United States Department of Agriculture

**Progress Report**

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| **Title:** | **Stop the rot: Combating onion bacterial diseases with pathogenomic tools and enhanced management strategies** |

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**Non-Technical Summary**


Onion bulb crops are grown on ~140,000 acres/year in the U.S. at a farm-gate value of $925M. Bacterial pathogens cause >$60M in losses annually to this industry. Losses can be particularly severe for stored bulbs as bacterial bulb rots typically only develop in storage, after all production costs have been incurred. Poor scientific understanding of the diversity and epidemiology of bacterial pathogens, and the lack of systemic bactericides limit industry capacity to mitigate these losses; this is in sharp contrast to the significant work that has been accomplished with fungal pathogens of onion. This 'Stop the Rot' project organizes 24 scientists in diverse disciplines across the U.S. to research the complete system (host, pathogen, and environment) of bacterial diseases of onion. The long-term goal is to support profitability and sustainability of onion production in the U.S. using a coordinated, national survey of bacterial pathogens affecting onion crops combined with a stakeholder-focused, systems approach to investigate how production practices, inoculum sources, and environmental conditions can be managed to develop effective, practical, economically-viable, and environmentally-sound strategies to limit losses to bacterial diseases.

The project has two primary objectives linked iteratively in a systems approach. The first objectives utilizes comparative genomics to identify genetic factors that enable some bacteria to cause diseases on onion, and to develop practical diagnostic tools as well as phenotypic resistance screening methods for bacterial pathogens of onion. A survey of onion bacterial diseases over three seasons in each of 12 states representing the seven primary regions of onion production in the U.S. will be used to understand the diversity of onion bacterial pathogens in the U.S., and to develop a National Onion Bacterial Strain Collection. Genomic assessment of this bacterial collection will enable us to understand the genetic basis of bacteria that can cause diseases of onion across the U.S. This, in turn, will be used to design rapid, accurate, and robust methods of detecting and identifying onion bacterial pathogens. The collection also will be used to develop methods of screening onion germplasm for resistance to bacterial pathogens. The screening methods can then be used in breeding programs to develop cultivars with greater resistance than currently available. The second objective focuses on onion bacterial disease management by examining

how irrigation practices, fertility practices, pesticide programs, cultural practices, post-harvest practices, and bacterial disease modeling can be managed to develop effective, practical management programs. A 12-person, nation-wide onion Stakeholder Advisory Panel worked with our team from 12 states to prioritize the objectives and develop approaches for this project. Broad, stakeholder-based evaluations of the research results over the duration of the project will ensure results are delivered to constituents and that solutions developed are viable economically and environmentally.

## Accomplishments

### Major goals of the project

The ability of growers to manage bacterial diseases of onion is limited compared to many fungal diseases because of unique epidemiological and management aspects of the bacterial pathogens, which cause >$60 million/year in damages to the U.S. onion industry. Losses can be particularly severe for stored onions as bacterial bulb rots typically develop after harvest, with losses ranging from 5-100% in individual fields. The cost of sorting symptomatic bulbs can result in rejection of entire fields if the incidence of rot exceeds 30%. There are effective tools to manage other factors that can cause storage losses (e.g., sprouting and fungal bulb rots), in contrast to bacterial rots. This project takes a systems approach encompassing the pathogen, host, environment, economics, and stakeholder priorities to address the need to manage onion bacterial diseases far more effectively. The goal of this project is to support long-term profitability and sustainability of onion production in the U.S. using a stakeholder-informed, systems approach by:

1. Undertaking a national survey of onion bacterial diseases;
2. Developing a National Onion Bacterial Strain Collection (NOBSC);
3. Using this resource for genotypic characterization of the pathogens to design rapid, accurate, and robust methods for detecting and identifying onion bacterial pathogens across the U.S.;
4. Developing methods of screening onion germplasm for resistance to these bacteria;
5. Integrating the diagnostic and detection tools into comprehensive integrated disease management research trials;
6. Generating predictive bacterial disease models across diverse regions of onion production in the U.S.; and
7. Implementing a broad, Stakeholder Advisory Panel (SAP)-informed dissemination plan to deliver results to constituents.

