

Mike Derie and Lindsey du Toit, Washington State University
National Allium Research Conference, San Antonio, TX
Nov. 30-Dec. 2, 2023



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



United States
Department of
Agriculture

National Institute
of Food and
Agriculture

Onion bacterial diseases

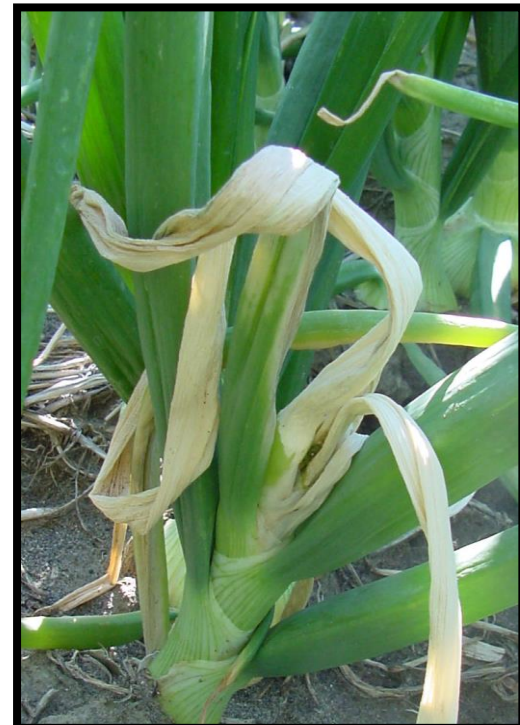
- Ubiquitous
- Difficult to manage:
 - Lack effective, rapid detection methods
 - Poor understanding of the genetic basis of pathogenicity, and epidemiology of complex of bacteria associated with onions
 - Few/no resistant onion cultivars
 - No systemic, curative, highly effective bactericides



Stop the Rot

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

- \$4,044,300 + \$4,200,000 matching (universities, stakeholders)
- 4 year-project: September 2019-August 2023 (+ 1-yr no-cost extension)
- 24 collaborators
 - PD = Lindsey du Toit, WSU
 - Co-PI's = Bhabesh Dutta & Brian Kvitko, University of Georgia; Christy Hoepting, Cornell Extension; Brenna Aergenter, University of California; Mark Uchanski, Colorado State University
 - 12 states + Teresa Coutinho, University of Pretoria, South Africa
- 13-member national Stakeholder Advisory Panel
 - Onion growers, seed company breeders & pathologists, consultants



