2025 California Garlic & Onion Symposium
Tulare, CA
10 February 2025

Stop the Rot

Bacterial Bulb Rot Management in Onion

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

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

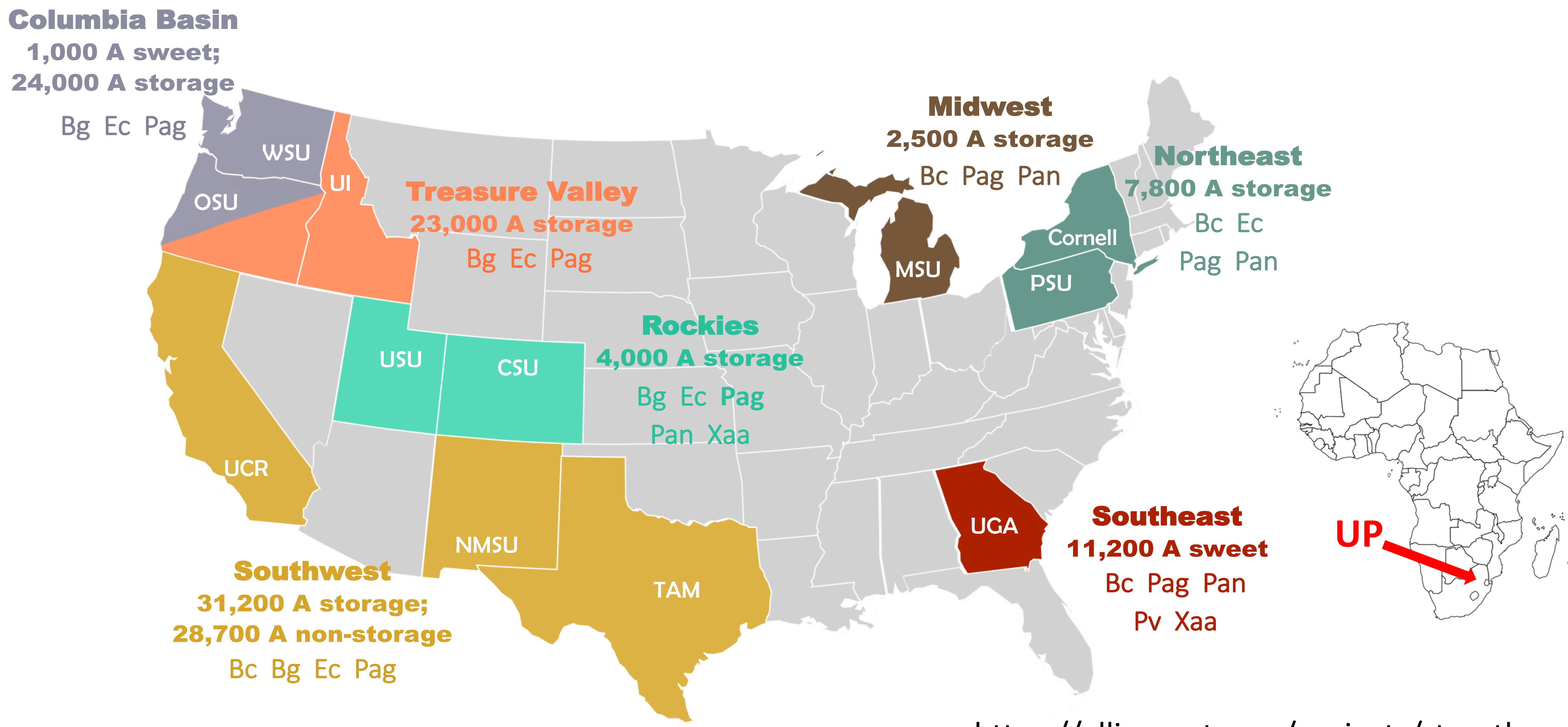
USDA NIFA SCRI Project No. 2019-51181-30013

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

Onion bacterial diseases

- Bacterial pathogens of onion are 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: 2019-2025



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

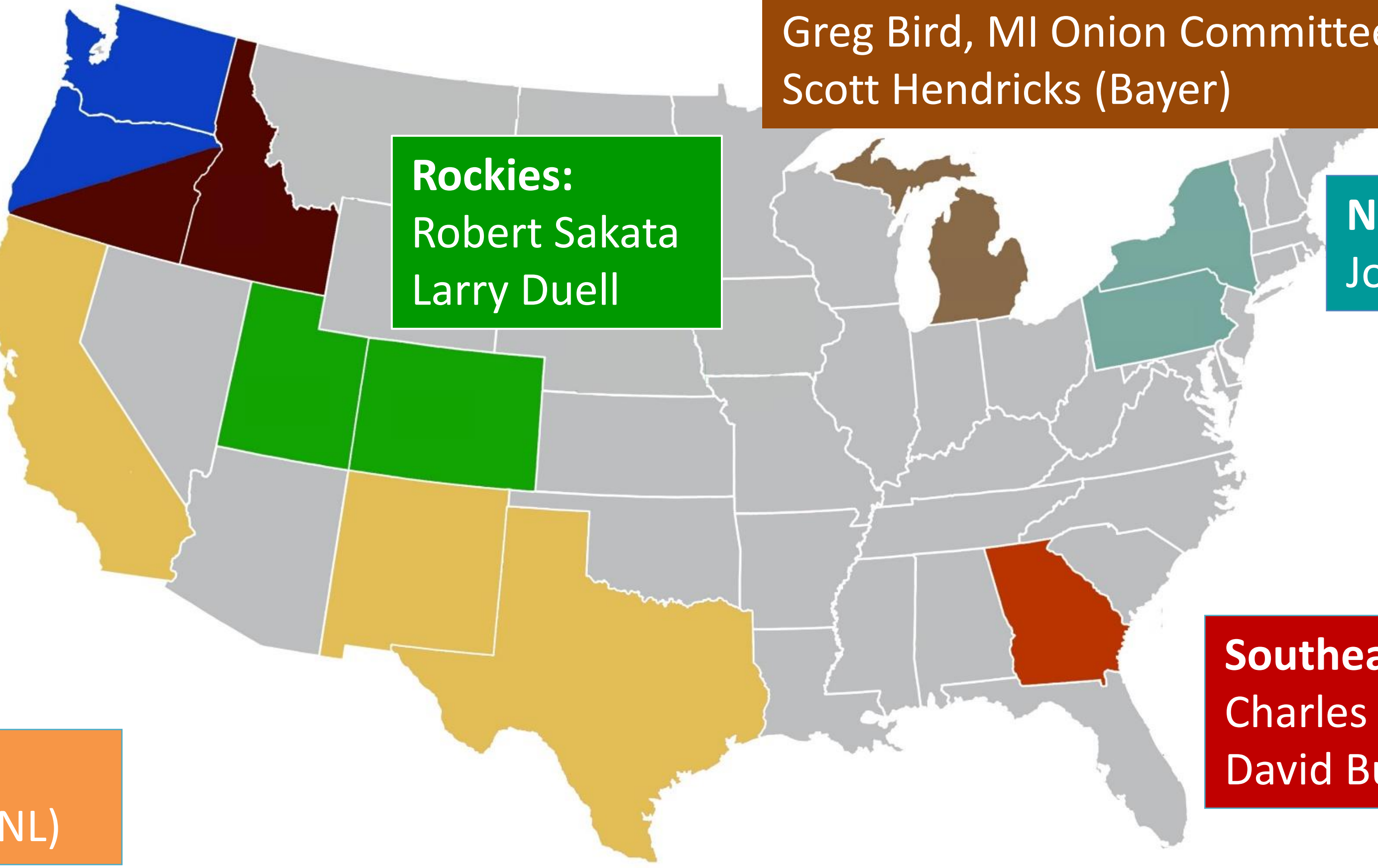
Stop the Rot – Stakeholder Advisory Panel

Pacific Northwest:
Michael Locati
Kerrick Bauman
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



Southwest:
Bob Ehn, CGORAB

Southeast:
Charles Hall, GFVGA
David Burrell

International:
Margreet Asma (Bejo NL)

Stop the Rot

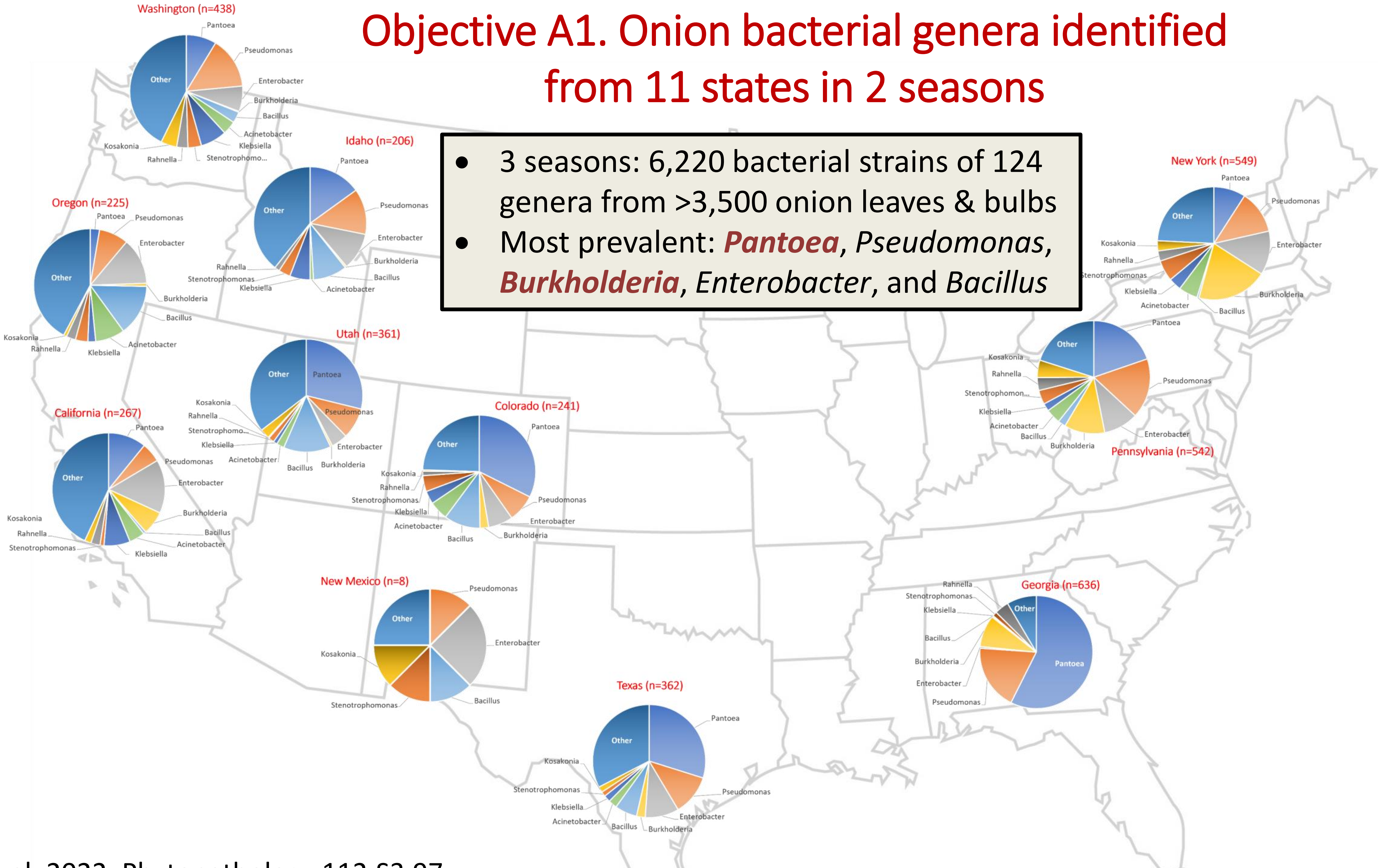
https://alliumnet.com/projects/stop-the-rot/