The goal utilizes a coordinated, national survey of bacterial pathogens affecting onion crops combined with a stakeholder-focused, systems approach to investigating how production practices, inoculum sources, and environmental conditions can be managed to develop effective, practical, economically-viable, and environmentally-sound strategies to limit losses to bacterial diseases. The project has two primary objectives linked iteratively in a systems approach:
A: Utilize comparative genomics to identify virulence factors and develop practical diagnostic tools, as well as phenotypic resistance screening methods for bacterial pathogens of onion (60% of the effort for this project). The four activities for this objective entail: **A1**) national onion bacterial disease surveys and development of a National Onion Bacterial Strain Collection (NOBSC), **A2**) onion bacterial pathogenomics, **A3**) development of onion bacterial pathogen detection tools, and **A4**) development of onion phenotyping (screening) protocols for reactions to bacterial pathogens.

B: Examine how key production practices, environmental factors, and inoculum sources that impact bacterial disease outbreaks can be managed to develop practical solutions that are viable environmentally and economically (40% of the project effort). This will entail six areas of investigation: **B1**) irrigation management, **B2**) fertility management, **B3**) pesticide programs, **B4**) cultural management, **B5**) post-harvest management, and **B6**) bacterial disease modeling.
Objective A addresses the SCRI focus area of "efforts to identify and address threats from pests and diseases" by clarifying for stakeholders nationwide, using standardized protocols, the diversity of onion bacterial pathogens causing losses in each of three growing seasons. The National Onion Bacterial Strain Collection resulting from this project will provide an invaluable resource for this and future projects on genetic studies of pathogens and associated bacteria in/on onions, e.g., whole genome sequencing to find virulence factors in order to develop robust molecular tools to detect and differentiate pathogenic vs. non-pathogenic bacteria. This will facilitate development of effective phenotypic methods of screening onion germplasm for reactions to diverse bacterial pathogens, alone and in combinations, which will facilitate future efforts to breed for resistance.
Objective B addresses the SCRI focus area efforts to identify and address threats from pests and diseases" as well as "efforts to improve production efficiency, handling and processing, productivity, and profitability". This coordinated, multi-state objective will determine how regional onion production practices, environmental conditions, and inoculum sources can be managed using practical, economically-viable, and environmentally-sound strategies to limit losses to bacterial rots in fields, storage, and shipping.

### What was accomplished under these goals?

OBJECTIVE A: PATHOGENOMICS TOOLS

A1. Bacterial disease surveys, NOBSC

Onion foliage and bulbs were surveyed in 12 states. In Years 1 and 2, 116 bacterial genera were isolated from >4,800 samples of symptomatic onion leaves and bulbs, the 5 most prevalent being Pantoea, Pseudomonas, Burkholderia, Enterobacter, and Bacillus. The distribution and pathogenicity of genera varied across regions. 1,265 strains (pathogenic and non-pathogenic) are now in the National Onion Bacterial Strain Collection (NOBSC), to represent diversity in the regions surveyed. These are identified to species and tested for pathogenicity on onion. NOBSC metadata will be available publicly on Alliumnet.com.

A2. Onion bacterial pathogenomics

Bacterial community analyses in symptomatic and asymptomatic onion bulbs were completed, with a manuscript in preparation. Dickeya and Pectobacterium, soft rot bacteria, were found in asymptomatic but not in symptomatic bulbs from Georgia. Virome analyses of symptomatic bulbs revealed bacteriophages. We are isolating those that infect Pantoea ananatis and P. agglomerans. One purified and characterized to date is in the Autographiviridae. MLSA of Rahnella and Enterobacter strains was initiated. R. perminowiae, R. aceris (most prevalent), R. aquatalis, R. rivi, and R. sonasera were identified. All were non-pathogenic except a WA isolate, an Ewingella sp. (first report on onion).

We compiled 81 Pantoea genomes (66 P. agglomerans) for the survey plus international isolates. There was no link between P. agglomerans geographic source and phylogeny. Consistent with P. ananatis, presence of the HiVir gene cluster in P. agglomerans correlated with pathogenicity on onion. Genomic comparison identified a region in the HiVir cluster conserved enough to design a PCR primer set for virulent Pantoea strains.

