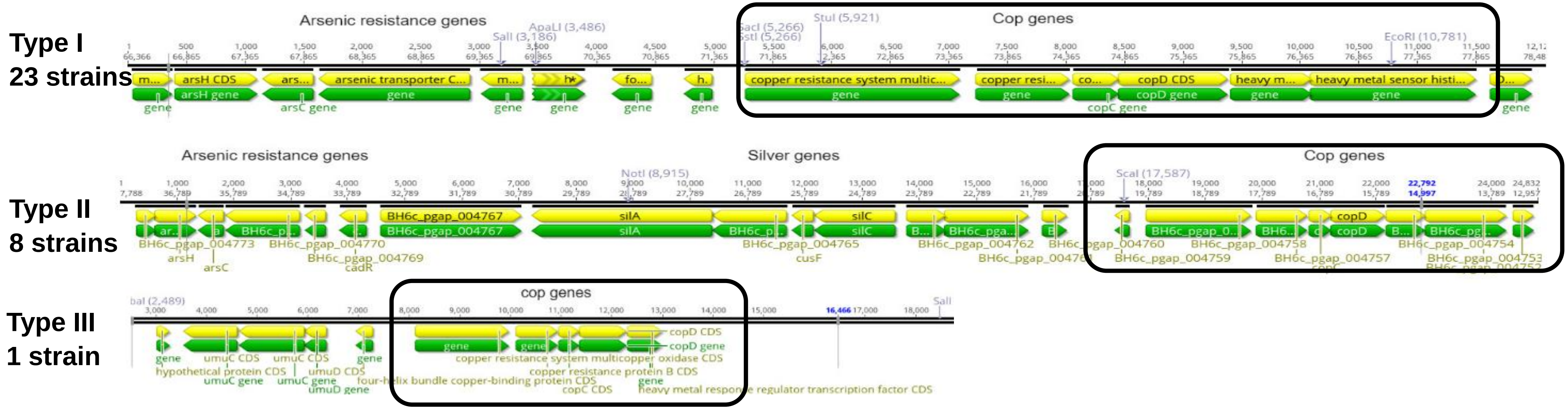
du Toit et al. 2022. Phytopathology 112:S3.97.
Poster presented at Plant Health 2022, Pittsburgh, PA.

Pathogenicity to onion of bacterial strains submitted to the National Onion Bacterial Strain Collection (NOBSC) to date (red scale assay)



A2. Copper resistance genes are common in onion isolates of *Pantoea agglomerans*

- ~50% of *P. agglomerans* strains sequenced to date have **copper resistance (*cop*) genes** on accessory plasmids, similar to those in other bacterial plant pathogens
- *cop* genes and *alt* genes (confer tolerance to onion sulfur compounds) are often on the same plasmids
- *cop* genes not been found in *P. ananatis* strains sequenced to date from this project
- *cop*+ strains are resistant to >100 ppm copper sulfate on CYE agar medium



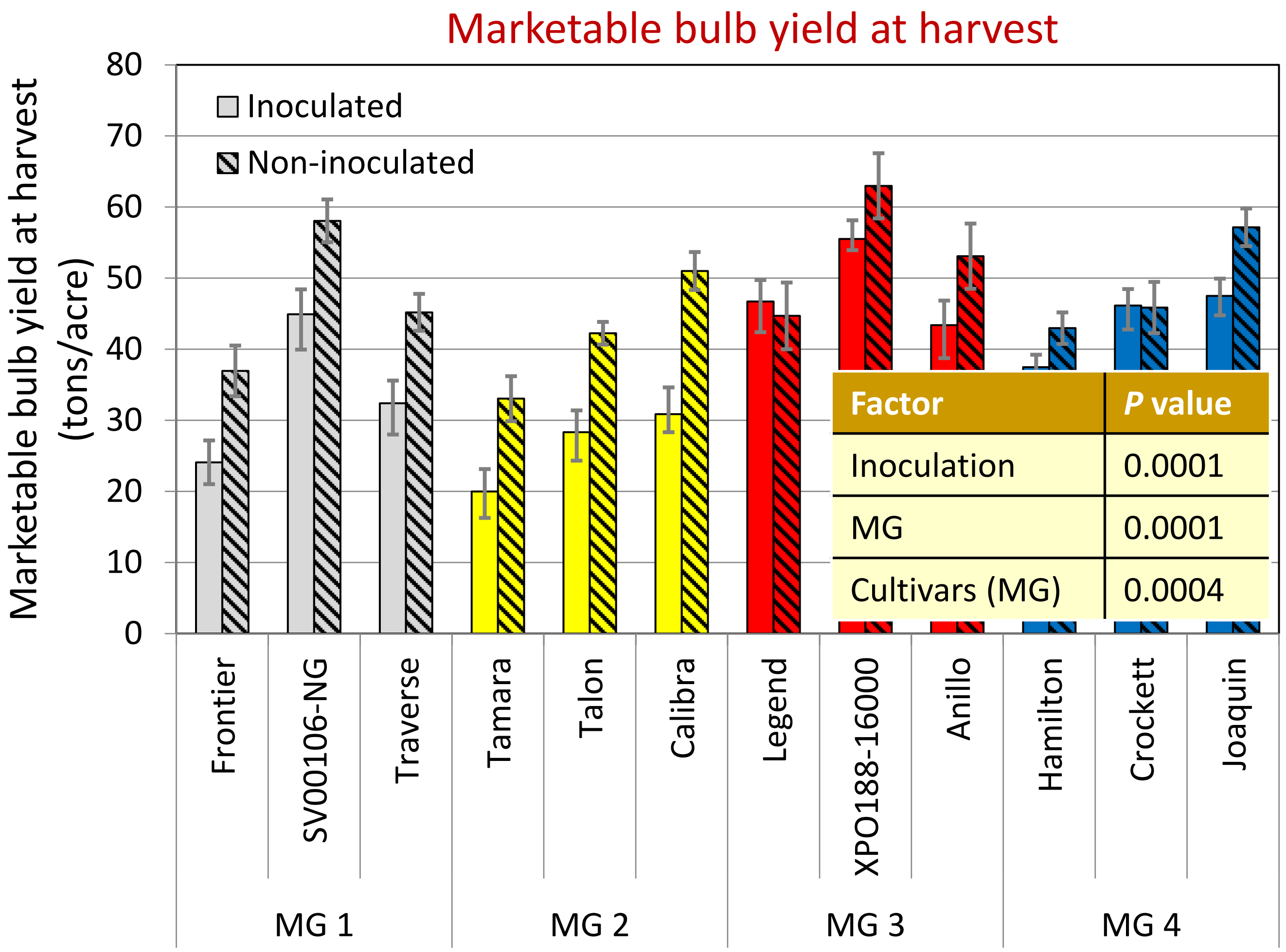
Objective A4: Develop methods to screen onion cultivars for resistance

Lindsey du Toit (WSU), Bhabesh Dutta (UGA), Steve Beer & Christy Hoepting (Cornell), Brenna Aegerter & Jas Sidhu (UC), Claudia Nischwitz (USU)