- 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

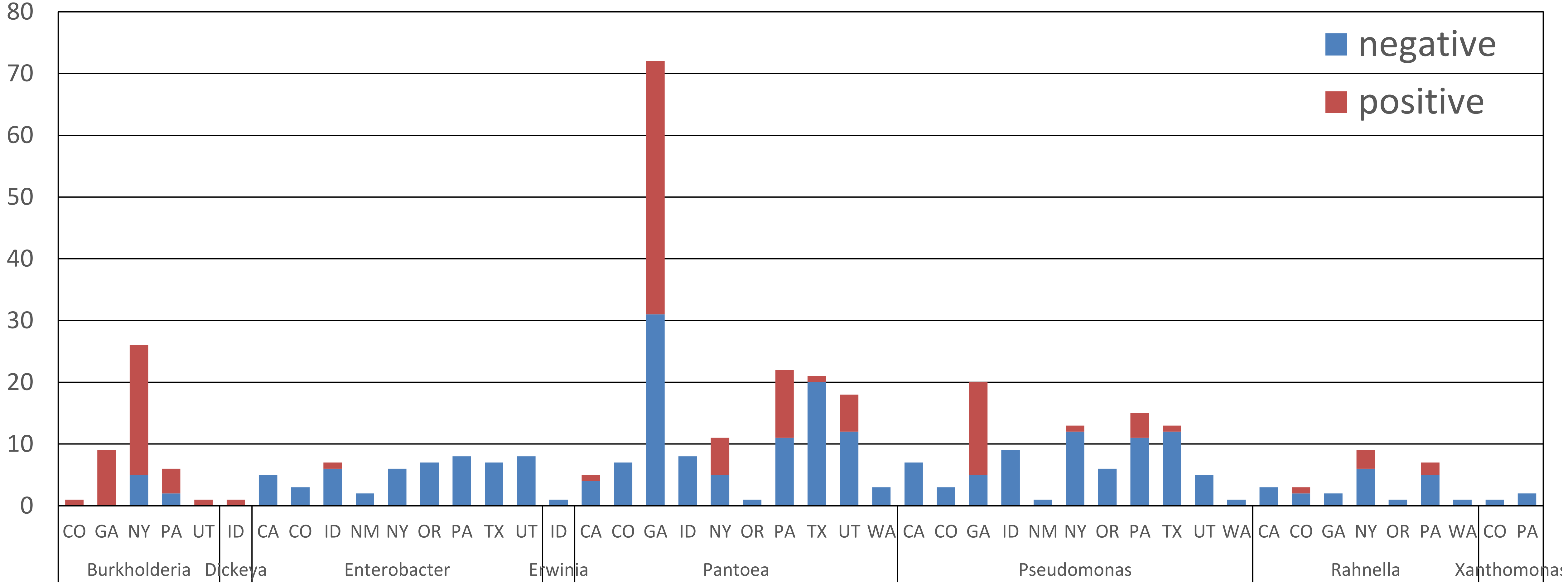
Objective A1. Onion bacterial genera identified from 11 states in 2 seasons

- 3 seasons: 6,220 bacterial strains of 124 genera from >3,500 onion leaves & bulbs
- Most prevalent: ***Pantoea***, *Pseudomonas*, ***Burkholderia***, *Enterobacter*, and *Bacillus*



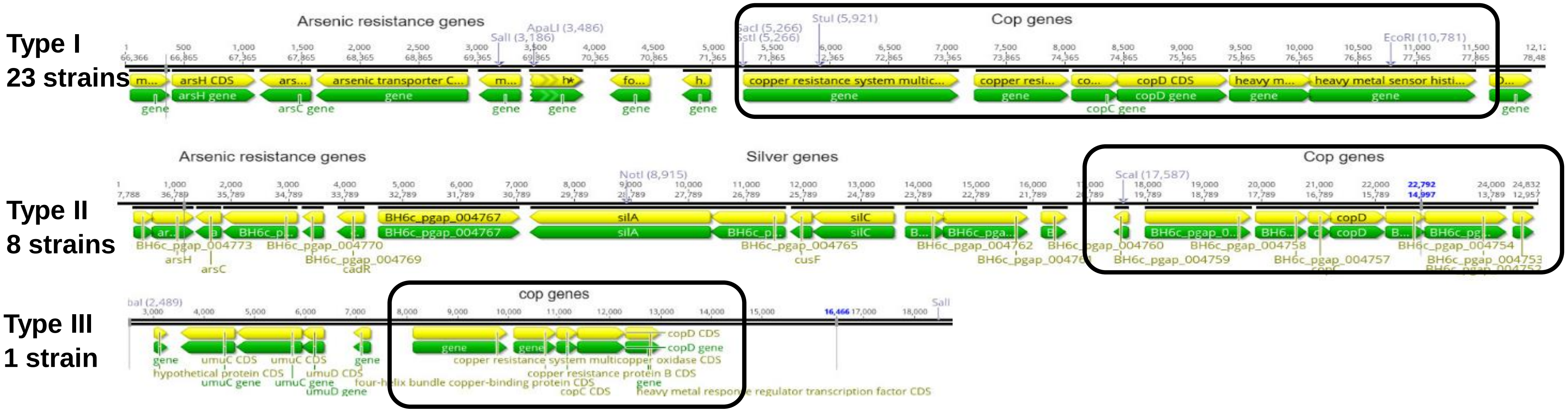
du Toit et al. 2022. Phytopathology 112:S3.97

Pathogenicity to onion of bacterial strains in the National Onion Bacterial Strain Collection (red scale necrosis assay)



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

- ~50% of *P. agglomerans* strains sequenced have **copper resistance (*cop*) genes** on accessory plasmids, similar to other bacterial plant pathogens
- *cop* genes and *alt* genes (tolerance to sulfur compounds) on same plasmids
- *cop*+ strains of *P. agglomerans* tolerant to >100 ppm copper sulfate on CYE agar medium
- *Burkholderia gladioli* strains from Columbia Basin are tolerant to >200 ppm copper sulfate



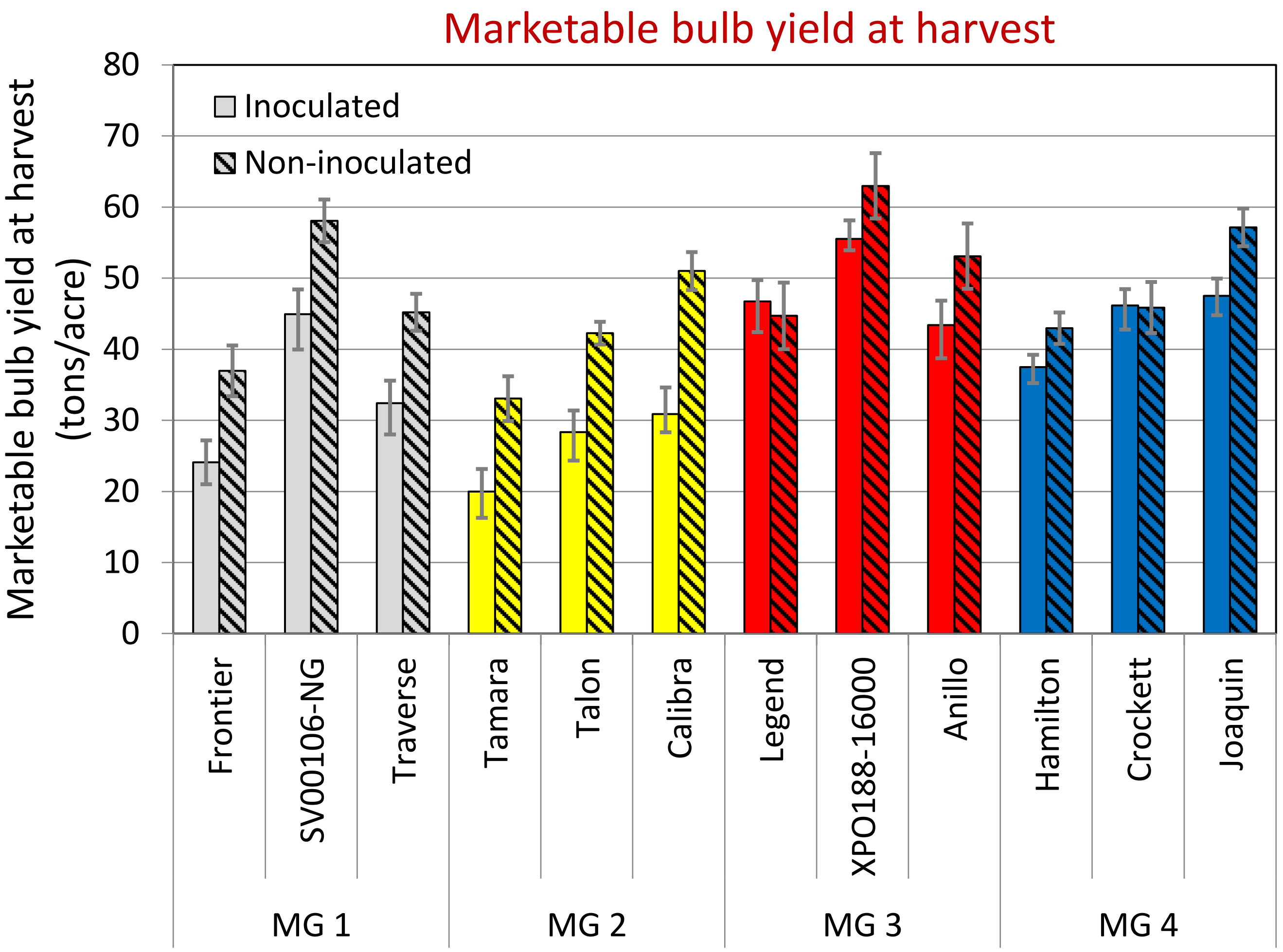
A4: Develop methods to screen onion cultivars for resistance