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

Columbia Basin
 1,000 A sweet;
 24,000 A storage

Bg Ec Pag

WSU
 OSU
 UI

Treasure Valley
 23,000 A storage

Bg Ec Pag

UCR

USU
 CSU

Rockies
 4,000 A storage

Bg Ec Pag
 Pan Xaa

Southwest
 31,200 A storage;
 28,700 A non-storage

Bc Bg Ec Pag

NMSU
 TAM

Midwest
 2,500 A storage

Bc Pag Pan

MSU

Northeast
 7,800 A storage

Bc Ec
 Pag Pan

Cornell
 PSU

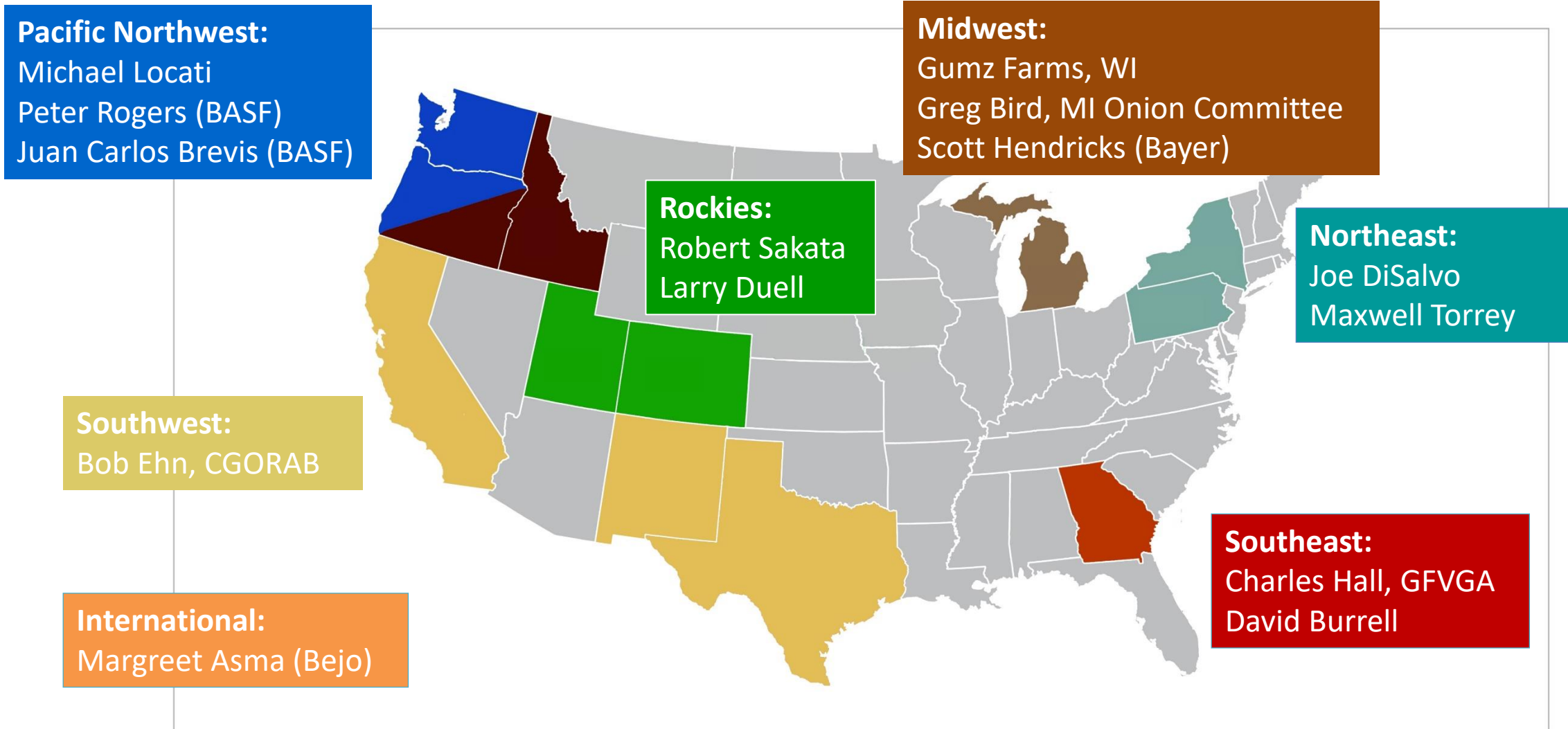
Southeast
 11,200 A sweet

Bc Pag Pan
 Pv Xaa

UGA



Stop the Rot – Stakeholder Advisory Panel



Stop the Rot

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

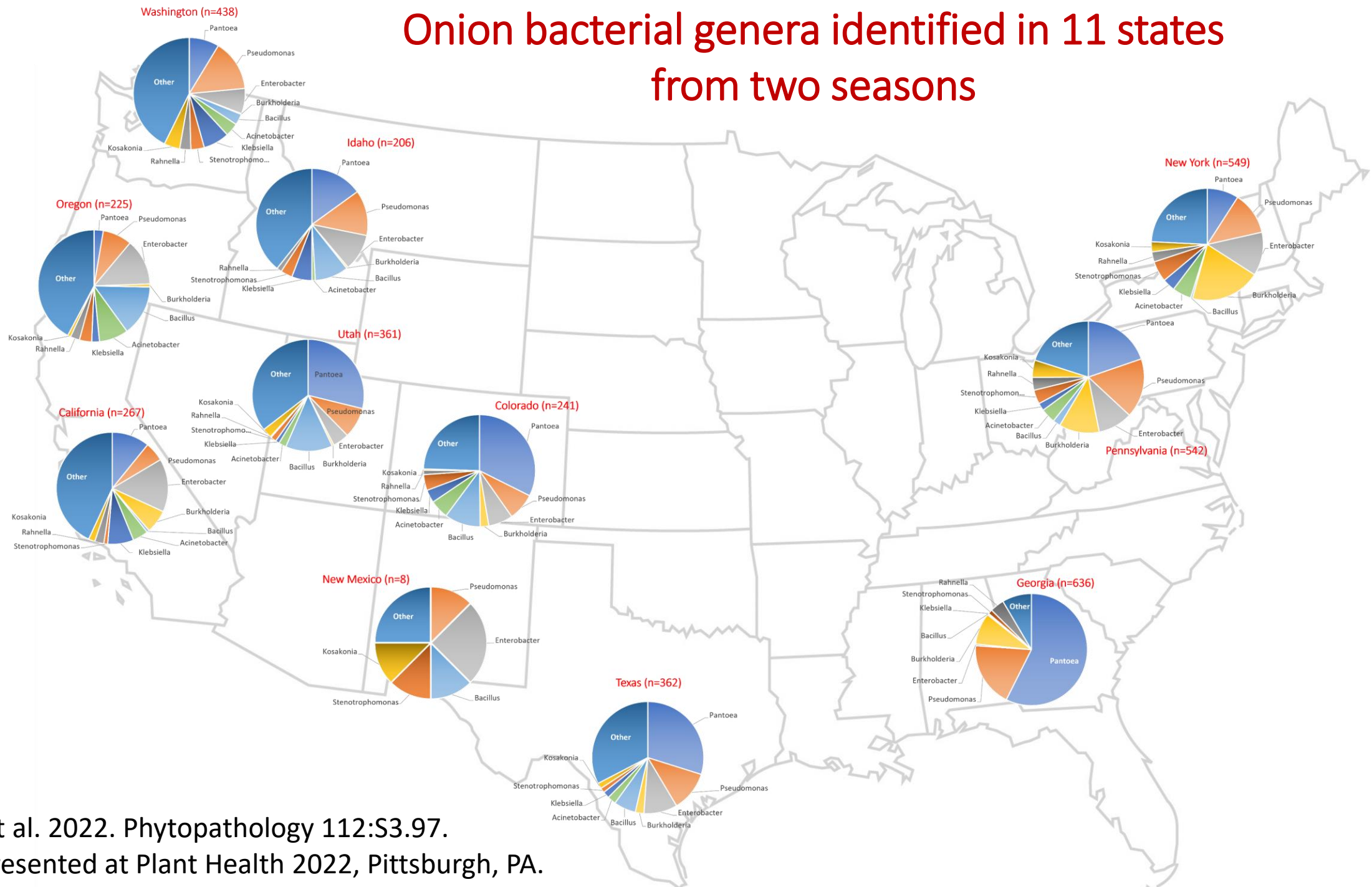
- **Objective A: Onion bacterial disease characterization**
 - A1 – Survey onion crops nationally for bacterial pathogens
 - A2 – Genetic analyses, virulence factors, bacterial communities
 - A3 – Develop molecular diagnostic tools
 - A4 – Develop methods to screen for resistance to bacterial diseases
- **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