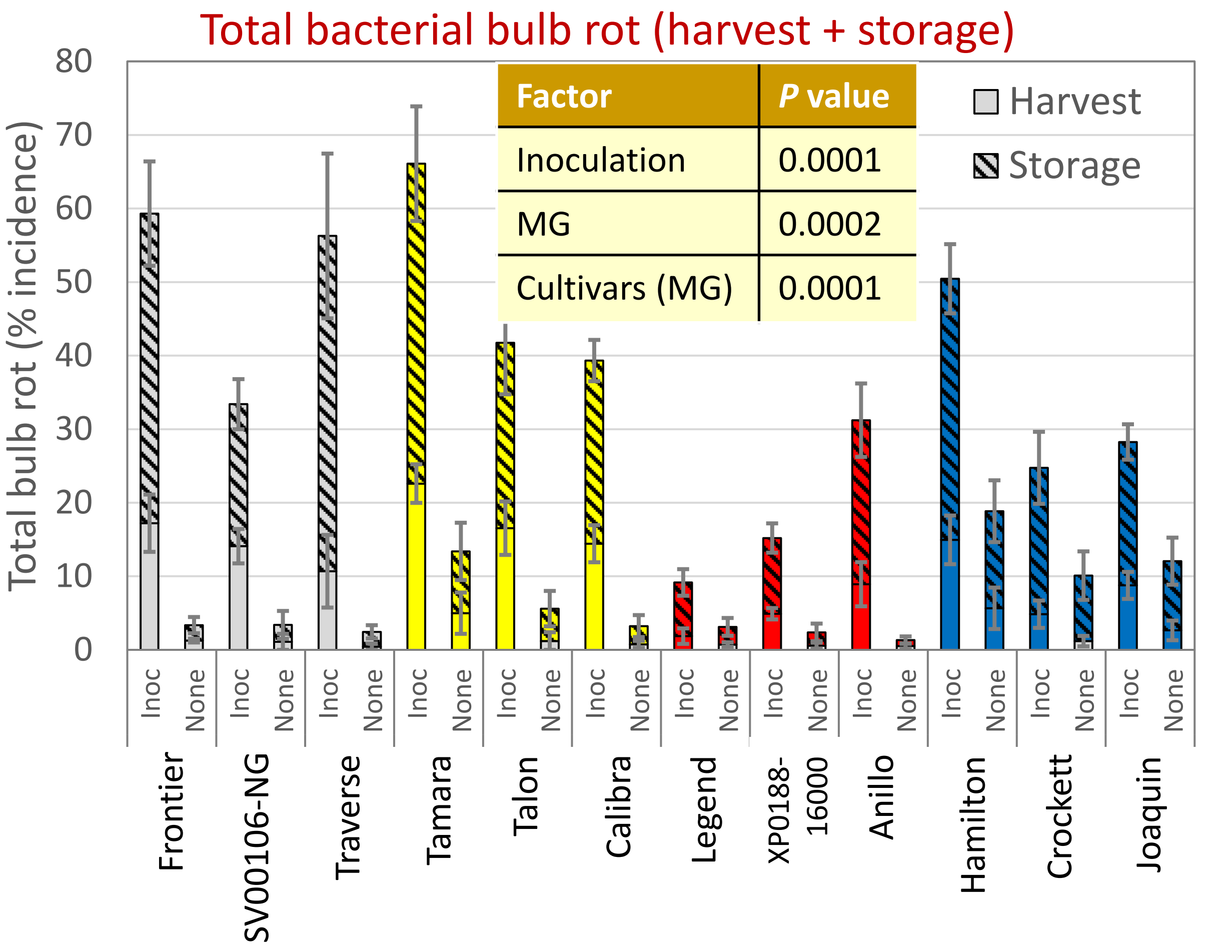
Seasons 1 (2020), 2 (2021), and 3 (2022):

- **Georgia:**
  - Greenhouse test of 2 inoculation methods did not differentiate susceptibility among cultivars
  - Field screening of USDA *Allium* germplasm collection: Differences in susceptibility to *P. ananatis*
- **New York:**
  - Various methods of screening in a growth chamber had inconsistent results (2020)
  - Field trial: 16 cultivars planted on 2 dates (trials), & half plots treated with insecticides (2021, 2022)
- **Washington:**
  - Field trial: 12 cultivars, 3/maturity group, each group inoculated at early tops down & 2 weeks later (2020 pivot irrigation; 2021 & 2022 sprinklers)
  - Comparison of bulb injection vs. scale assay for 54 cultivars (2022)
- **California:**
  - Field trial: 10 cultivars (2022) - bulb rot at harvest vs. bulb injection vs. scale assay
- **Utah:**
  - Field trial: 10 cultivars (2022)

Objective A4, Season 2 (2021-22): Washington Cultivar Trial



Factor	*P* value
Inoculation	0.0001
MG	0.0001
Cultivars (MG)	0.0004



Factor	*P* value
Inoculation	0.0001
MG	0.0002
Cultivars (MG)	0.0001

du Toit et al. 2022. Plant Disease Management Reports 16:V151.

Objective B1. Effects of irrigation practices

G. LaHue, B. Aegerter, T. Belo, S. Caldwell, T. Coolong, M. Derie, B. Dutta, E. Feibert, H. de Jesus, S. Reitz, A. da Silva, T. Waters, R. Wilson, J. Woodhall, and L. du Toit

Oregon:
- Irrigation frequency and final irrigation timing
- Irrigated with drip
- Yellow storage onion
- Spring planted

Washington:
- Irrigation frequency/ final irrigation timing
- Sprinkler irrigation
- Yellow storage onion
- Spring planted

California:
- Drip vs. sprinkler irrigation
- Fresh-market onion
- Spring planted

Georgia:
- Drip vs. sprinkler irrigation
- Vidalia sweet onion
- Fall planted

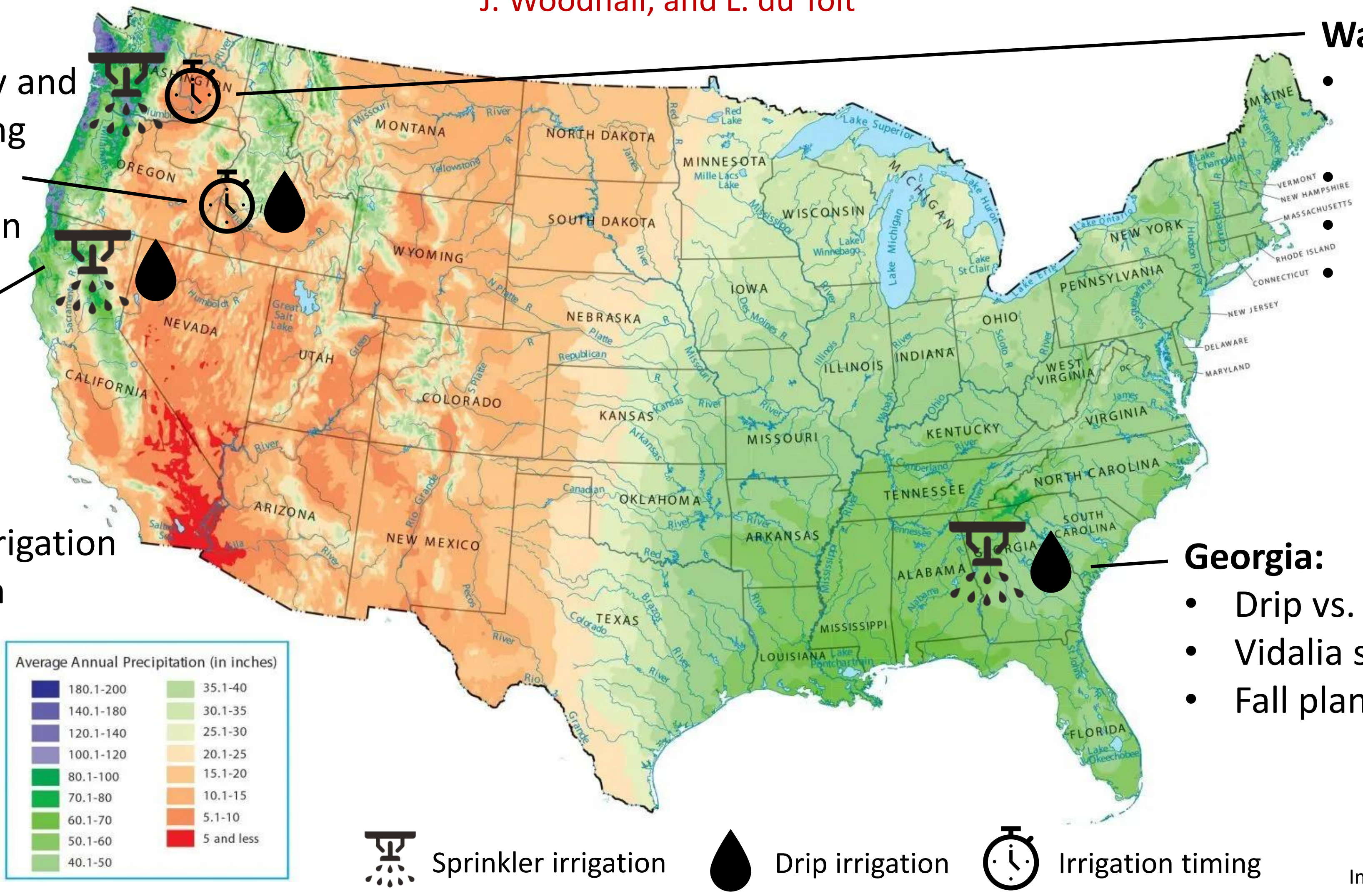


Image credits: GIS Geography, SUBPNG

Objective B1. Irrigation methods

- Drip irrigation reduced bacterial bulb rot in a drier climate (CA), but results were mixed in a humid, rainfed climate (GA)