Plasmid-borne copper resistance gene clusters (copABCDRS) were found in about half the sequenced P. agglomerans strains, in three clusters (A, B, and C). The A type was most common, with P. agglomerans strains resistant to 200 ppm copper sulfate. Strains with a B2 sub-type were resistant to at least 300 ppm. Cop genes were more prevalent in onion pathogenic strains (20/26) vs. non-pathogenic strains (14/40). Strains with cop genes were alt positive (tolerant of sulfur). Cop genes might clarify why copper treatments been ineffective in some trials.

A3. Diagnostic tools

Species-specific PCR assays were designed for P. agglomerans and P. ananatis, with primers and probes specific to the HiVir gene cluster. An assay designed to HiVirD looks promising. Assays for P. ananatis and P. agglomerans will be evaluated in Year 4. Samples of soil, seed, irrigation water, and onion plants from NY, WA and CA were sent to Woodhall for validating the diagnostic assays.

A4. Phenotypic screening methods

The 2021-22 WA onion cultivar trial used 3 cultivars from each of 4 maturity groups, inoculated with Pantoea agglomerans and Burkholderia gladioli. Differences in bulb yield of inoculated vs. non-inoculated plots were greater for earlier maturing cultivars. Blocking inoculations by cultivar maturity avoided confounding maturity at inoculation with susceptibility to bacterial pathogens. Severe heat stress in June 2021 impacted earlier maturing cultivars more (yield and bacterial diseases). The trial was repeated in 2022, with bulbs to be rated in Feb. 2023. In GA, 52 Vidalia onion cultivars and the USDA NPGS Allium germplasm collection were evaluated for resistance to P. ananatis in an inoculated field trial. A 2022 cultivar trial in CA was inoculated and harvested. Bulb rot incidence and yield will be measured. A 2022 cultivar trial was planted in NY. Bulbs from non-inoculated plots in the CA, WA and NY cultivar trials will be used to compare phenotypic screening using bulb injection vs. scale inoculation.

OBJECTIVE B: ONION BACTERIAL DISEASE MANAGEMENT

Results of Year 2 trials were finalized in Year 3 once bulbs in storage were rated for bacterial rots. Trials in Year 3 focused on management options that showed promise in Years 1 and 2, including irrigation practices (WA, OR), fertility practices (WA, GA, PA), cultural practices (WA, GA, NY), pesticide programs (WA, PA, UT, GA, CA, OR, CO), and postharvest disinfection (WA, CO). Year 3 trial results are pending.

Recent results with practical application include:

- In OR, drip irrigation reduced bulb rot but not bulb yield compared to overhead irrigation. In CA, bacterial leaf blight and bulb rot were less prevalent, and bulb yield was greater, in drip vs. overhead irrigated plots.
- Changing irrigation frequency did not affect bacterial bulb rots in WA in Year 2.
- In WA, early termination of overhead irrigation did not affect bulb yield but reduced bacterial bulb rot. In OR, early termination of drip irrigation reduced bulb yield but not bacterial bulb rots.
- In GA, N-fertility rates and timing of final N application did not affect bulb rot in Year 3, with low disease pressure.
- In GA trials, LifeGard + copper bactericides reduced bulb rots. In contrast, coppers and Lifegard had no effect on bacterial bulb rots in WA, PA, and UT.
- Year 2 WA trials on 3 cultural practices: Undercutting treatments did not affect bacterial leaf blight, bulb rot, or bulb yield. Rolling tops increased bacterial leaf blight but not bulb yield or bulb rot. Early topping increased bacterial bulb rot vs. normal

and late topping as necks had not cured by early topping, resulting in injury to moist, green necks predisposed to infection. Cultural practice trials were repeated in Year 3 in WA, with harvest bulbs to be evaluated in storage in Feb. 2023.

- Year 2 and 3 trials in GA showed clipping onion necks 3 or 5 inches long led to less bacterial bulb rot vs. clipping 1 inch long. Following 3 years of trials, growers in GA are training workers to leave onion necks 3-5 inches long when clipping by hand, or growers are switching from straight-blade undercutters to chain diggers for harvest to reduce bacterial bulb rot.
- Year 2 trials in WA and CO again indicated no benefit to applying ozone or hydrogen peroxide + peroxyacetic acid products to onion bulbs in storage. The products do not penetrate wrapper scales. A WA grower-co-operator trial had similar results.