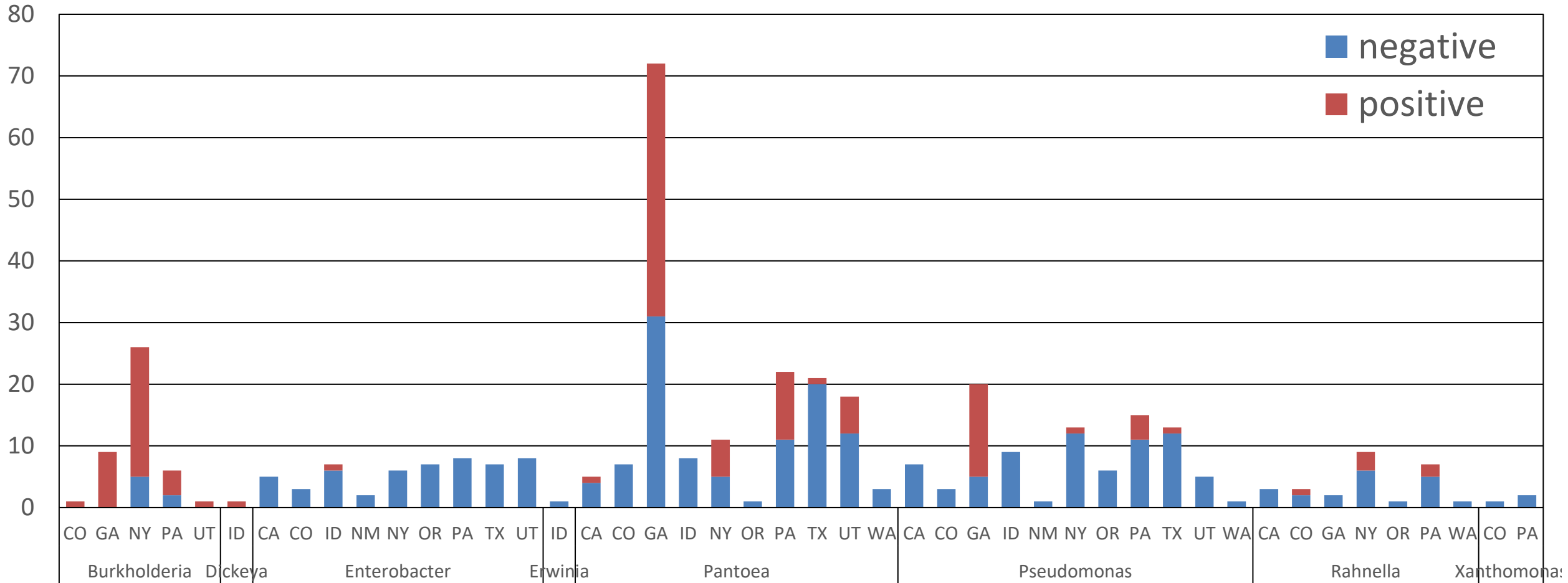


Onion bacterial genera identified in 11 states from two seasons



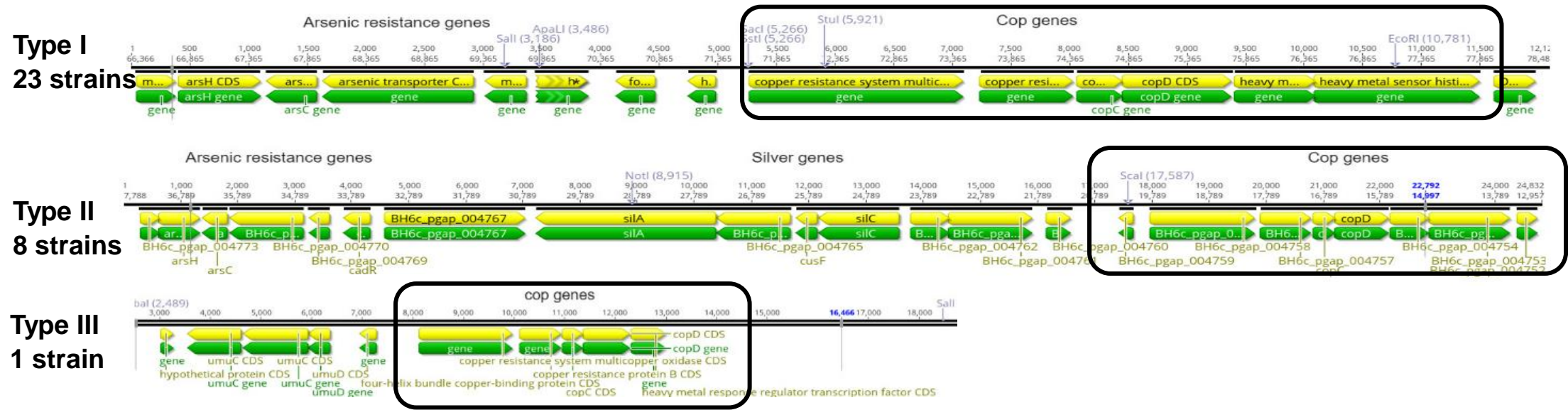
du Toit et al. 2022. *Phytopathology* 112:S3.97.
 Poster presented at Plant Health 2022, Pittsburgh, PA.

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 Hoeping (Cornell), Brenna Aegerter & Jas Sidhu (UC), Claudia Nischwitz (USU)

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

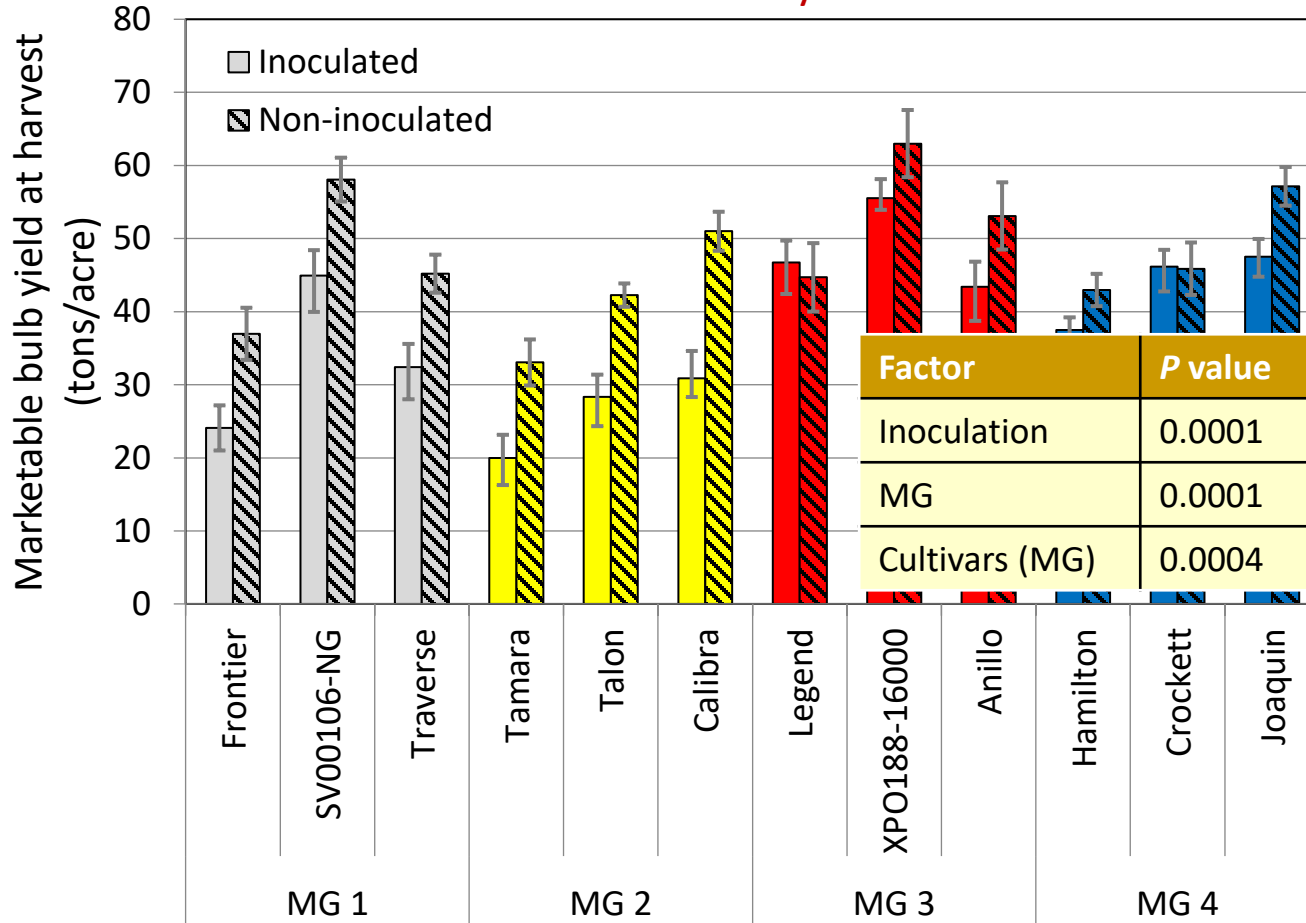
- **Georgia:**
 - Greenhouse test of 2 inoculation methods did not differentiate susceptibility among cultivars
 - Field screening of USDA *Allium* germplasm collection: Differences in susceptibility to *P. ananatis*
- **New York:**
 - Various methods of screening in a growth chamber had inconsistent 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)