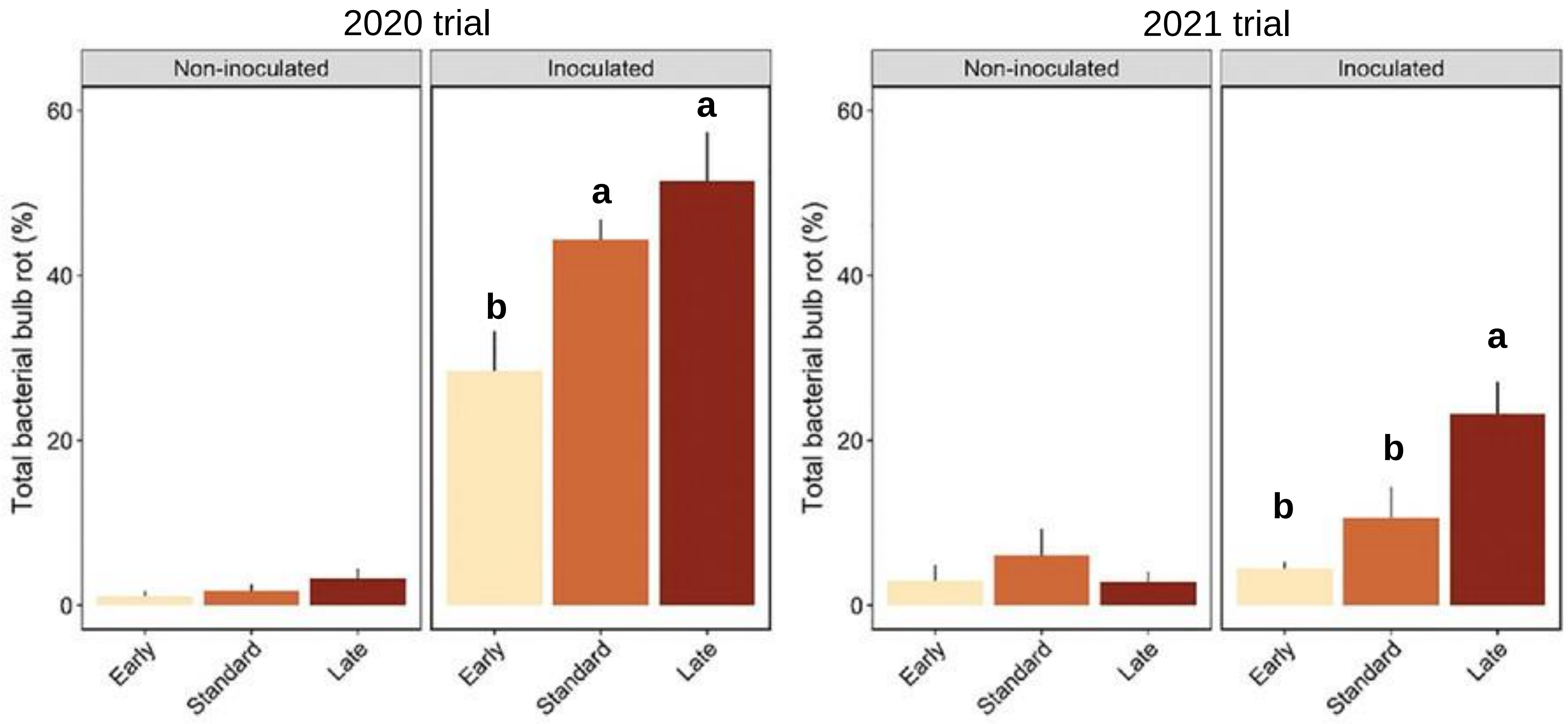
2021 California irrigation trial: Drip vs. solid-set irrigation

Treatment	Foliar bacterial disease incidence AUDPC*	Foliar bacterial disease severity AUDPC	Total bulb yield (t/A)	Average bulb size (oz)	Bacterial bulb rot incidence (% by weight)	Onion stand at harvest (# / bed-ft)
Solid-set irrigation	339 a**	269 a	48.5 b	9.5 b	22.25 a	11.3 a
Drip irrigation	96 b	24 b	59.1 a	11.1 a	0.67 b	11.8 a

Wilson et al. 2022. Plant Disease Management Reports 16:V154.

Objective B1. Late termination of sprinkler irrigation increased bacterial bulb rot. Irrigation frequency did not affect bacterial bulb rot

Belo et al. 2023. Ag Water Management 288:108476



Objective B1. Effects of irrigation practices

Agricultural Water Management 288 (2023) 108476

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journal homepage: www.elsevier.com/locate/agwat

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Check for updates

Reducing the risk of onion bacterial diseases through managing irrigation frequency and final irrigation timing

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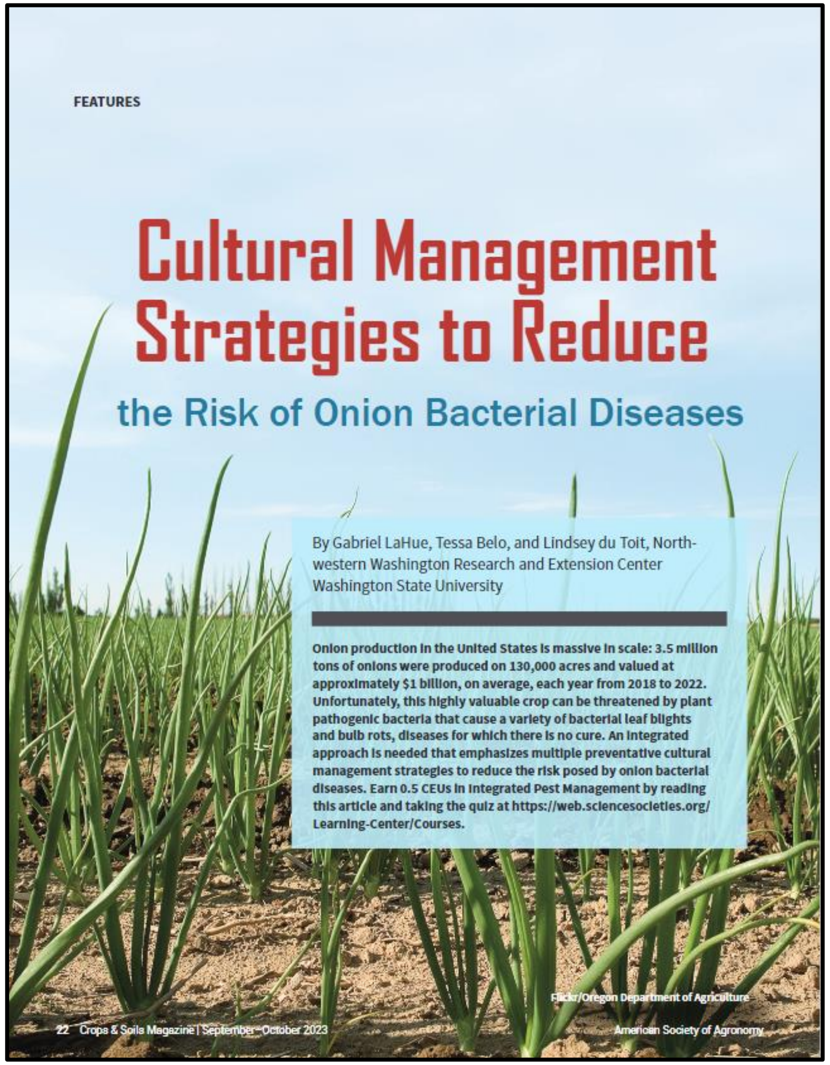
Agronomy Journal