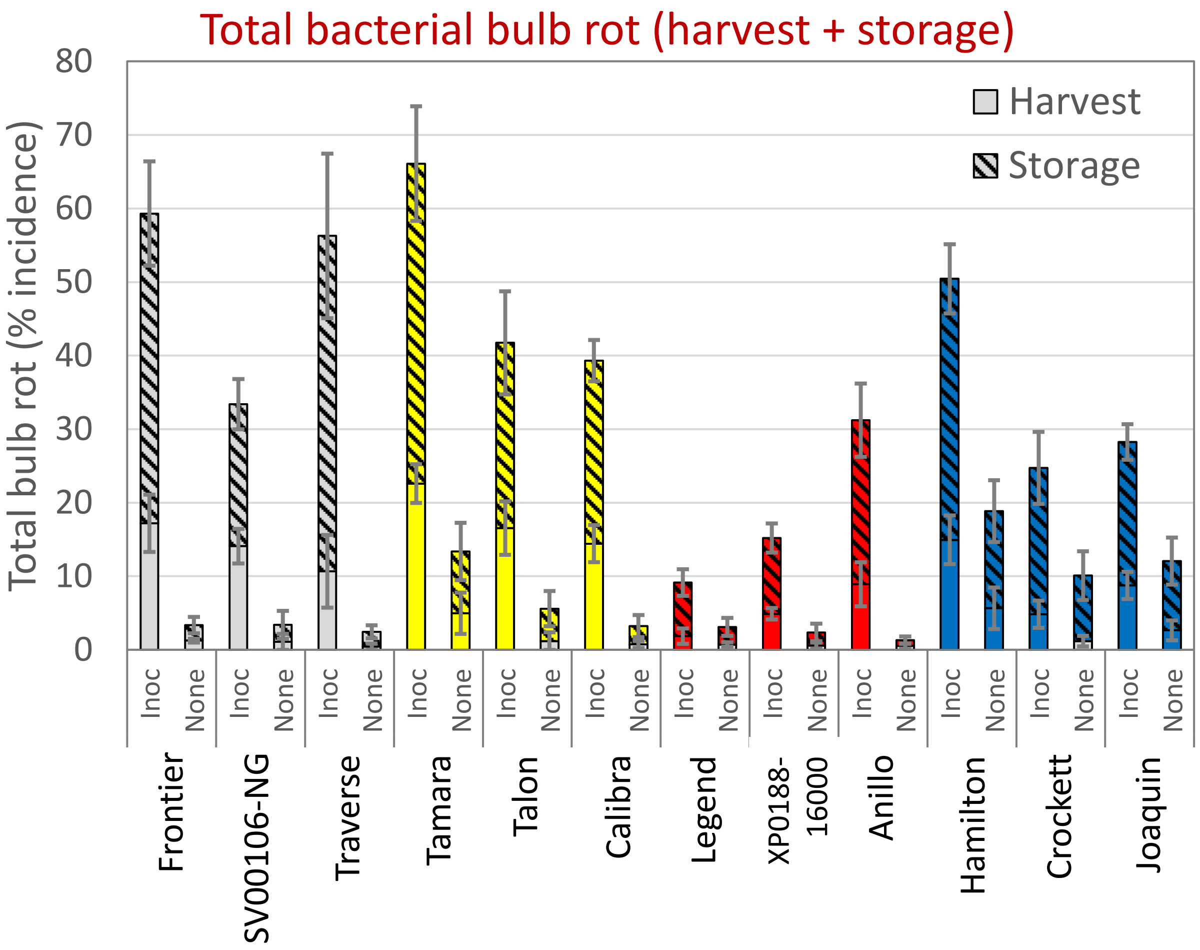
Lindsey du Toit (WSU), Bhabesh Dutta (UGA), Steve Beer & Christy Hoepting (Cornell), Brenna Aegerter & Jas Sidhu (UC), Claudia Nischwitz (USU)

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)

A4: 2021-22 Washington Cultivar Trial





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

Objective A4, Season 3 (2022): California Cultivar Trial (Brenna Aergerter, 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

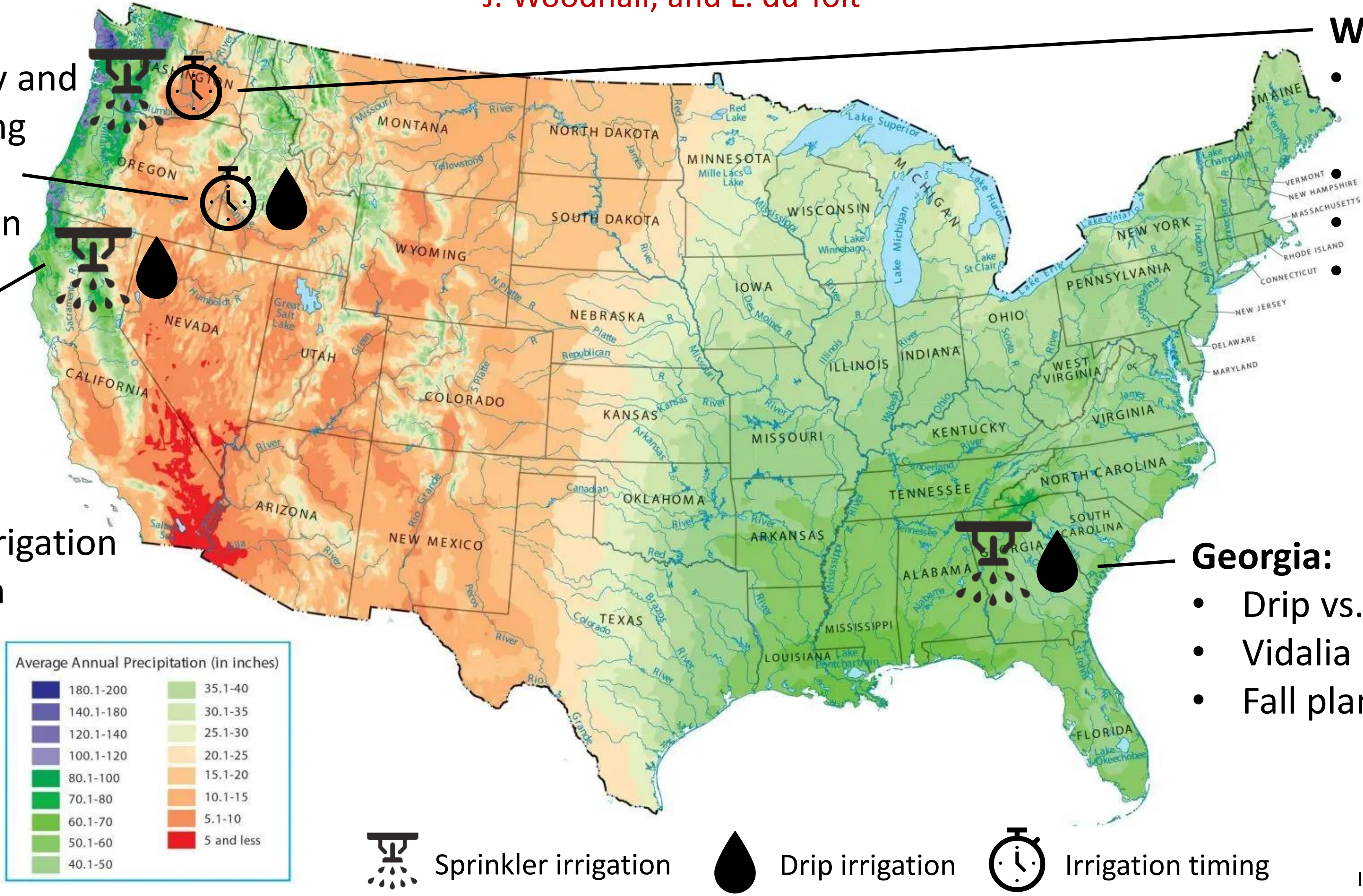
			Field trial, 9-Aug		Field trial, at harvest				Postharvest assays			
Cultivar	Type	Days to maturity (listed)	Foliar bacterial disease incidence (%)		Bulb rot incidence (%)		Marketable yield (t/A)		Bulb rot severity (%)		Scale lesion area (mm^2)	
Tannat	LD mid to late, Red	115	12.5	e*	48.4	a	19.6	bcd	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
Marenge	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

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 dry climate (northern CA), but results were mixed in a humid, rainfed climate (GA)

The influence of irrigation method on bacterial disease symptoms and onion yield across years and inoculation treatments for 2021 and 2022 field experiments in Tulelake, CA

Treatment	Foliar bacterial disease incidence (AUDPC)[y]	Foliar bacterial disease severity (AUDPC)	Total bulb yield (t/ha)	Average bulb weight (g)	Bulb rot incidence (%)	Onion plant population (#/m)
Solid-set sprinkler irrigation	461 ± 39[z]	197 ± 21.3	116 ± 3.0	269 ± 7.0	15.0 ± 2.7	43.3 ± 1.0
Drip irrigation	90 ± 10.8	16 ± 2.7	131 ± 1.2	295 ± 3.4	0.5 ± 0.2	44.7 ± 0.8
P value	0.0002	0.0002	0.005	0.029	0.003	0.322

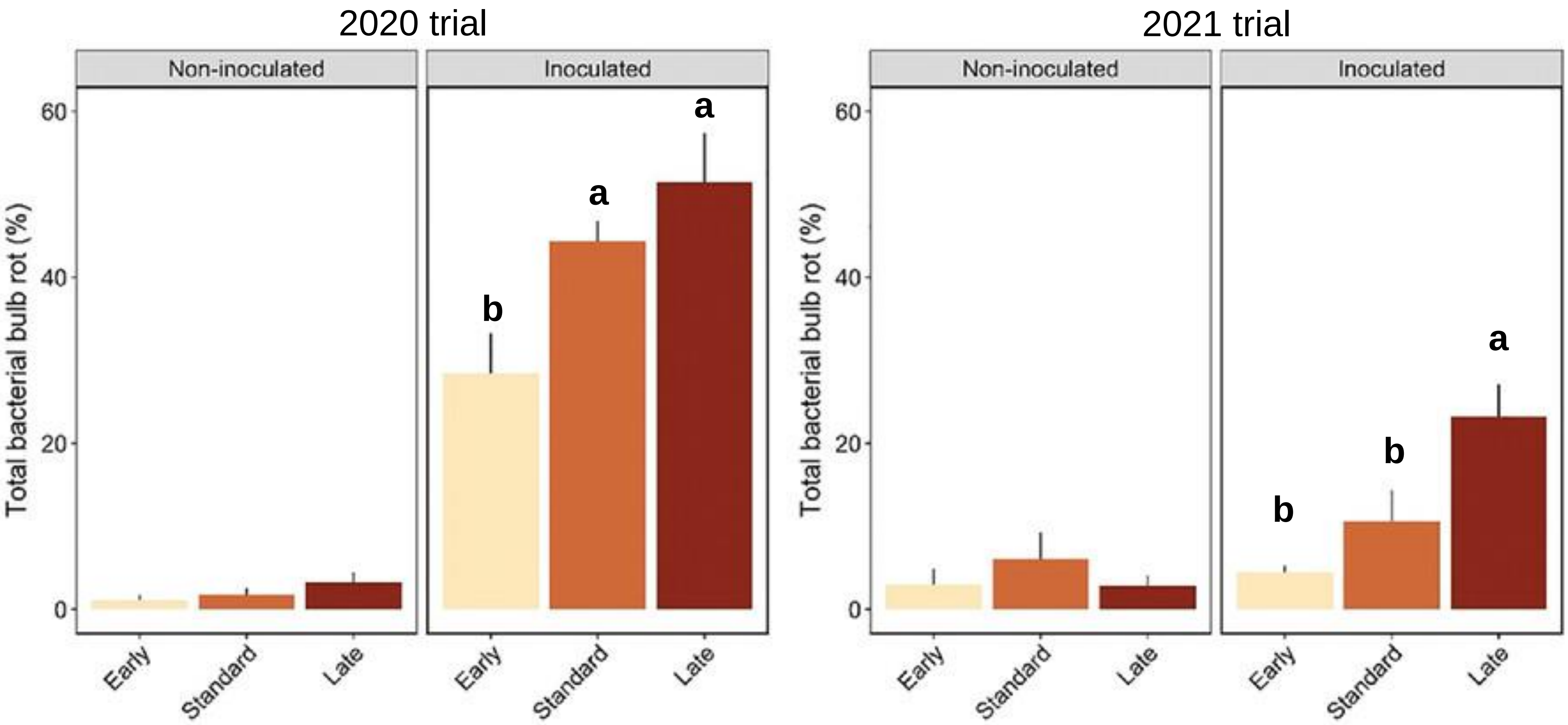
[y] Area under the disease progress curve (AUDPC) values for leaf blight incidence and severity were calculated based on weekly visual ratings from the first sign of disease in August to mid-September.

[z] Standard error of the means.

Wilson, Aegerter, and LaHue. 2024. Plant Health Progress 25:293-298.