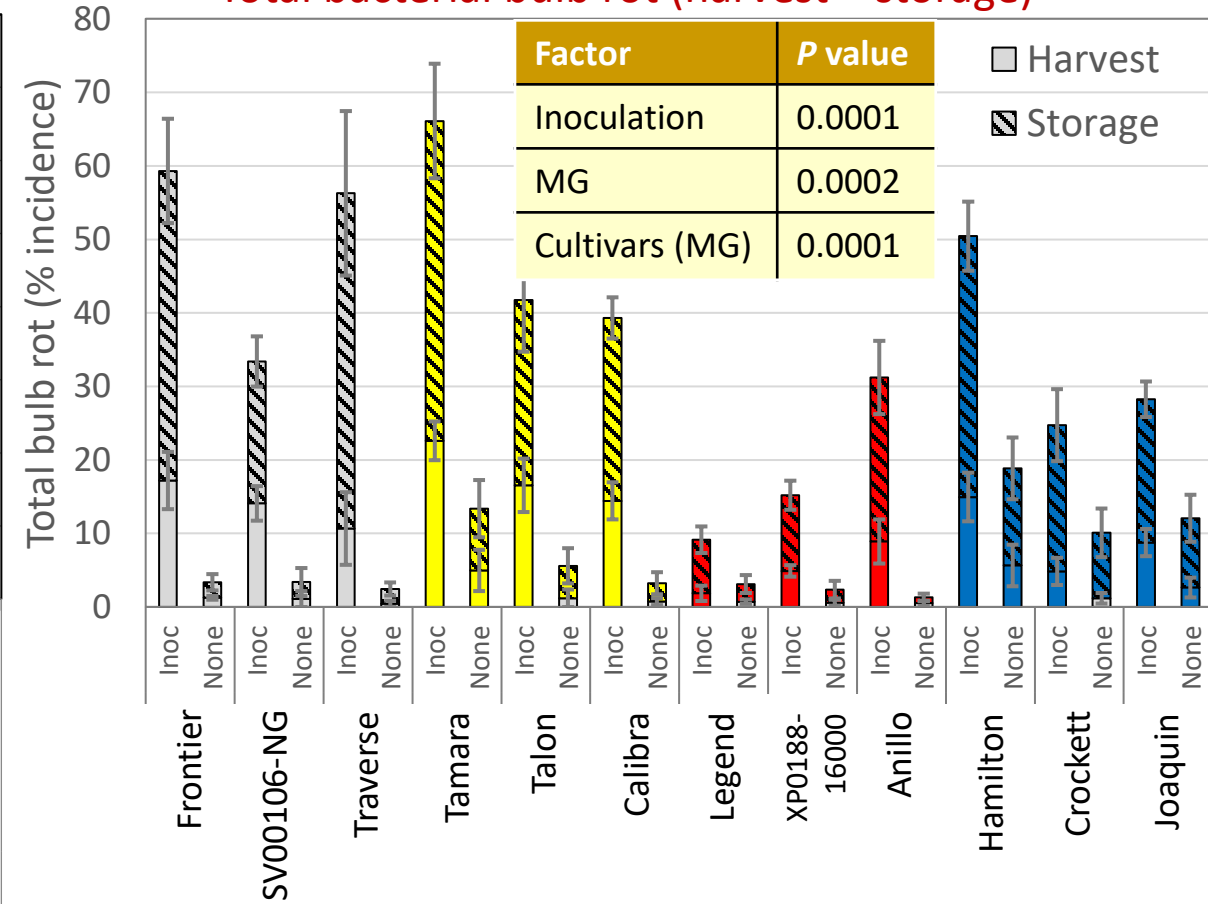
Objective A4, Season 2 (2021-22): Washington Cultivar Trial



Marketable bulb yield at harvest



Total bacterial bulb rot (harvest + storage)



Objective A4, Season 3 (2022): California Cultivar Trial (Brenna Aergenter, Jas Sidhu)

- **Field trial:** Some cultivars (e.g., Derby, Joaquin) had less bacterial bulb rot
- **Postharvest assays:** Significant differences in bulb rot and scale lesion size among cultivars, but results of 2 bulb injection vs. scale inoculation were poorly correlated, and poorly correlated with bulb rot in field trial

Cultivar	Type	Days to maturity (listed)	Field trial, 9-Aug		Field trial, at harvest				Postharvest assays			
			Foliar bacterial disease incidence (%)		Bulb rot incidence (%)		Marketable yield (t/A)		Bulb rot severity (%)		Scale lesion area (mm ²)	
Tannat	LD mid to late, Red	115	12.5	e*	48.4	a	19.6	bcd	53.9	e	79.9	cd
Minister	INT early, Yellow	107	13.8	e	38.1	ab	27.3	abc	65.5	bc	112.9	b
Marengo	LD mid to late, Red	115	16.3	de	34.7	bc	15.5	d	63.2	cd	185.3	a
Vaquero	LD mid to late, Yellow	118-120	35.6	ab	30.2	bcd	22.3	bcd	72.0	ab	91.3	bc
Caliber	LD late, Yellow	122	20.6	bcde	28.5	bcd	22.3	bcd	58.3	de	82.3	cd
Red Angel	INT early, Red	110	29.4	abcd	26.0	cde	28.5	ab	44.8	f	62.7	d
Granero	LD mid to late, Yellow	115-118	38.8	a	24.4	cde	22.3	bcd	70.5	abc	89.2	c
Campero	LD early, Yellow	100	35.0	abc	22.0	def	17.8	cd	66.8	bc	85.9	c
Derby	INT early, Yellow	??	18.8	cde	16.6	ef	34.3	a	65.5	bcd	93.4	bc
Joaquin	LD late, Yellow	135	24.4	bcde	12.1	f	24.4	abcd	75.0	a	94.9	bc
		P value	0.012		<0.0001		0.043		<0.0001		<0.0001	

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

California:

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

Washington:

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

Georgia:

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

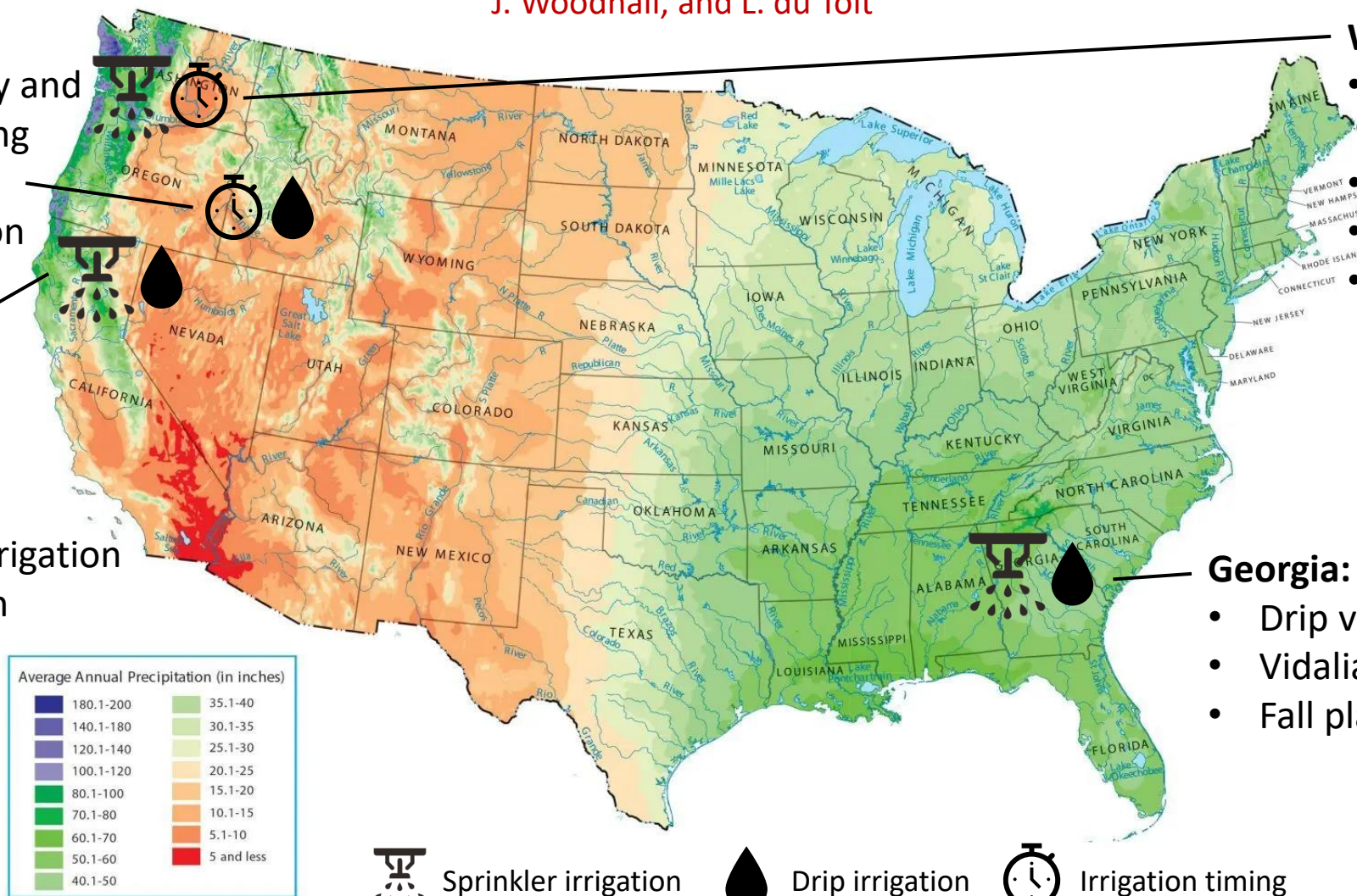


Image credits: GIS Geography, SUBPNG

Objective B1. Irrigation methods

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

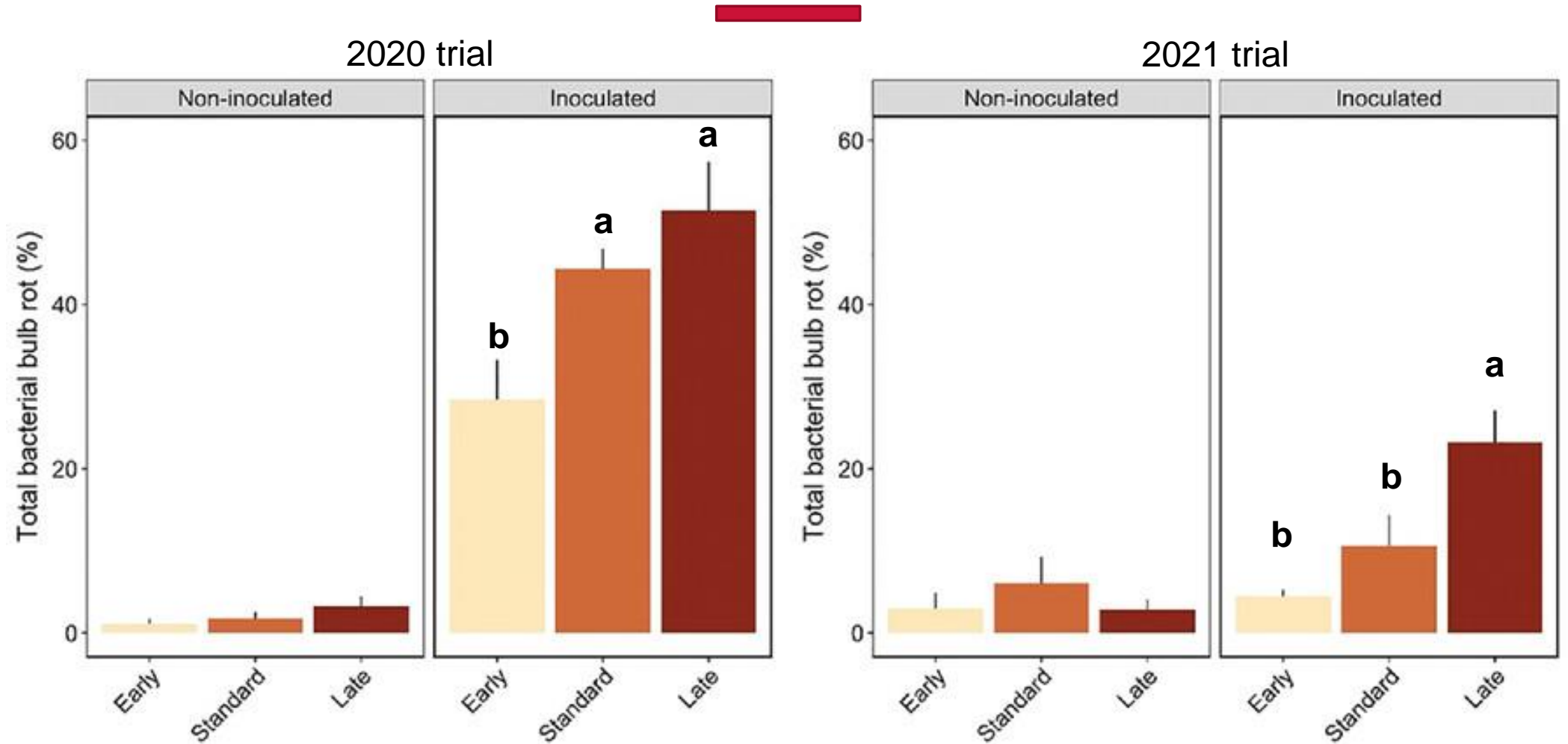
2021 California irrigation trial: Drip vs. solid-set irrigation

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

Contents lists available at [ScienceDirect](#)



Agricultural Water Management

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



Check for updates

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

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REVIEW

Pest Interactions in Agronomic Systems

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

Tessa Belo¹ | Lindsey J. du Toit² | Gabriel T. LaHue¹

Agronomy Journal

FEATURES

Cultural Management Strategies to Reduce the Risk of Onion Bacterial Diseases

By Gabriel LaHue, Tessa Belo, and Lindsey du Toit, Northwestern Washington Research and Extension Center Washington State University

Onion production in the United States is massive in scale: 3.5 million tons of onions were produced on 130,000 acres and valued at approximately \$1 billion, on average, each year from 2018 to 2022. Unfortunately, this highly valuable crop can be threatened by plant pathogenic bacteria that cause a variety of bacterial leaf blights and bulb rots, diseases for which there is no cure. An integrated approach is needed that emphasizes multiple preventative cultural management strategies to reduce the risk posed by onion bacterial diseases. Earn 0.5 CEUs in Integrated Pest Management by reading this article and taking the quiz at <https://web.sciencesocieties.org/Learning-Center/Courses>.