REVIEW

Pest Interactions in Agronomic Systems

Reducing the risk of onion bacterial diseases: A review of cultural management strategies

Tessa Belo[1] | Lindsey J. du Toit[2] | Gabriel T. LaHue[1]



Objective B3: Effects of pesticide programs

- 7 trials in 2020 & 2021, 3 in 2022: CA, CO (3), GA (3), NY, OR, TX, UT (2), WA (3)
- Various onion cultivars: Avalon, Calibra, Century, Granero, Salute, Vaquero
- Many products evaluated alone or in combinations:

  Actigard 50WG, Agrititan, Aliette, Badge SC, BlightBan A506, Champ, Cueva, Cuprofix Ultra 40 Disperss dry flowable, Harbour, Kocide 3000, Leap, Lifegard WG, ManKocide, Mastercop, Nano-MgO, Nordox, NuCop, Oxidate 2.0, Oxidate 5.0, Serenade, Water control, Zerotol 2.0
- Applications: 4 to 6 applications at 7- to 10-day application intervals, maximum label rate
- Inoculation: CO, OR, WA, & UT trials inoculated twice late in the season
- Inoculum: *Burkholderia gladioli* pv. *alliicola, Pantoea agglomerans*, & *Pantoea ananatis*
- **Results:**

  CA, CO, NY, OR, TX, & UT: Insufficient bacterial disease to see if treatments worked

  WA: ManKocide had very limited efficacy in only 1 of 3 seasons, no other treatment reduced bacterial bulb rot, coppers caused phytotoxicity in 1 season

  GA: Most treatments reduced bacterial bulb rot to some degree in all 3 seasons

2020 Bactericide trial for management of onion center rot in Georgia

Dutta, B., and Foster, M. J. 2021. Plant Disease Management Reports 15:V027.

Treatment and rate of product per acre	Application No. [z]	Initial disease severity (%) on 25 Mar	Final disease severity (%) on 28 Apr[y]	AUDPC[x]	Center rot incidence in bulb (%)[w]
Mankocide 2.5 lb	1-6	10.7 b[x]	43.8 c	358.8 c	9.1 c[v]
Kocide 3000 1.5 lb	1-6	28.9 ab	50.0 bc	540.7 bc	29.8 bc
Champ 1.5 lb	1-6	15.1 ab	51.3 b	464.8 bc	18.0 c
Oxidate 5.0 32 fl oz per 100 gal	1-6	40.0 a	71.3 a	791.2 ab	55.2 a
Agrititan 800 ppm	1-6	29.4 ab	58.8 b	602.8 bc	19.5 c
LifeGuard 2 fl oz	1-6	22.7 ab	48.8 bc	469.2 bc	26.8 bc
Nordox 1 lb	1-6	18.0 ab	53.8 b	502.4 bc	17.2 c
Mastercop 1 pt	1-6	23.7 ab	48.9 bc	489.6 bc	12.2 c
Leap 1 qt	1-6	32.4 ab	70.0 a	703.8 ab	52.5 ab
Actigard 0.5 fl oz	1-6	34.9 ab	70.0 a	699.5 ab	57.5 ab
NUCop 1.5 lb	1-6	15.2 ab	55.0 b	485.4 bc	18.8 c
Non-treated check	**-**	**44.9 a**	**87.5 a**	**1012.2 a**	**74.8 a**

Have not seen this efficacy in trials in other states

Objective B4: Effects of cultural practices on onion bacterial diseases

Lindsey du Toit (WSU), Bhabesh Dutta (UGA), Christy Hoepting (Cornell)

Washington: Trials inoculated with *B. gladioli* & *P. agglomerans*

- Effects of **rolling onion tops** or not (2020, 2021, 2022)
- Effects of **timing of undercutting bulbs** or not (2020, 2021, 2022)
- Effects of **timing of topping** onion bulbs (2020, 2021, 2022)

Georgia: Natural infection

- Manual vs. mechanical **harvest** (2020, 2021, 2022)
- Two **different mechanical harvesters** (2020, 2021, 2022)
- **Length of necks** at topping (2021, 2022)

New York: Natural infection

- Rolling tops that died 'standing up' (2020, 2021, 2022)
- Outdoor curing vs. forced air indoor curing (2020, 2021, 2022)

Objective B4. 2020, 2021, & 2022 Georgia trials on onion harvest methods (Vidalia sweet onion cultivars, harvested with green tops)

	Incidence (%) of bulbs with internal bacterial rot		
Method of digging onion bulbs	2020	2021	2022
Chain digger (TopAir)	3.5 b	9.0 b	1.3 b
Straight-blade undercutter (TopAir)	10.2 a	20.5 a	10.7 a
P value	<0.001	<0.001	<0.0001

Dutta and Tyson. 2020. Plant Disease Management Reports 15:V025.

Mechanical vs. manual harvest	2020	2021	2022
Mechanical harvest (TopAir)	2.2 b	4.5 b	3.0 b
Manual harvest	10.5 a	14.5 a	12.5 a
P-value	0.024	0.031	<0.0001

Dutta and Tyson. 2020. Plant Disease Management Reports 15:V026.

Objective B4. 2021 & 2022 GA trials evaluating the length of topping bulbs (Vidalia sweet onion cultivar with green tops)

2021 trial on length of neck after topping	Internal bacterial bulb rot incidence (%)
12.5 cm	4.5 y
7.5 cm	4.0 y
2.5 cm	19.0 z

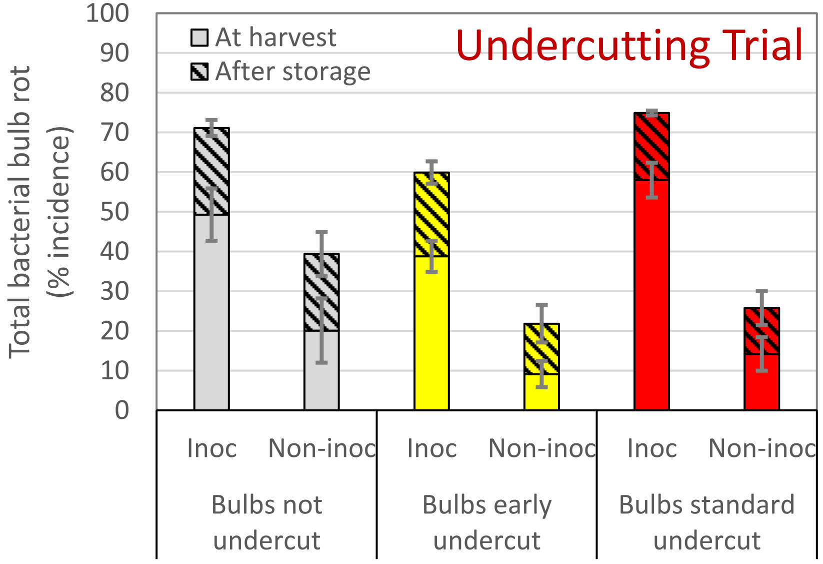
Dutta et al. 2022. Plant Disease Management Reports 16:V107.