Objective B1. Late termination of sprinkler irrigation increased bacterial bulb rot

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

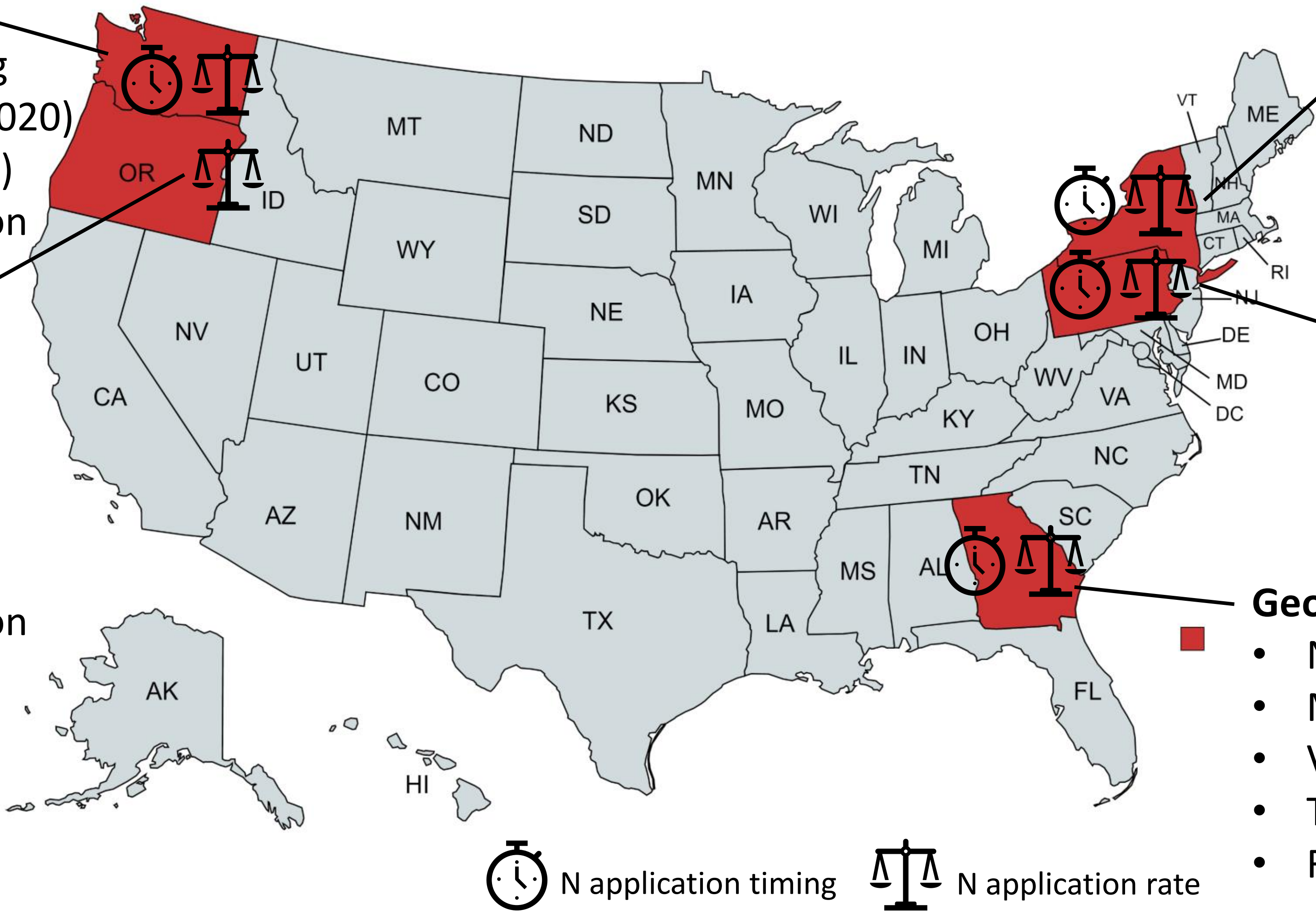


Objective B2. Effects of soil fertility practices

G. LaHue, T. Belo, S. Caldwell, T. Coolong, M. Derie, B. Dutta, B. Gugino, E. van der Heide, C. Hoepting, H. de Jesus, J. Mazzone, M. Murdock, B. Nault, K. Nicholson, K. Regan, S. Reitz, A. Rivera, A. da Silva, I. Trenkel, T. Waters, K. Wieland, R. Wilson, J. Woodhall, and L. du Toit

Washington:
- N rate and N timing
- Loamy fine sand (2020) and silt loam (2021)
- Yellow storage onion
- Spring planted

Oregon:
- N application rate
- Silt loam soil
- Yellow storage onion
- Spring planted



New York:
- N rate and N timing
- **Many field sites**
- Muck soil
- Yellow storage onion
- Spring planted

Pennsylvania:
- N rate and timing
- Mineral soil
- Transplanted onions
- Spring planted

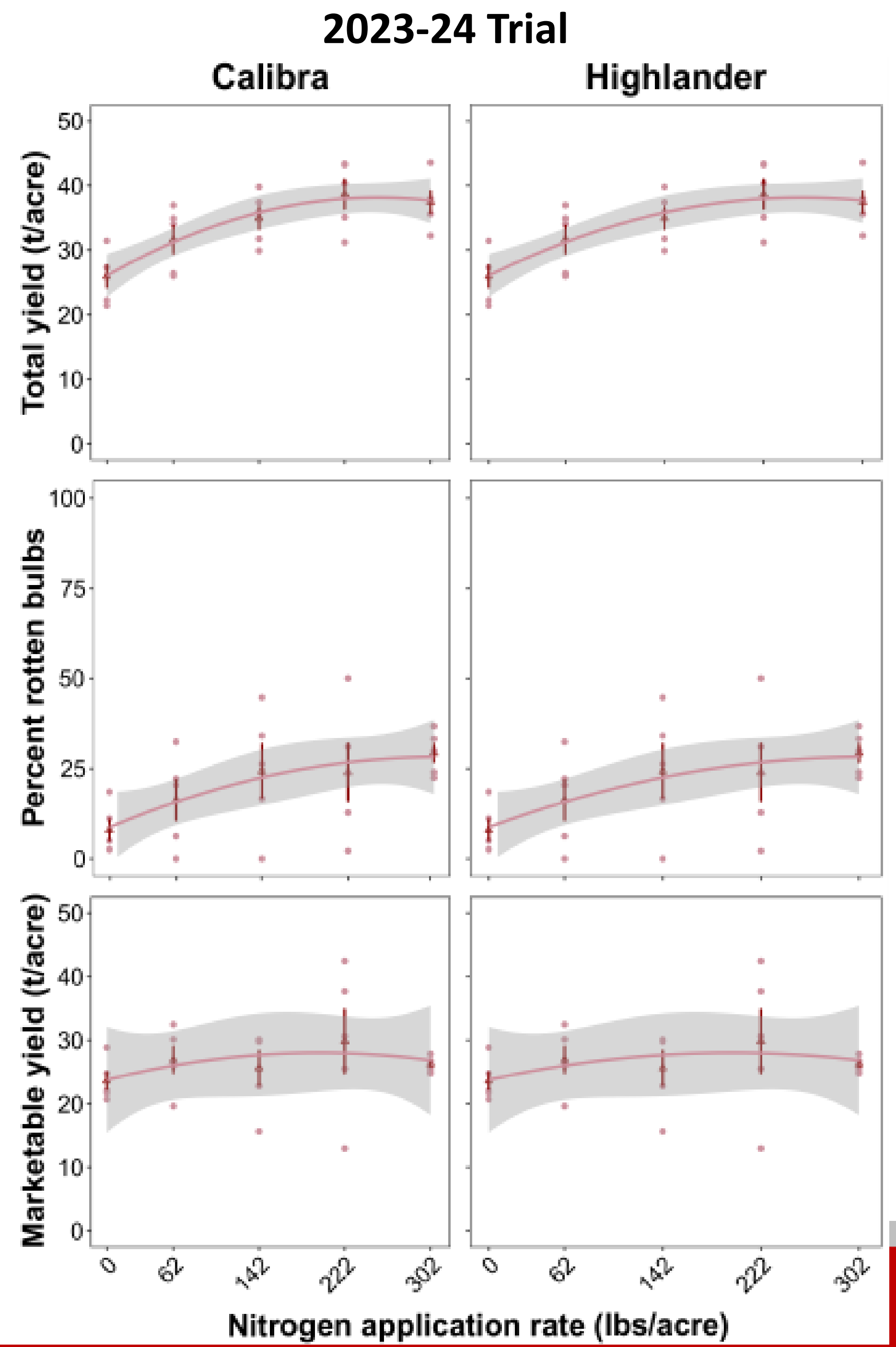
Georgia:
- N rate and N timing
- Mineral soil
- Vidalia sweet onion
- Transplanted
- Fall planted

Image credits: Map Chart

B2. Effect of N application rates: Columbia Basin (WA) trials in 2023-24

Thapa et al. 2024. Plant Disease Management Reports.

- Total yield of Calibra increased with increasing N application rate (2023 and 2024 trials)
- Earlier-maturing Highlander was less responsive than later-maturing Calibra
- Losses to bacterial bulb rot increased with increasing N application rate (more in 2023 than 2024, especially for Calibra)
- Marketable yield (total yield – bulbs rotten) of Calibra was highest at 200 lb total available N/acre (residual + applied)
- N application rates to maximize marketable yield are less than rates to maximize total yield because of bulb rot at higher rates
- Results of 2024-25 field trials being analyzed



Objective B3. Pesticide efficacy: 2020 GA bactericide trial

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 other states (very poor/no efficacy in 5 years of trials in WA)

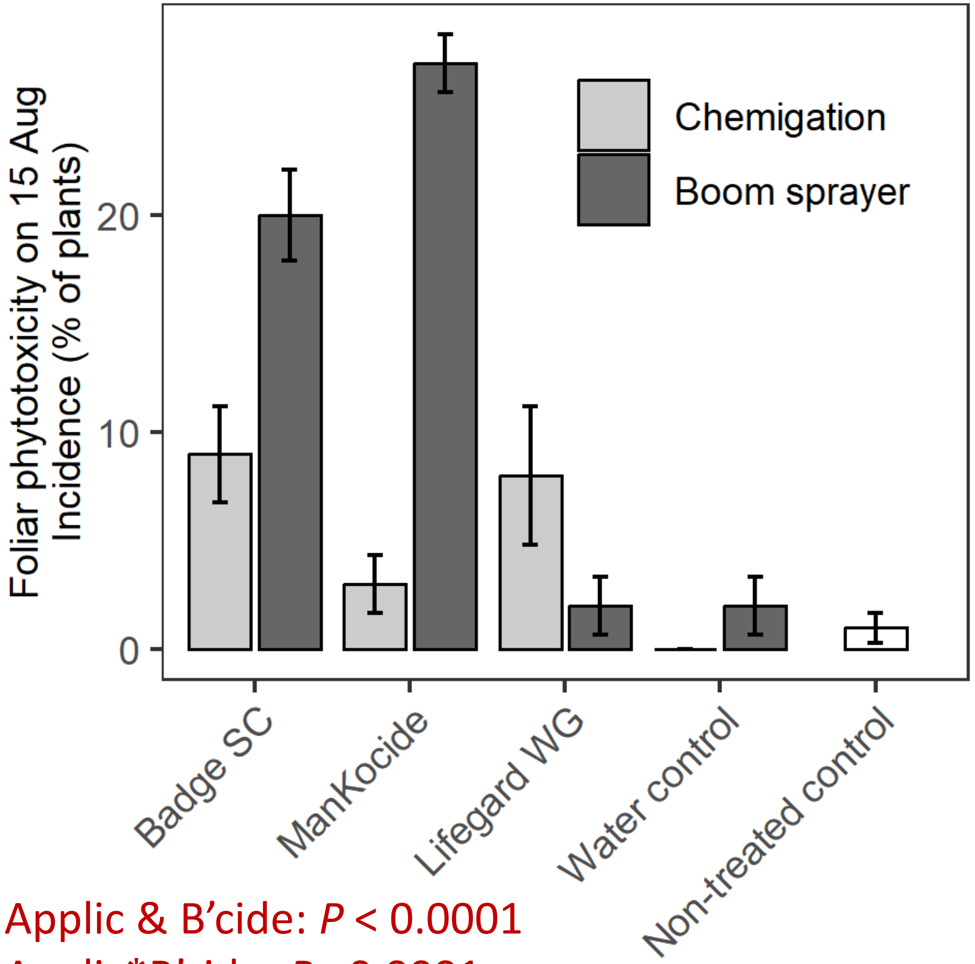
B2. 2023-24 Washington State Bactericide Trial