22 Crops & Soils Magazine | September–October 2023

Florida/Oregon Department of Agriculture American Society of Agronomy

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, Lifeguard 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:** No treatment reduced bacterial bulb rot (2 seasons), coppers caused phytotoxicity in 2020 (Season 1)
 - 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
<i>Mankocide 2.5 lb</i>	1-6	10.7 b ^x	43.8 c	358.8 c	9.1 c ^v
<i>Kocide 3000 1.5 lb</i>	1-6	28.9 ab	50.0 bc	540.7 bc	29.8 bc
<i>Champ 1.5 lb</i>	1-6	15.1 ab	51.3 b	464.8 bc	18.0 c
<i>Oxidate 5.0 32 fl oz per 100 gal</i>	1-6	40.0 a	71.3 a	791.2 ab	55.2 a
<i>Agrititan 800 ppm</i>	1-6	29.4 ab	58.8 b	602.8 bc	19.5 c
<i>LifeGuard 2 fl oz</i>	1-6	22.7 ab	48.8 bc	469.2 bc	26.8 bc
<i>Nordox 1 lb</i>	1-6	18.0 ab	53.8 b	502.4 bc	17.2 c
<i>Mastercop 1 pt</i>	1-6	23.7 ab	48.9 bc	489.6 bc	12.2 c
<i>Leap 1 qt</i>	1-6	32.4 ab	70.0 a	703.8 ab	52.5 ab
<i>Actigard 0.5 fl oz</i>	1-6	34.9 ab	70.0 a	699.5 ab	57.5 ab
<i>NUCop 1.5 lb</i>	1-6	15.2 ab	55.0 b	485.4 bc	18.8 c
<i>Non-treated check</i>	-	44.9 a	87.5 a	1012.2 a	74.8 a

Very little to no efficacy observed with copper and other products in trials in Washington and other states over 3+ seasons

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

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
<i>P</i> 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
<i>P</i> -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

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

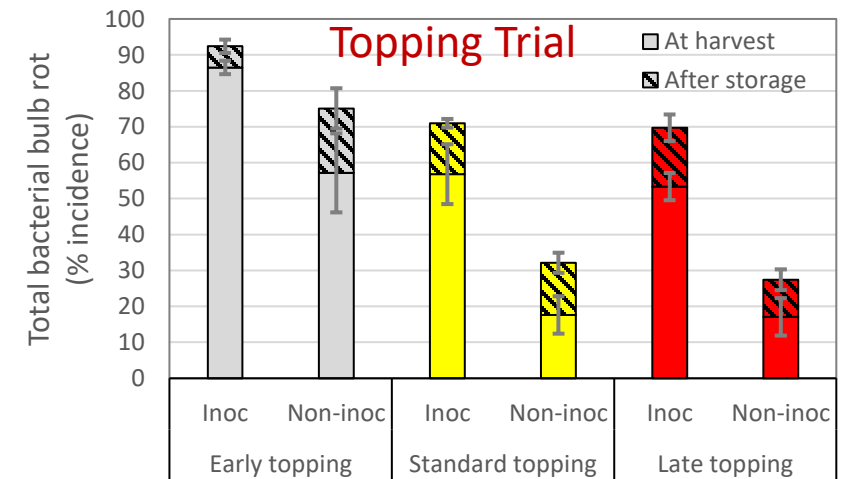
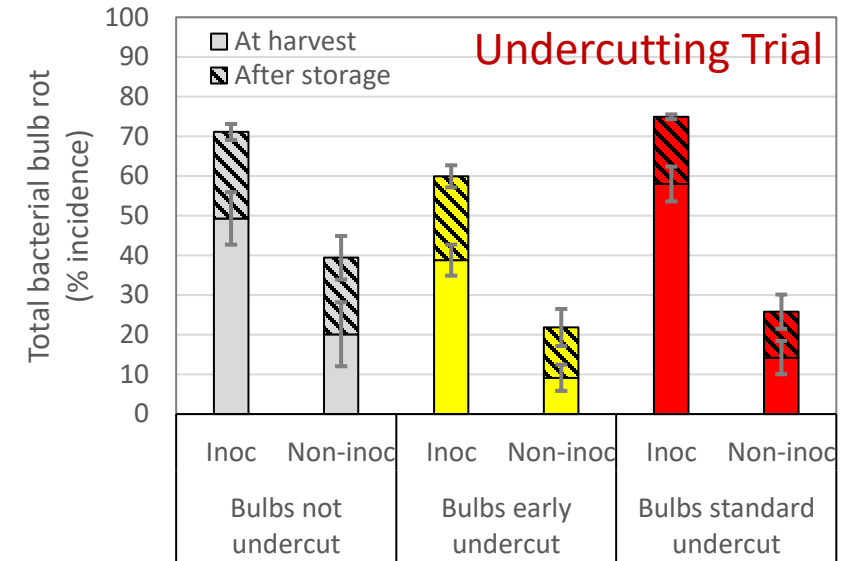
Dutta et al. 2022. Plant Disease Management Reports 16:V107.

2022 trial	Internal bacterial rot incidence (%)
7.5 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



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

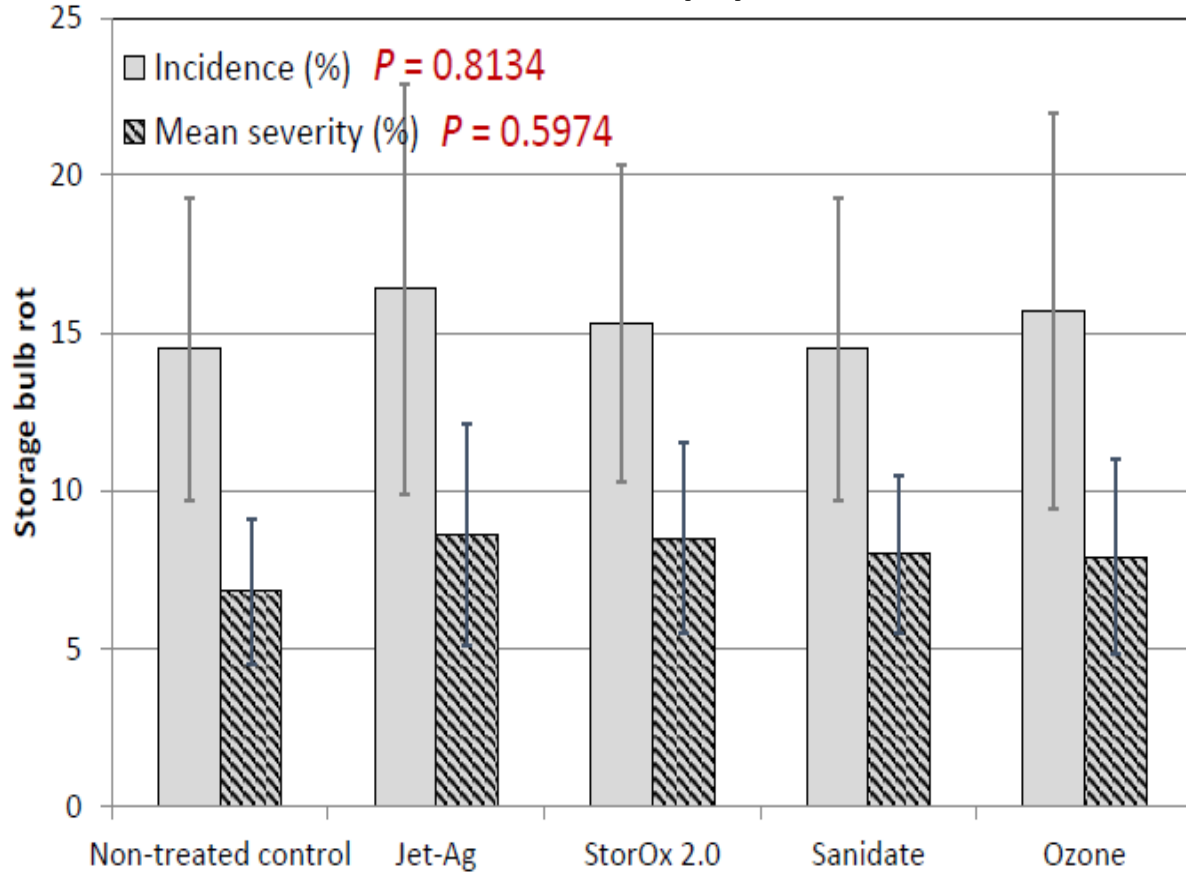
- Repeat treatments
- **Commercial storage evaluations:** Growers remove sample of bulbs during treatment, replace non-treated bulbs, evaluate for storage rots