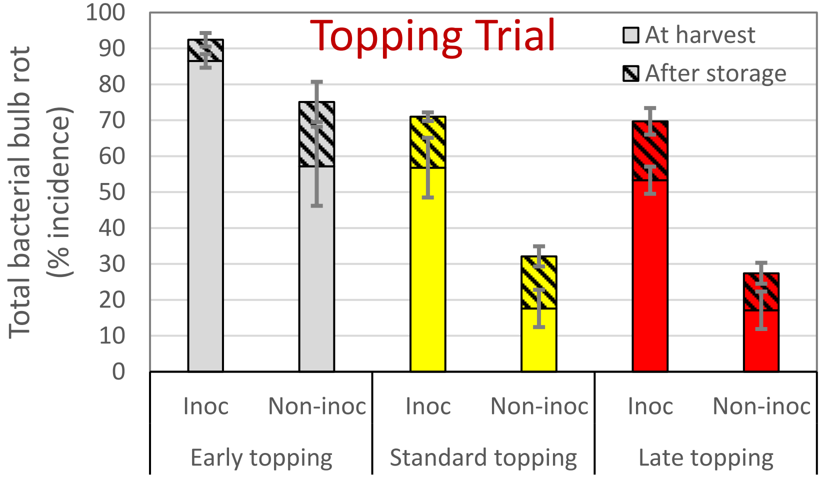
2022 trial	Internal bacterial rot incidence (%)7.5
7.5 cm	10.0 b
5.0 cm	11.5 b
2.5 cm	18.0 a
0 cm	19.5 a

Dutta et al. 2023. Plant Disease Management Reports 17:V008.

Objective B4, Season 3 (2022): Washington Cultural Practice Trials

- Undercutting bulbs:
  - Early undercutting (50% tops down) increased marketable bulb yield and reduced bacterial bulb rot at harvest & in storage compared to undercutting at 100% tops down or not undercutting
- Timing of topping bulbs:
  - Early topping (~50% tops down) reduced marketable bulb yield by 54%, and increased bacterial bulb rot (harvest + storage) to 84% vs. 49-52% of bulbs topped late in inoculated plots
- Rolling tops:
  - Rolling tops at the onset of tops down did not affect bacterial leaf blight, marketable bulb yield, or bulb rot at harvest & in storage

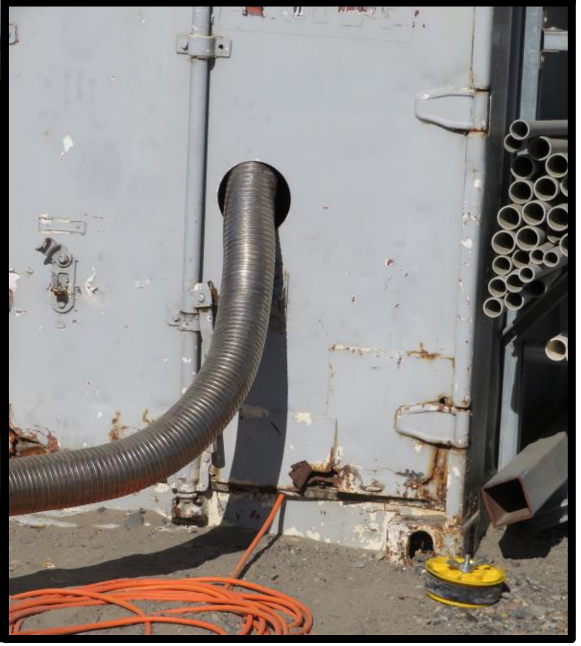




du Toit et al. 2023. Plant Disease Management Reports 17:V125, V128, V129.

Objective B5: Postharvest application of disinfectants to onion bulbs

Tim Waters & Lindsey du Toit (WSU), Mark Uchanski & Jane Davey (CSU)



2020-21 WA trial

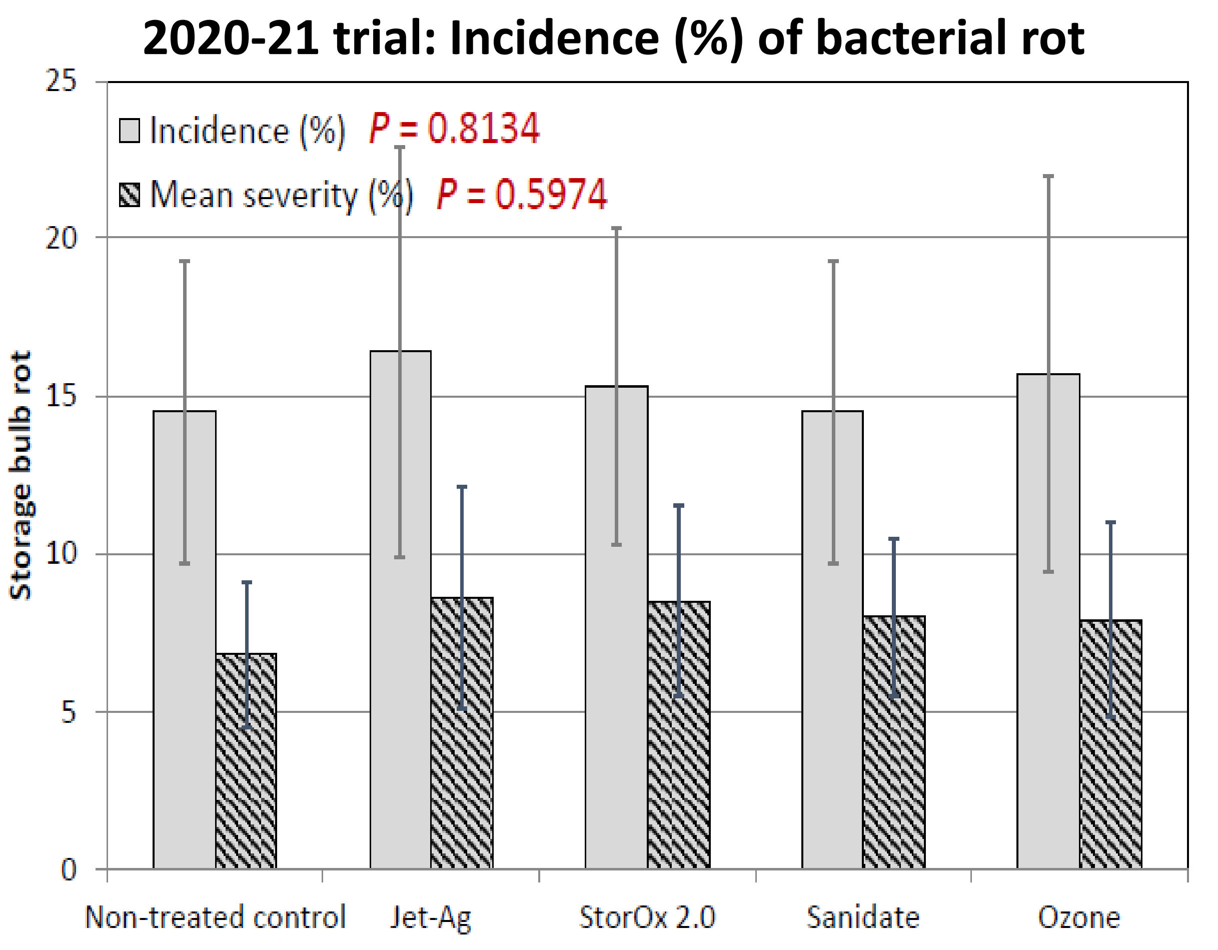
- Bulbs harvested from:
  1. Plots inoculated with bacteria (*B. gladioli* & *P. agglomerans*)
  2. Non-inoculated plots
- Disinfectants applied postharvest by IVI with commercial equipment:
  1. Jet-Ag at 24 fl oz thermofogged for 1 h, container sealed for 8 h
  2. Sanidate 5.0 at 24 fl oz thermofogged for 1 h, container sealed for 8 h
  3. StorOx 2.0 at 24 fl oz thermofogged for 1 h, container sealed for 8 h
  4. Ozone applied at 8,500 mg ozone/hour for 8 h
  5. Non-treated control bulbs thermofogged with water
  6. Non-treated control bulbs not thermofogged
- Bulbs in commercial storage, evaluated for bacterial rot in February 2021