Chemigation vs. spray boom application

- Pasco, center-pivot irrigated field
- Split-split plot RCBD
  - Main plots: Inoculated (*Burkholderia gladioli* & *Pantoea agglomerans*) (28 Jul = early tops down, & 11 Aug.), or not inoc.
  - Split plots:
    1. Chemigation (2,700 gpa)
    2. Spray boom application (40 gpa, 25 psi)
  - Split-split plots: 5x, weekly intervals, 13 Jul.-10 Aug.
    1. Badge SC
    2. ManKocide
    3. LifeGard WG
    4. Water control treatment
    5. No water control treatment

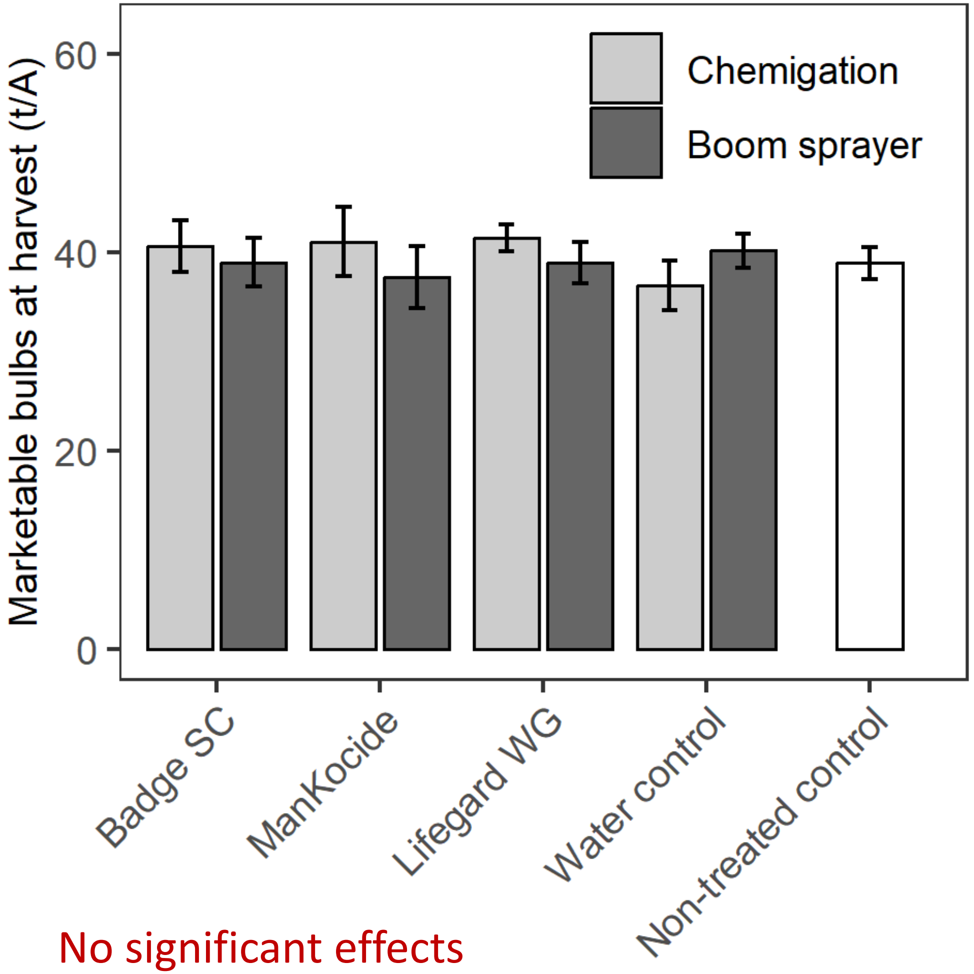
2023-24 Washington State Bactericide Trial

Foliar phytotoxicity



Applic & B'cide: $P < 0.0001$
Applic*B'cide: $P < 0.0001$

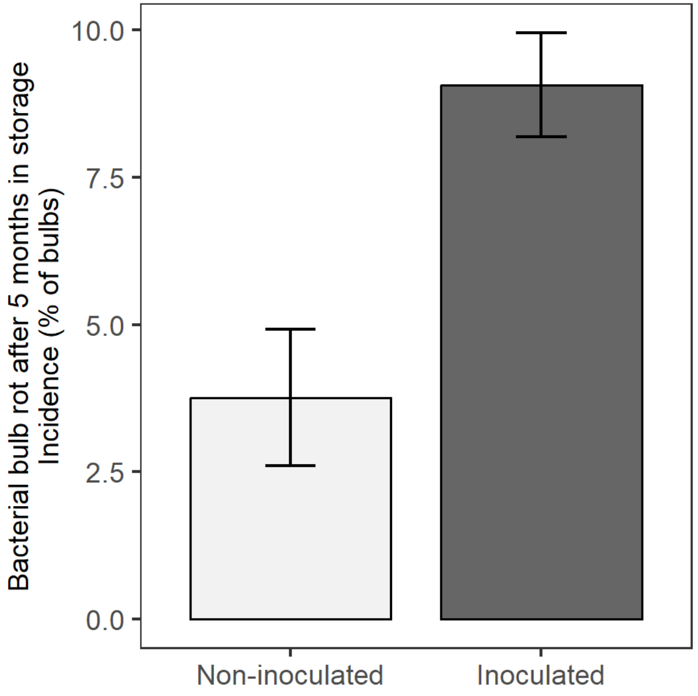
Marketable bulb yield at harvest (t/A)

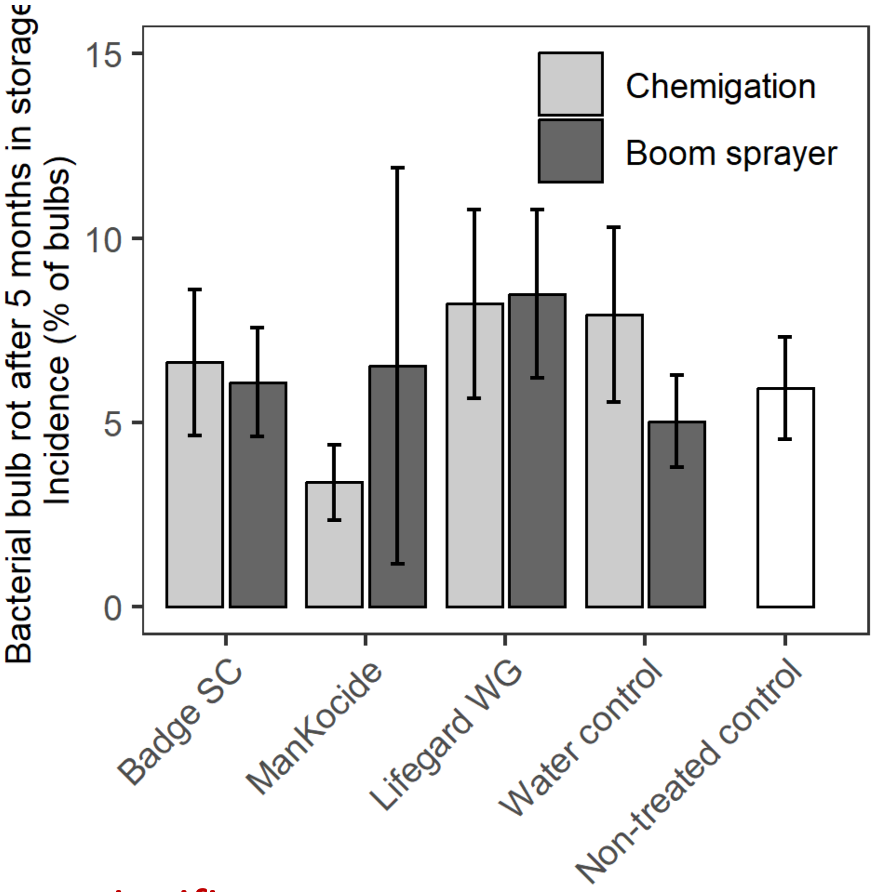


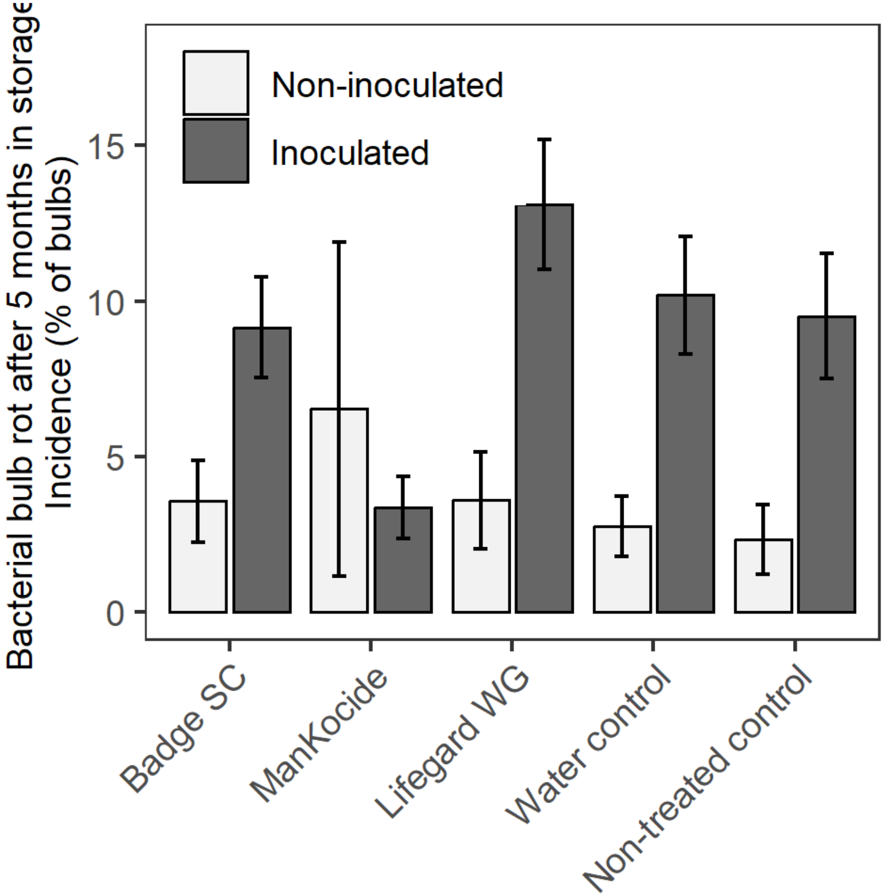
No significant effects

2023-24 Washington State Bactericide Trial

Total bacterial bulb rot (at harvest + after 5 months in storage)







Inoculation: *P* <0.0001
All other ANOVA factors were not significant

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

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

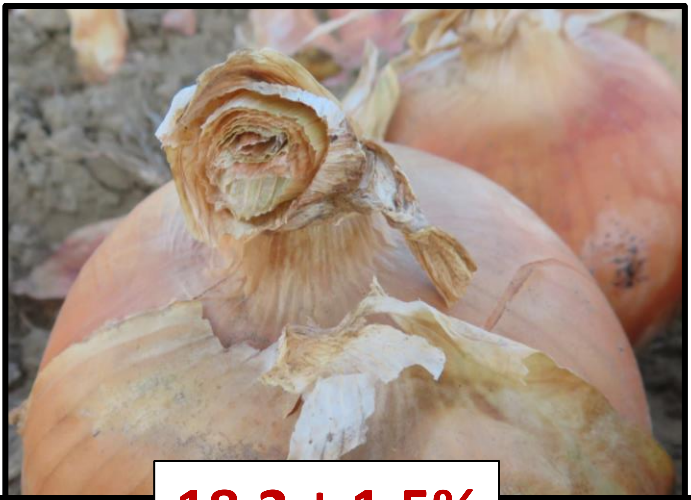
Dutta et al. 2022. Plant Disease Management Reports 16:V107.