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

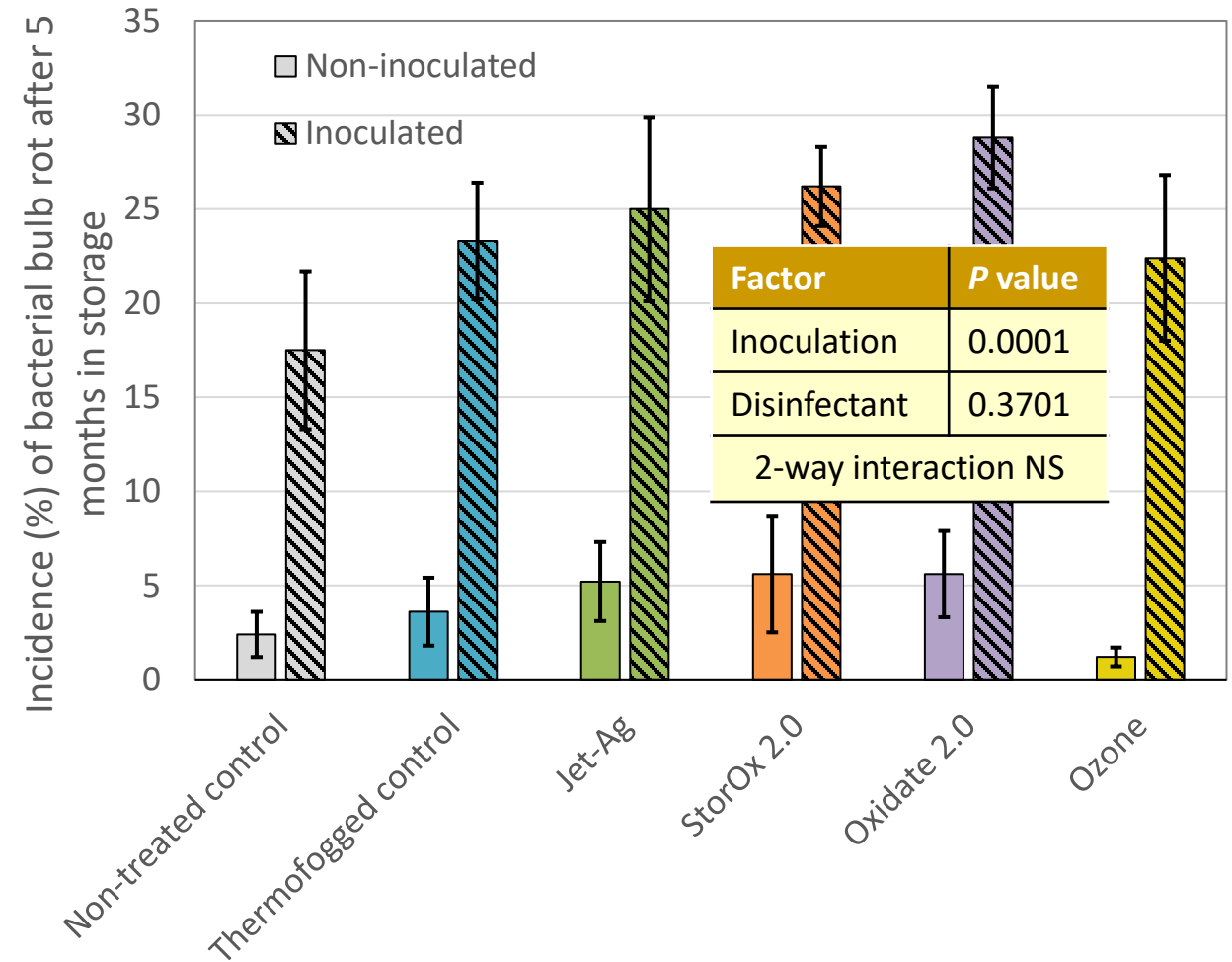


WA trials evaluating postharvest applications of disinfectants

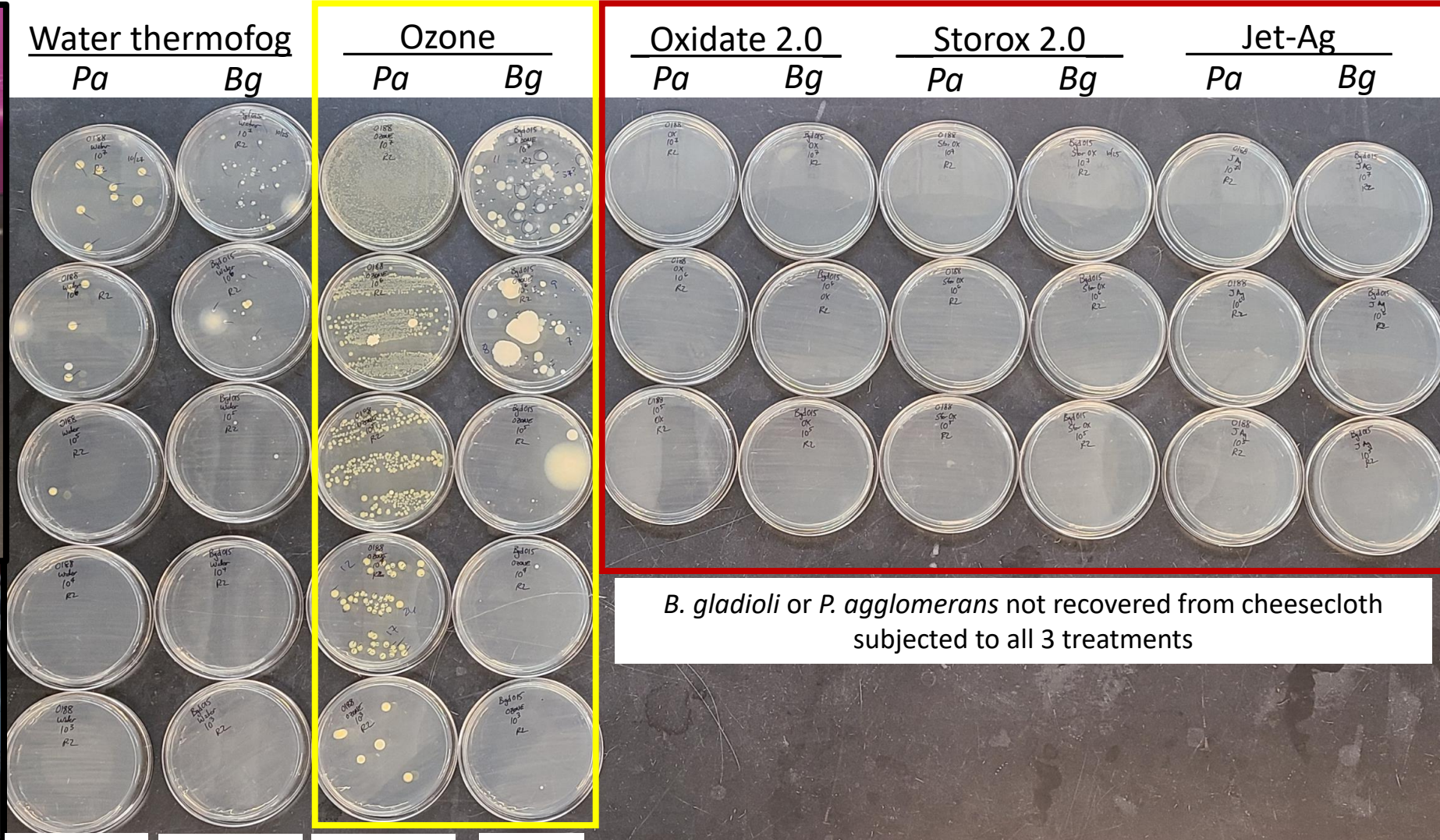
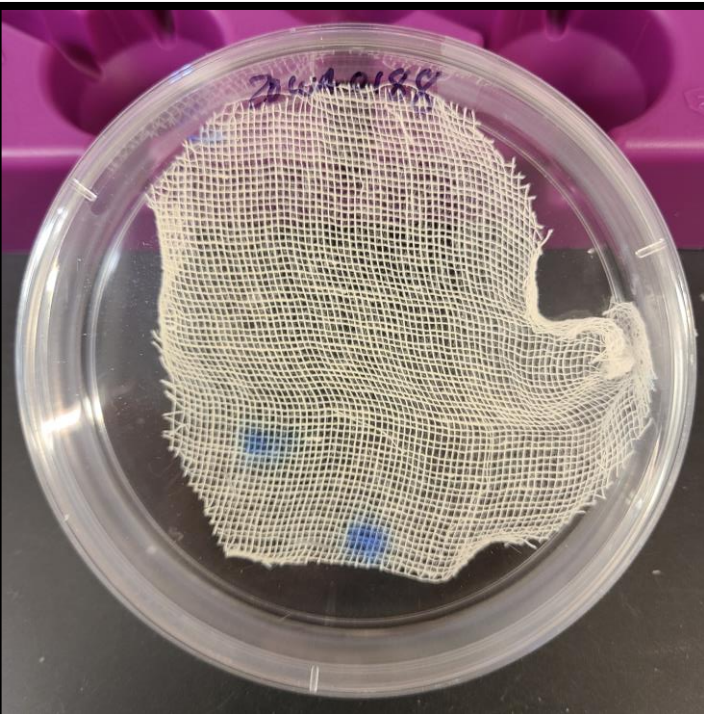
2020-21 trial: Incidence (%) of bacterial rot



2021-22 trial: Incidence (%) of bacterial rot



2021-22 WA trial evaluating postharvest application of disinfectants



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
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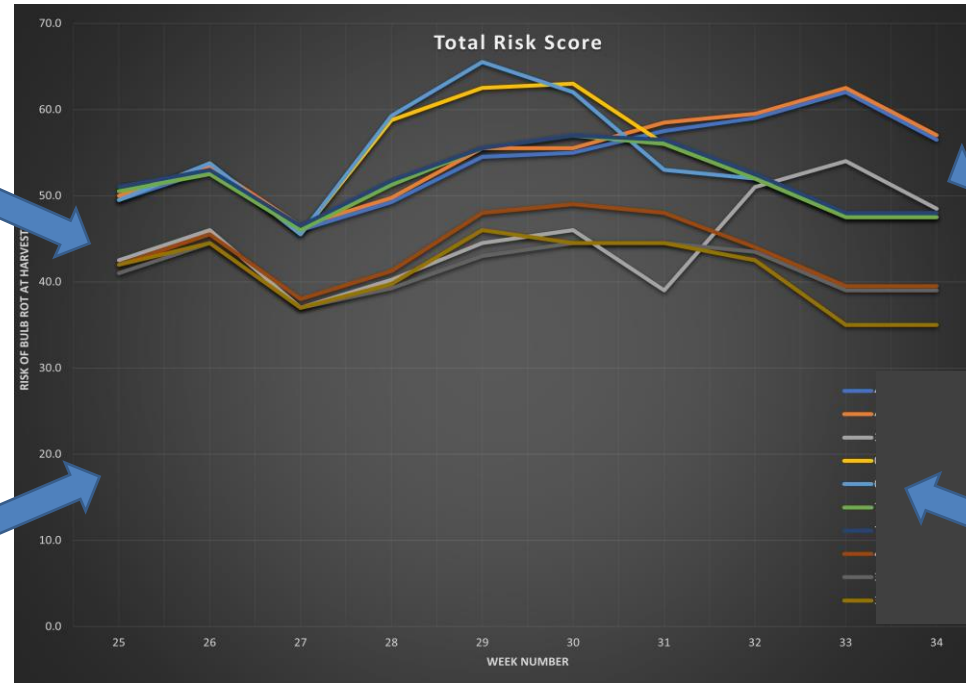
Objective B6. Modeling the risk of onion bacterial diseases

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

Help “Stop the Rot”!
Please take our Onion Survey
‘Stop the Rot’ USDA NIFA SCRI Onion Bacterial Project 2019-51181-30013

Dear Members of the Onion Industry:

During the last four years, researchers, extension educators, and industry stakeholders from across the United States have collaborated on a USDA-funded project to combat onion bacterial diseases using pathogenomic tools and optimized management practices. This project is led by the Project Director, Lindsey du Toit (dutoit@wsu.edu) in the Department of Plant Pathology at Washington State University.

Since this project strives to reduce economic losses for the onion industry, we have been aiming to understand:

- (a) severity of the threat of bacterial diseases to economic stability of the onion industry,
- (b) what growers are doing to combat bacterial diseases,
- (c) what is and what is not working, and
- (d) what future research would be most valued by the onion industry.

To help answer these questions, please complete a 10-minute survey.
No identifiable information will be collected to maintain your anonymity.
Thank you very much for your time and support as we continue our efforts to support the onion industry.