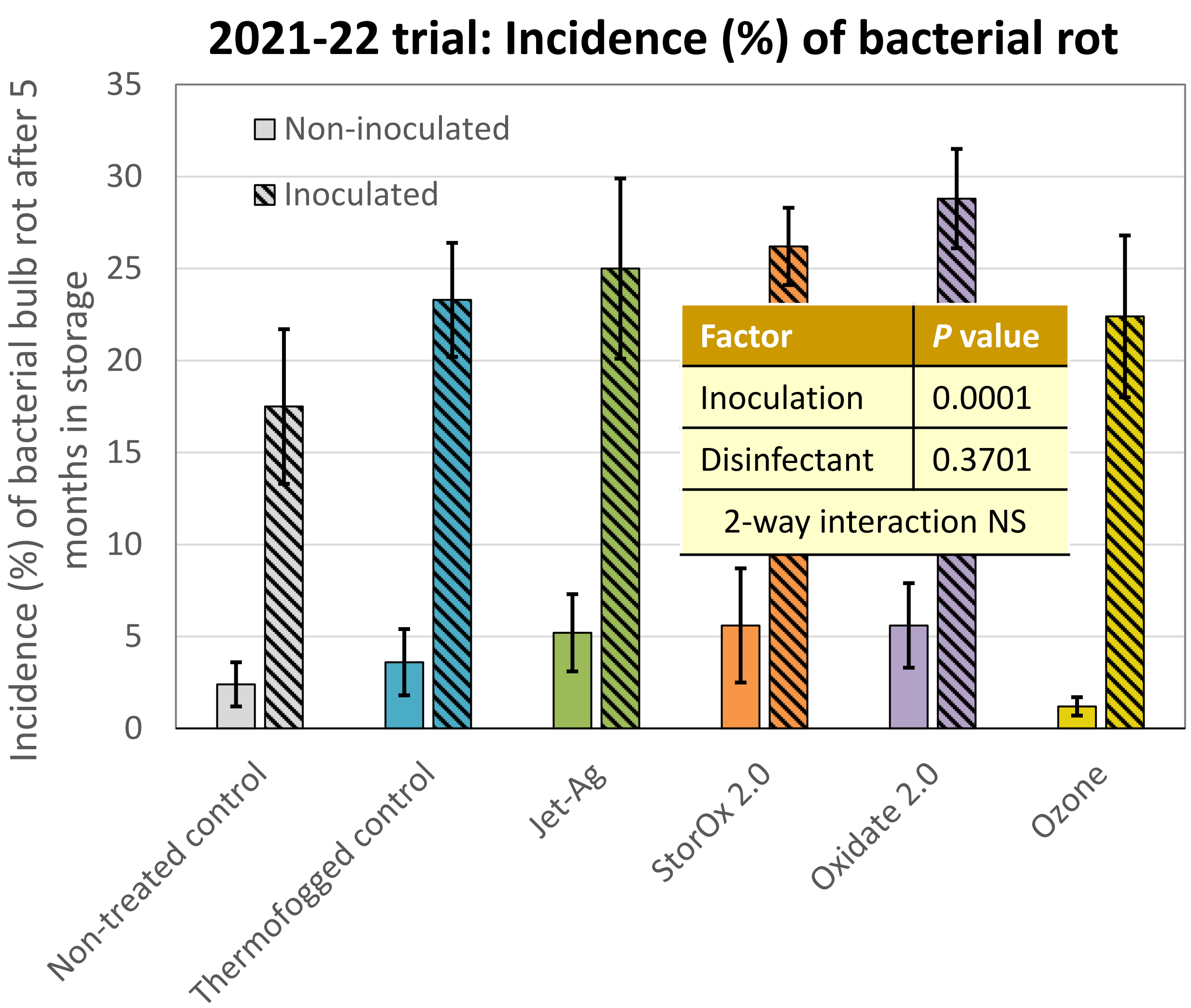
2021-22 and 2022-23 WA trials

- Repeat treatments
- **Commercial storage evaluations:** Growers remove sample of bulbs during treatment, replace non-treated bulbs, evaluate for storage rots

2021-22, 2022-23 CO trials - Mark Uchanski, CSU

WA trials evaluating postharvest applications of disinfectants



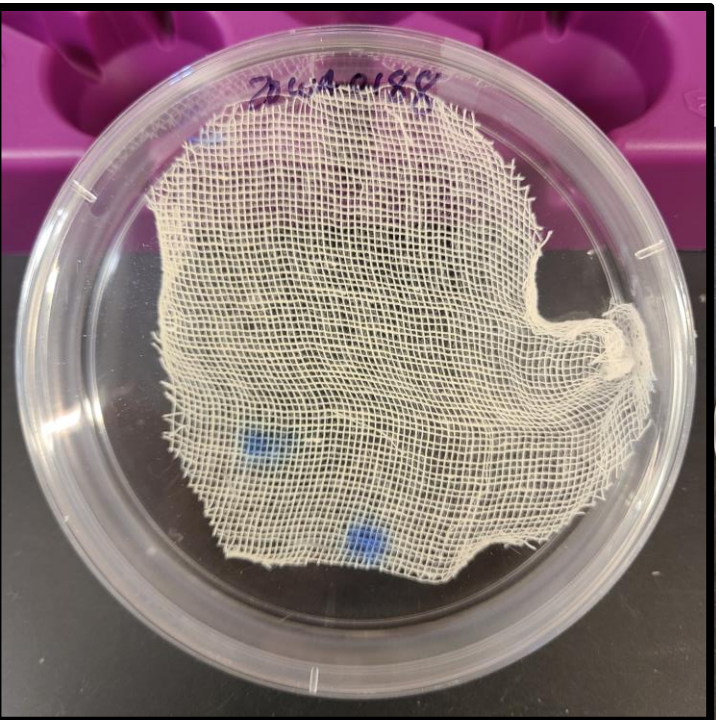


Factor	*P* value
Inoculation	0.0001
Disinfectant	0.3701
2-way interaction NS	

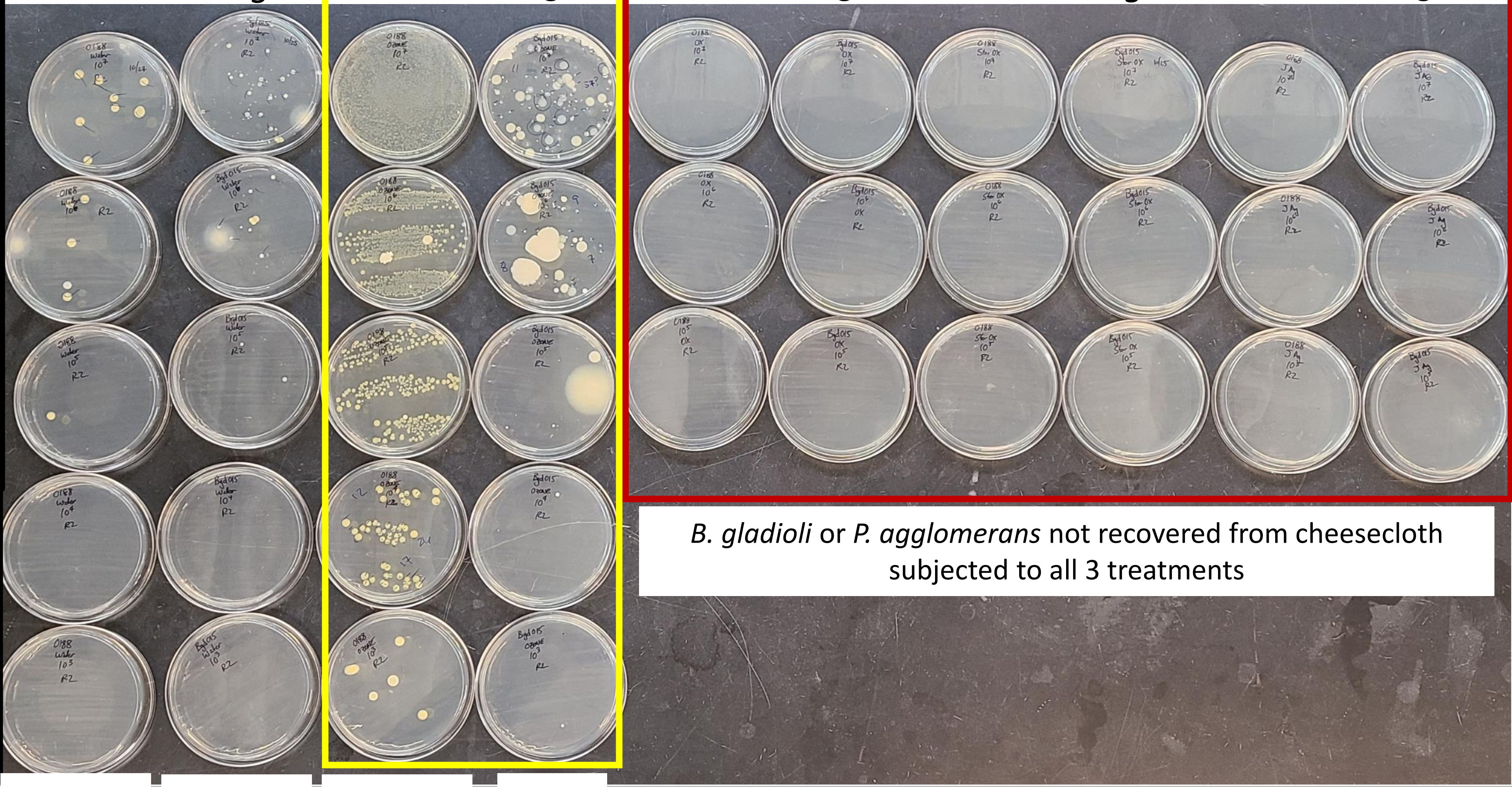
du Toit et al. 2021. Plant Dis. Management Reports 15:V102.
du Toit and Waters. 2021. Onion World, July/August 2021:6-9.