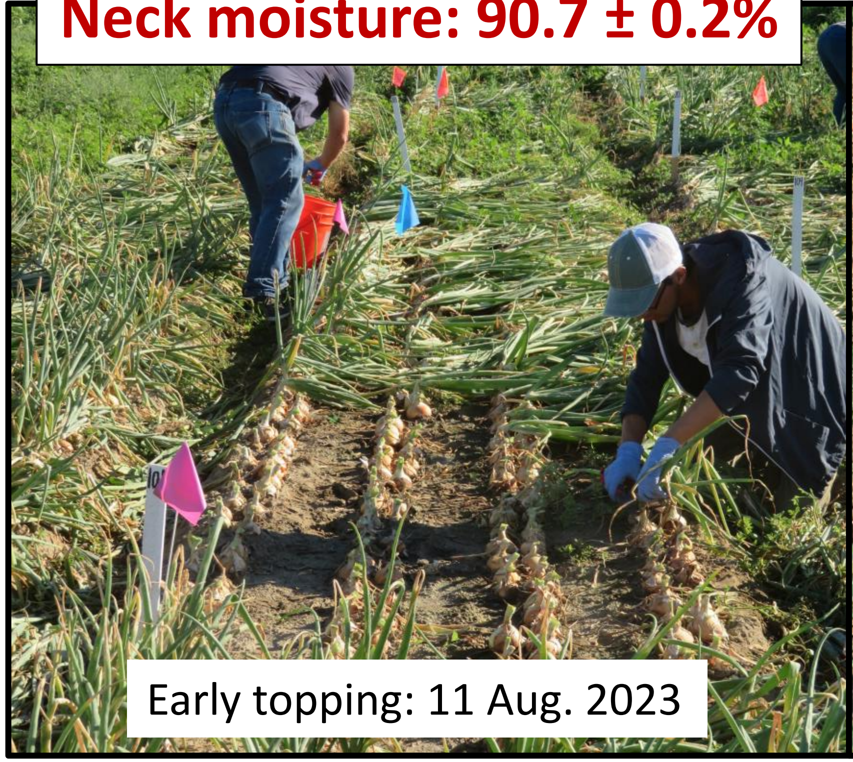
2022 trial	Internal bacterial rot incidence (%)7.5
7.5 cm	10.0 b
5.0 cm	11.5 b
2.5 cm	18.0 a
0 cm	19.5 a

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

2023-24 WA Timing of Topping Trial

- Trial in center-pivot irrigated field, WSU Vegetable Extension Farm, Pasco
- Split plot RCBD with 5 replications per treatment combination
  - Main plots: Inoculated (*B. gladioli* & *P. agglomerans*) or not at early tops down (27 July) & 2 weeks later (10 August)
  - Split plots: Bulbs topped early (11 Aug.), standard (25 Aug.), or late (12 Sep.)
- Measured moisture content in 2-cm cross-section of neck of ~50 bulbs/plot at topping
- Bulbs harvested, sized, weighed on 12 Sep., bacterial culls & marketable bulb yield
- Marketable bulbs stored for 5 months, rated incidence/severity of bulb rot

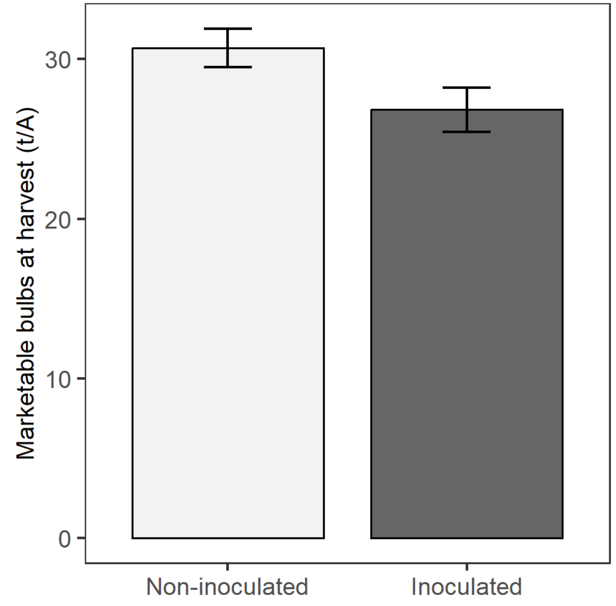


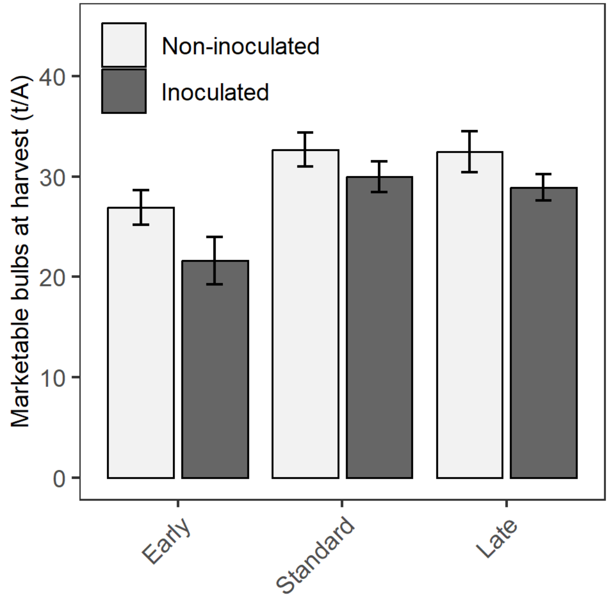

Neck moisture: 90.7 ± 0.2%
Early topping: 11 Aug. 2023


59.5 ± 2.0%
Standard topping: 25 Aug. 2023


18.2 ± 1.5%
Late topping: 12 Sep. 2023

2023-24 WA Timing of Topping Trial



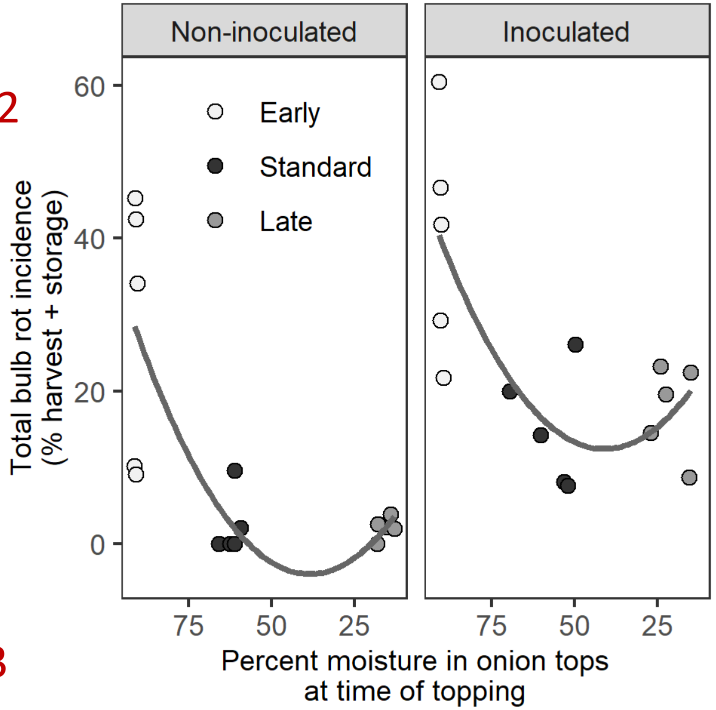


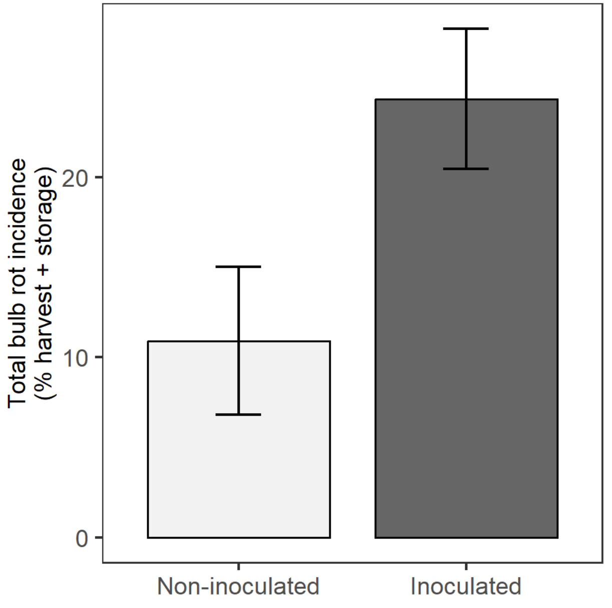
Marketable yield

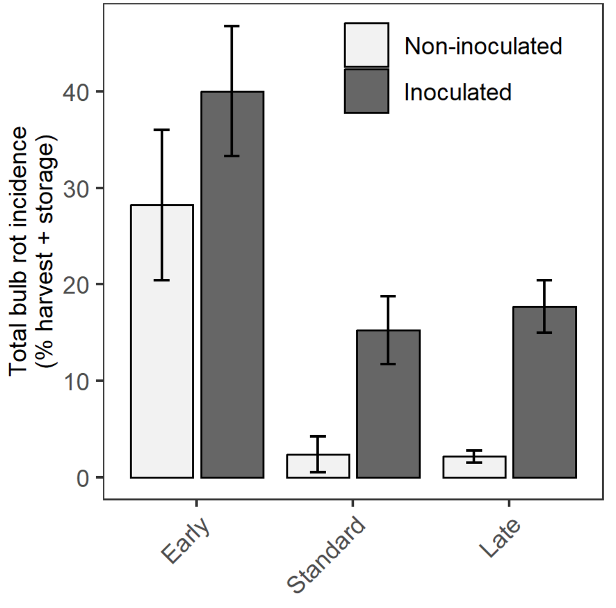
Inoculation: *P* = 0.0054

Topping: *P* = 0.0002

Inoc*Topping: *P* = 0.6822







Total bulb rot

Inoculation: *P* = 0.0003

Topping: *P* < 0.0001

Inoc*Topping: *P* = 0.8433

The Bacterial 'Rot Race'

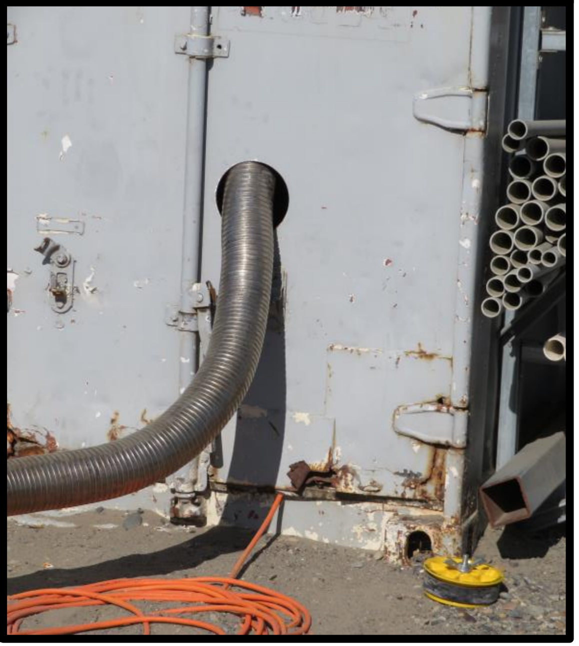
- Once tops start to fall, neck tissue is dying and losing resistance to infection
- While necks are still green (moist) and fallen over, bacteria (and fungi) become active and move down the neck toward the bulb
- **Race to dry the necks before infections get to the bulbs**
- Topping = wounding = entry for bacteria (and fungi) into the neck
- If necks are fully dry when topped, neck length is not critical
- If necks are moist (green) when topped, top long so necks dry before bacteria (and fungi) get to the bulbs
- Other cultural practices to speed field curing: undercutting, terminating irrigation by ~50% tops down, avoid excessive and late N applications