du Toit et al. 2022. Plant Disease Management Reports 16:V148.

2021-22 WA trial evaluating postharvest application of disinfectants



Water thermofog		Ozone		Oxidate 2.0		Storox 2.0		Jet-Ag	
Pa	*Bg*	*Pa*	*Bg*	*Pa*	*Bg*	*Pa*	*Bg*	*Pa*	*Bg*



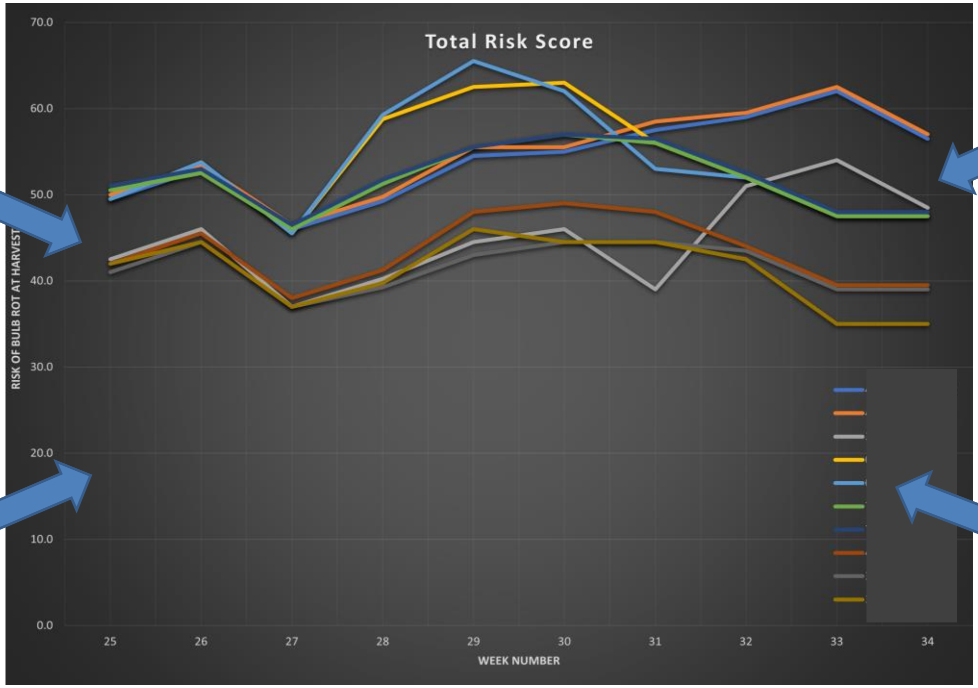
B. gladioli or *P. agglomerans* not recovered from cheesecloth subjected to all 3 treatments

1.7×10^3	3.1×10^5	1.6×10^6	0

Objective B6. Modeling the risk of onion bacterial diseases

1. Current/Cumulative risk
- Previous week's risk score
- Confirmed disease symptoms
- Crop stage

2. Field variables
- Soil type (light/heavy/muck)
- Irrigation type & strategy
- Rotation
- Variety
- Plant density



3. Environmental variables
- Max daily air temperatures
- Windspeed
- Relative humidity
- Precipitation
- Hail damage

4. Production variables
- Fertility (cumulative N)
- Fertility (N timing)
- Bactericide program
- Weed pressure

Week	Crop growth stage	Assessment date	Total risk score	Current/cumul risk	Field variables	Environmental variables	Production variables
1	(1) Seedling -1 leaf	4/10/2021	28.0	3	12	9	4
2	(2) 1-4 leaves	5/1/2021	30.0	4	11.5	10.5	4
3	(3) 4-8 leaves	5/23/2021	30.0	4	11.5	10.5	4
4	(4) Bulbing, 8-14 leaves	6/16/2021	41.8	6	11.5	20.25	4
5	(4) Bulbing, 8-14 leaves	7/6/2021	43.5	7	11.5	21	4
6	(5) 'Soft necks' stage: leaf	7/28/2021	57.5	12	11.5	30	4
7	(6) 5-50% tops down	8/19/2021	48.5	12	11.5	21	4
8	(7) 50-100% tops down	8/28/2021					
9	(8) At harvest, prior to sto	10/1/2021					
10	(9) In storage, post-harve	10/16/2021					

Objectives B7 & B8. Extension/Outreach & Economics

https://alliumnet.com/stop-the-rot/
https://alliumnet.com/stop-the-rot-publications-and-resources/

- Technical reports, presentations
- Plant Disease Management Reports
- Extension Bulletins & Educational Materials
- Videos
- Journal articles, popular press (Onion World, …)
- Frequently Asked Questions, Other resources

Southern IPM Center and Center for Invasive Species and Ecosystem Health, University of Georgia (Joe LaForest)

Economics (Greg Colson, UGA)

- Stakeholder surveys at start and end of project
- Economic analysis of results of management trials
- Integrate risk perception of growers into economic perspective of recommendations

Stemphylium Leaf Blight of Onion (*Stemphylium vesicarium*)