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 (24 fl oz) thermofogged for 1 h, container sealed for 8 h
  2. Sanidate 5.0 (24 fl oz) thermofogged for 1 h, container sealed for 8 h
  3. StorOx 2.0 (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

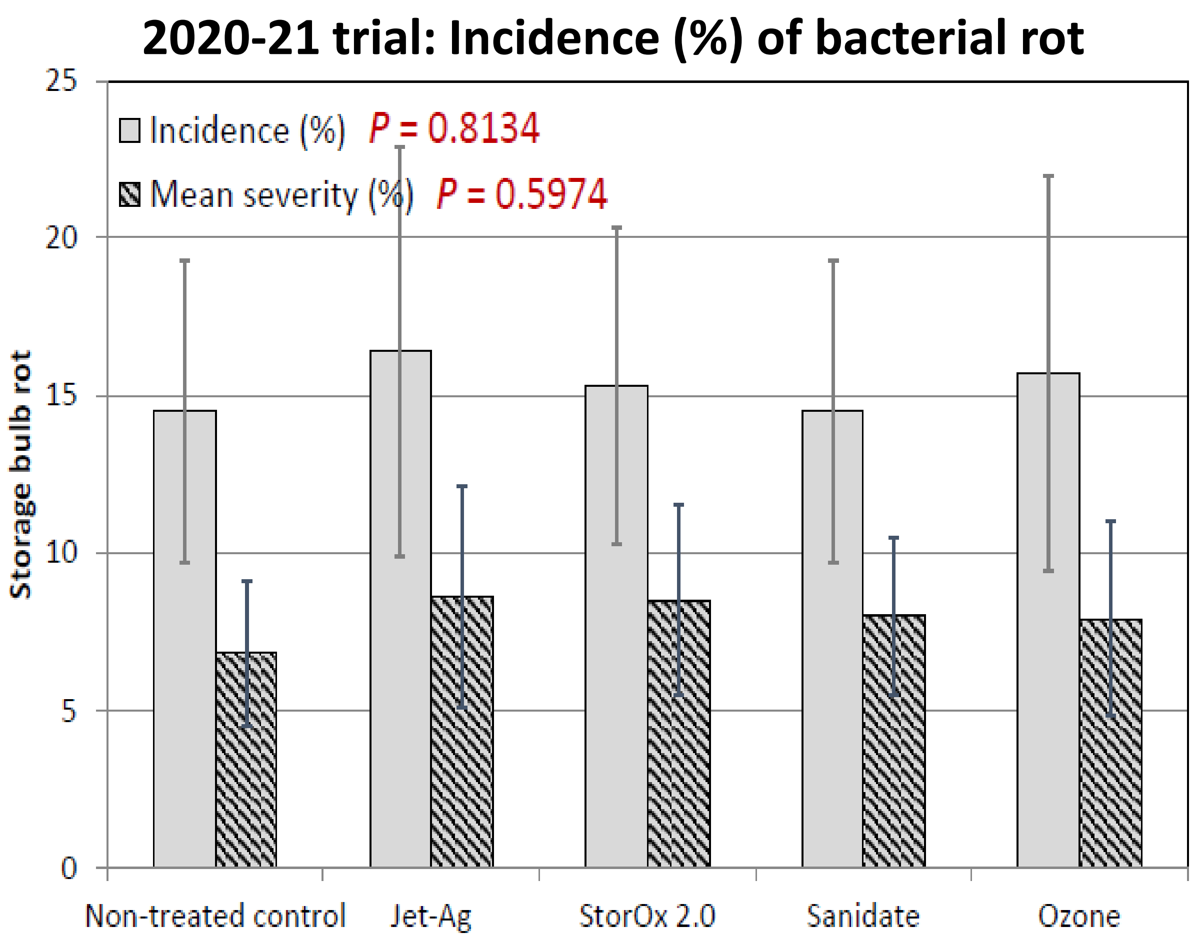


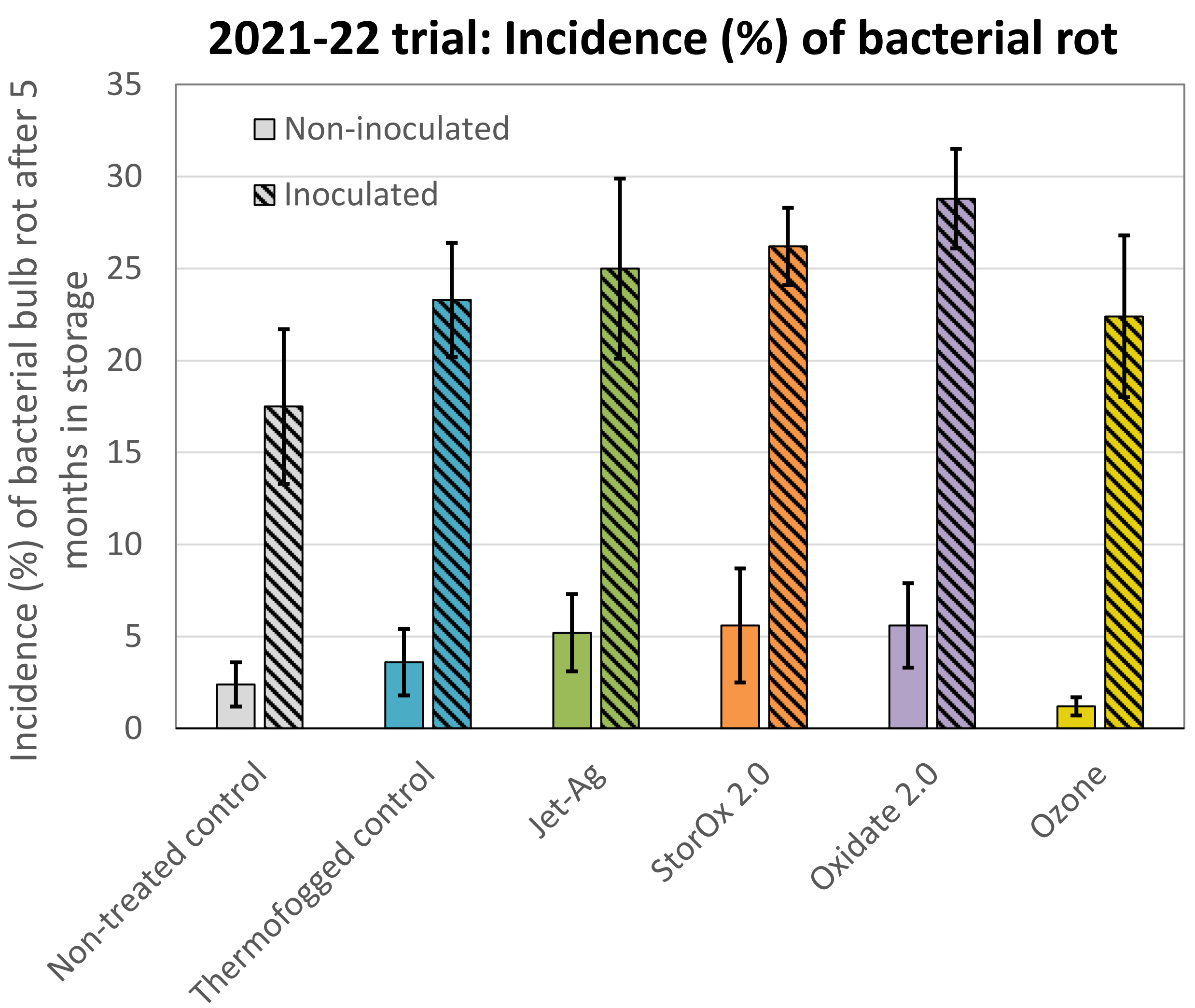
2021-22, 2022-23, 2023-24 WA trials

- 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





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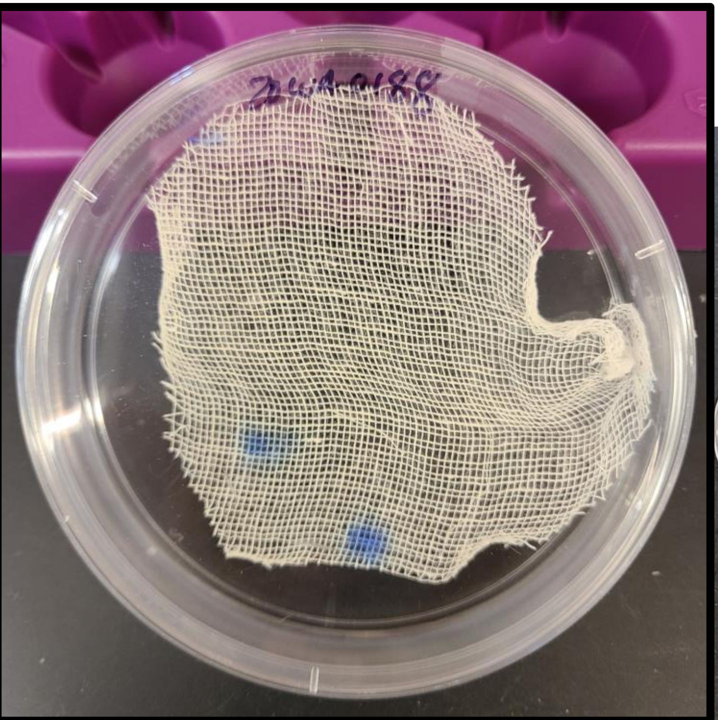
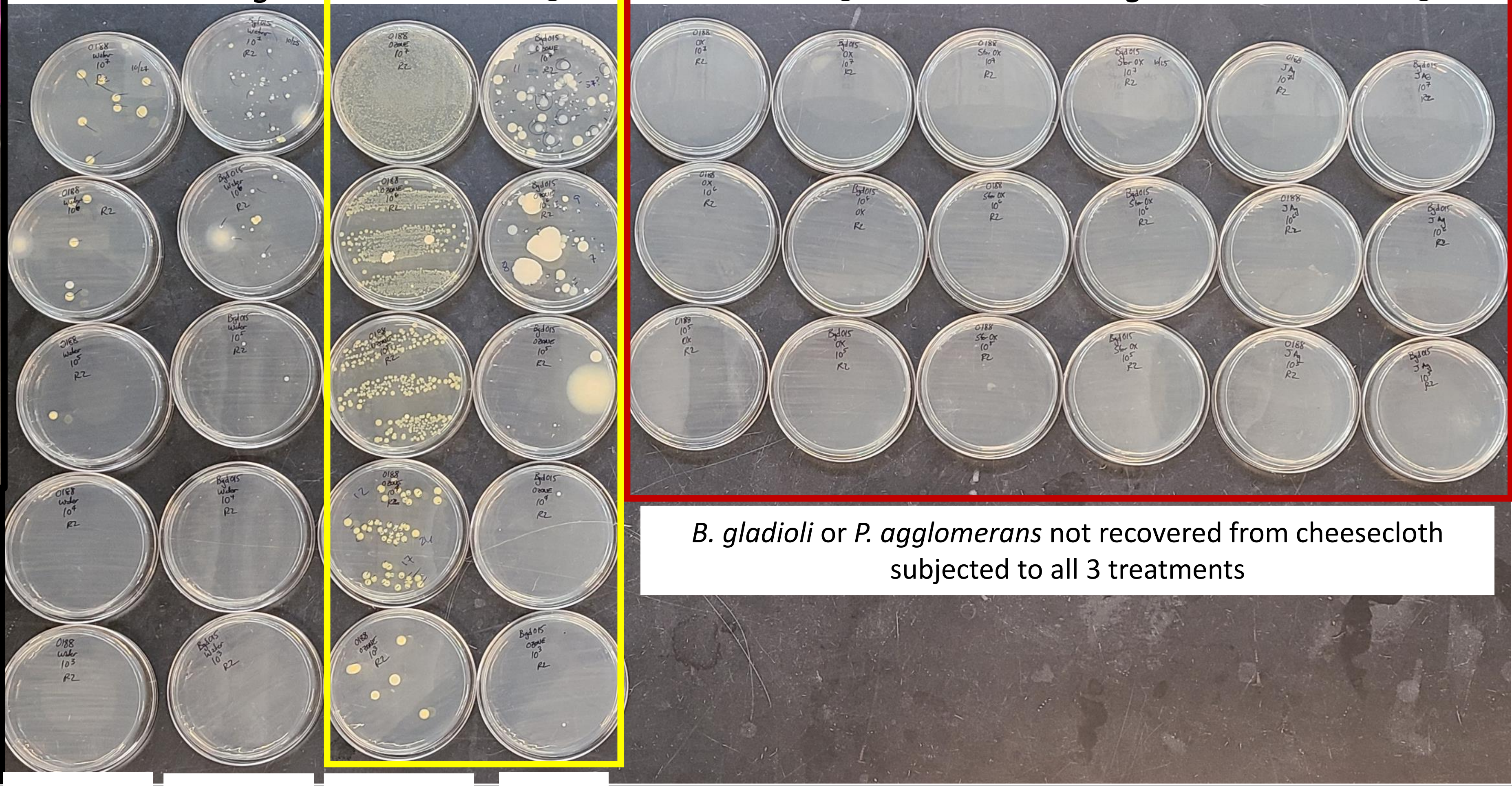
2021-22 WA trial evaluating postharvest application of disinfectants