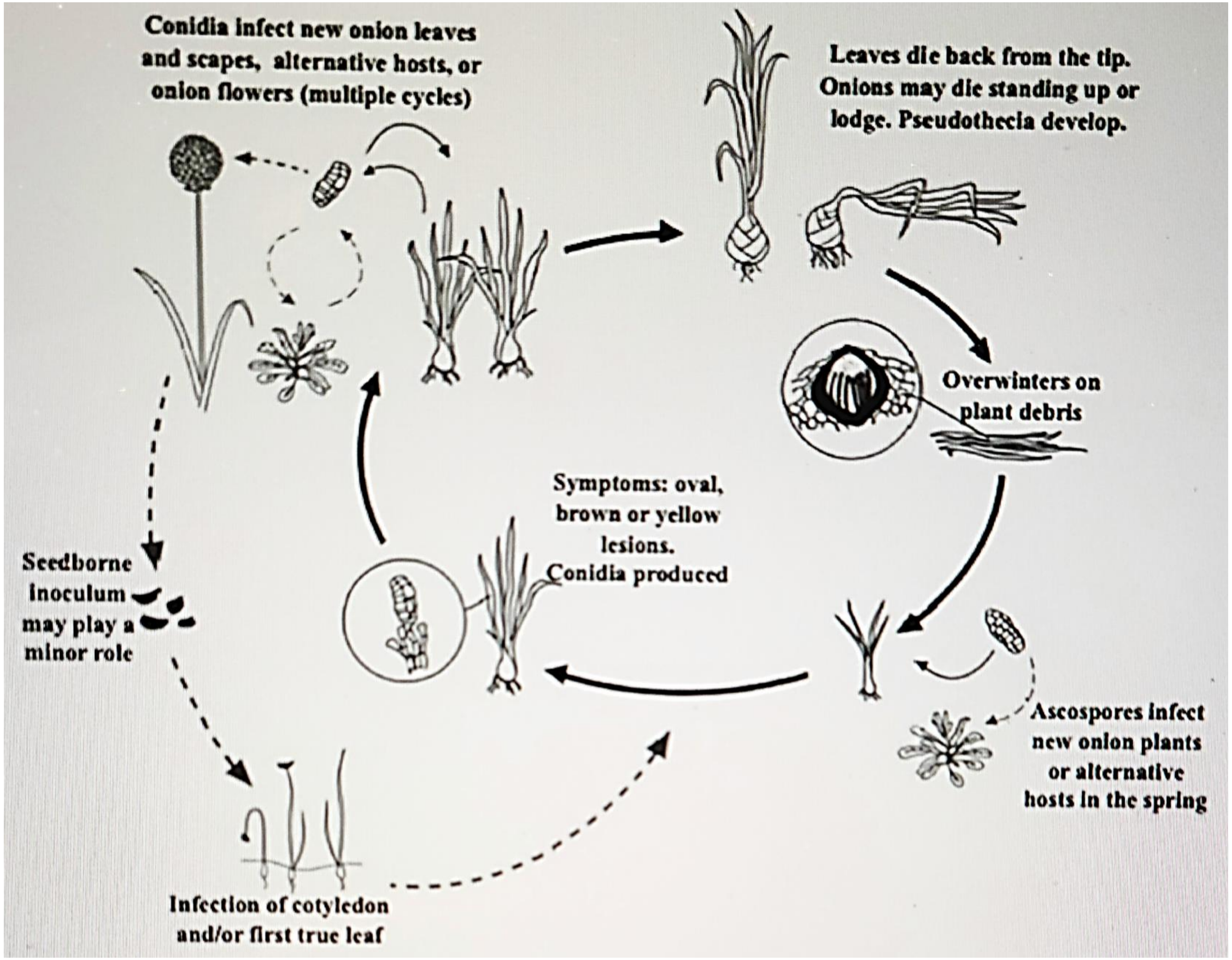
Opportunistic infections by *Stemphylium vesicarium*

Stemphylium vesicarium & downy mildew

Stemphylium vesicarium & thrips damage (also on IYSV lesions)

2006 Onion bulb crop in Columbia Basin, WA:
Leaf tip dieback (heat stress) followed by Stemphylium leaf blight

Life cycle of *Stemphylium vesicarium* on onion (Stricker 2021)



Management of Stemphylium leaf blight

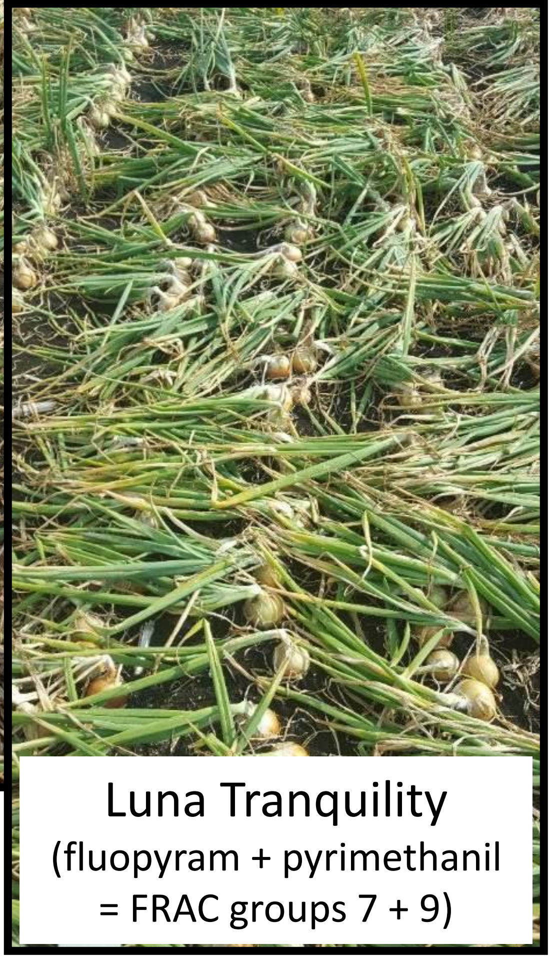
- Crop rotation (>2 years)
- Clean seed/treated seed
- Reduce duration of leaf wetness – irrigation frequency, method; plant density, row orientation into predominant wind direction
- Sanitation
  - NOT soilborne, survives in onion residues & on volunteers
  - Incorporate onion residues into soil
- Minimize injury & stress
- Resistance?
  - Most cultivars are susceptible
  - Sweet Spanish types tend to be more susceptible
- Fungicides

2013 Fungicide field trial in NY: Fungicide treatments for SLB

Christine Hoepting, Cornell Extension, 2013

Non-treated

Treated for DM & thrips



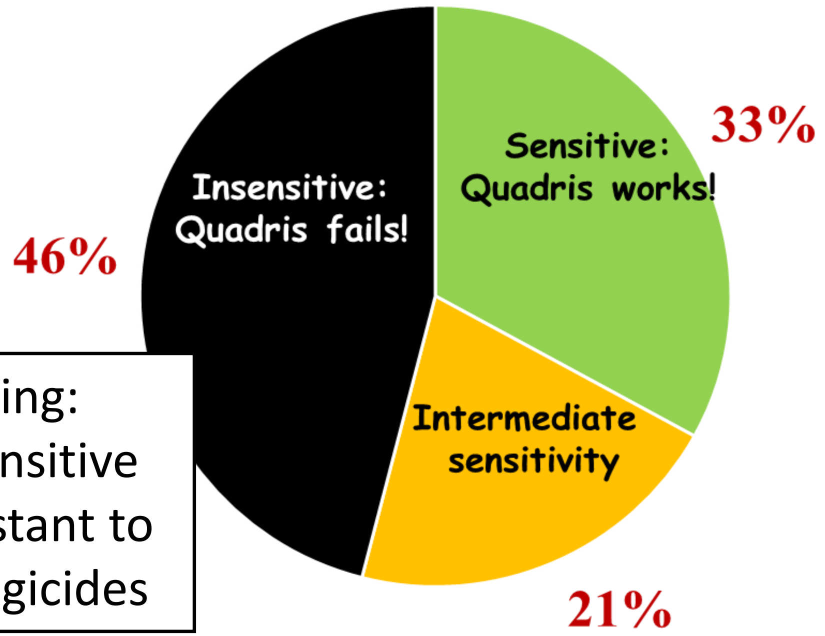
Luna Tranquility
(fluopyram + pyrimethanil
= FRAC groups 7 + 9)

Merivon
(fluxapyroxad + azoxystrobin
= FRAC groups 7 + 11)

Fontelis
(penthiopyrad
= FRAC group 7)

Stemphylium vesicarium resistance to Quadris (azoxystrobin) & 4-5 other FRAC groups in NY!

Fungicide sensitivity of *Stemphylium vesicarium* isolates to azoxystrobin (Quadris): Conventional onion fields (n = 24)



DNA testing:
86% of insensitive isolates resistant to FRAC 11 fungicides

S. Pethybridge and F. Hay 2015
(courtesy of C. Hoepting, Cornell Univ.)

Hay et al. (2021) found NY onion isolates resistant to FRAC groups:

2 (iprodione)
7 (boscalid, fluxapyroxad, fluopyram)
9 (cyprodinil, pyrimethanil)
11 (pyraclostrobin, azoxystrobin)
… and most recently
3 (difenoconazole, propiconazole)

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 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 to obtain all necessary permits in advance

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