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

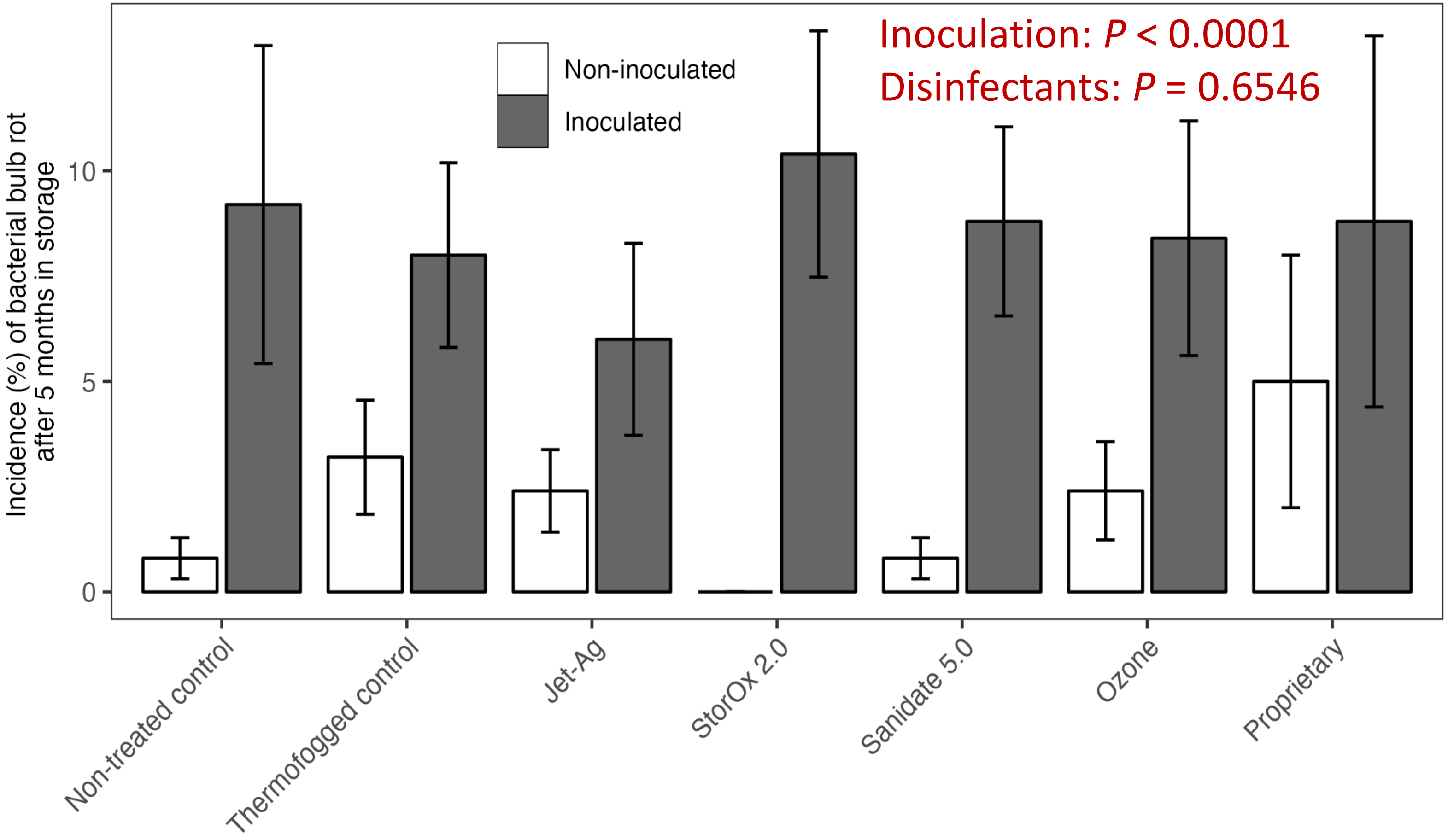


1.7×10^3	3.1×10^5	1.6×10^6	0

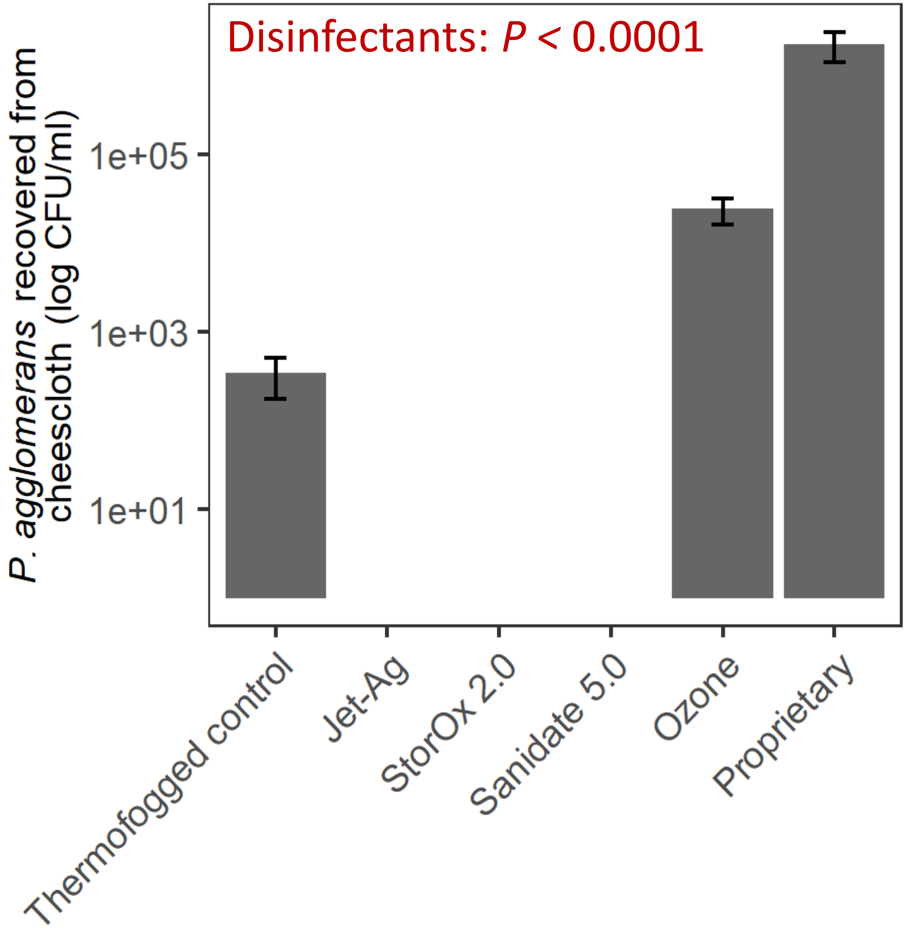
B. gladioli or *P. agglomerans* not recovered from cheesecloth subjected to all 3 treatments

2023-24 WA evaluation of postharvest disinfectant applications

Incidence (%) of bacterial bulb rot after 5 months in storage



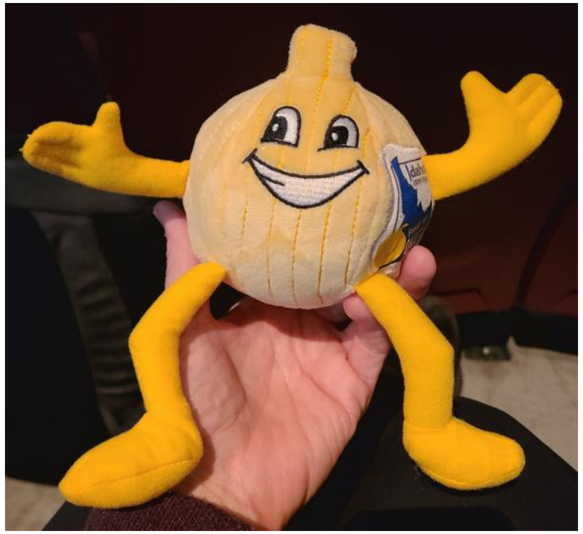
Recovery of *Pantoea agglomerans* from cheesecloth exposed to disinfectants



Evaluation of postharvest disinfectant applications for managing bacterial bulb rots in storage

- Application of disinfectants to onion bulbs after harvest provided no control of bacterial bulb rot in storage (3 years of WA trials & 2 years of CO trials)
- Hydrogen peroxide + peroxyacetic acid products were highly effective at killing *P. agglomerans* on cheesecloth
- Ozone had no effect on bulb rots and limited efficacy against *P. agglomerans* on cheesecloth
- Disinfectants do not penetrate outer, wrapper scales of onion bulbs so they do not make direct contact with bacterial (and fungal) infections inside bulbs
- Potential value for surface infections of other commodities?

Summary



- You cannot spray your way out of bacterial bulb rots
- Focus on **cultural management practices**:
  - Irrigation
    - Final irrigation at ~50% tops down
    - Frequency of irrigation, starting mid-June
  - Nitrogen
    - Avoid excessive rates of application
    - Avoid late-season applications
  - Field curing
    - Avoid topping when necks are still green/moist
    - Top long necks if you must top before necks are fully dry
    - Undercut to speed drying of necks
- Disinfectants applied to bulbs in storage will not prevent bacterial rot

Allium net

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

Acknowledgements

- **WSU Stop the Rot teams** – Tim Waters', Gabriel LaHue's, and Lindsey du Toit's teams
- **Other Stop the Rot team members**
- **Grower-cooperators & CBORC**
- **IVI**
- USDA NIFA SCRI Project No. 2019-51181-30013

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