RISK MODELING
Given challenges in gathering proprietary data from commercial onion farms and storage facilities, we refocused on field data collected in Stop the Rot field trials. Using knowledge from the trials, we are developing a simple risk-scoring approach for growers based on work done for an Onion ipmPIPE project. We will test this approach with onion stakeholders in Year 4.

ECONOMIC ASSESSMENTS
Co-PI Colson completed preliminary economic analyses of: Year 1 GA trials assessing onion yield and losses to center rot under low vs. high input vs. grower standard practices; returns for bactericides used by growers in GA, NY, and WA; nitrogen application rates for 2 years in NY. Colson developed an annual survey of the Stakeholder Advisory Panel in Year 3. Results were communicated to grant leadership and factored into team activities.

OUTREACH AND EXTENSION
Year 3 outreach included publication of results of Year 1 and 2 trials, and articles in trade publications and newsletters summarizing new knowledge, that have a wide reach to onion growers and industry.
Outreach has included:

- Articles in Onion World, Veg News, and in newsletters of the National Onion Association, regional grower associations, and extension services;
- Presentations at grower meetings, conferences, field days and tours;

- Re-launch and updating of Alliumnet.com. Visits increased significantly, driven by the combined annual meetings of NARC, W-4008, and Stop the Rot in 2022.

PROJECT MANAGEMENT
Coordination, communication, and integration have been supported by monthly videoconferences, bi-monthly conference calls, and annual meetings of the project team and SAP.

**What opportunities for training and professional development has the project provided?**

STUDENTS
The grant has provided the opportunity for several graduate students and post-doctorates to work on different aspects of the project:

- Adri Grobler, MSc student at the University of Pretoria, is working on detecting bacteriophages against Pantoea species, under the supervision of Prof. Teresa Coutinho.
- Fanele Mnguni, PhD student at the University of Pretoria, is continuing her work under the supervision of Prof. Teresa Coutinho, on identification and comparative genomics of Rahnella species, including strains isolated from onions in Stop the Rot bacterial surveys in the US.
- Patience Mateka Modiba, PhD student at the University of Pretoria is working on identification and comparative genomics of Enterobacter species under the guidance of Prof. Teresa Coutinho, including strains isolated from onions in Stop the Rot bacterial surveys in the US.
- Tessa Belo, MS student in the Soils & Water program at the Northwestern Washington Research and Extension Center of Washington State University. Advised by collaborator LaHue and co-advised by PD du Toit. Thesis topic: Impacts of irrigation and fertilization practices on bacterial diseases in onion bulb crops in the Columbia Basin. Completed in spring 2022.
- Antoinette Machado, MS student at Colorado State University in January 2020, supervised by co-PI Uchanski. Thesis topic: Evaluation of bactericides and plant defense inducers to manage center rot of onion in Colorado. Completed in spring 2022.
- Bed Prakash Bhatta, a PhD student at Texas A&M AgriLife Research - Uvalde is being trained on isolation, culture, and

inoculation of bacteria under this project. Thesis topic: Breeding for anthracnose and Fusarium wilt resistance in watermelon.

- Ram Neupane, Plant Pathology PhD student at Pennsylvania State University (started Spring 2021). Thesis topic will be related to bacterial diseases of onion.
- In Pennsylvania, three undergraduate students were involved in conducting lab and field activities associated with this project during summer 2022, from aiding in conducting the pathogenicity testing of isolates to planting, maintenance, and harvesting of field trials.
- Dr. Mei Zhao, postdoctorate in co-PD Dutta's program at the University of Georgia, focused on the bacterial survey, identification and characterization of bacterial isolates in GA, and greenhouse and field evaluations. Completed in spring 2022.
- Dr. Navdeep Singh, postdoctoral research associate at Washington State University (started Sep. 2020), primarily is working on other projects but is contributing to this work, particularly Objective B1, and will be engaged in this research until fall 2022.
- Dr. Gi-Yoon (Gina) Shin, postdoctorate in co-PI Kvitko's lab at the University of Georgia, is assisting with the bacterial survey, investigating the pathogenomics of Pantoea spp. that are pathogenic and non-pathogenic on onion, and identifying target regions of the genomes for developing molecular diagnostic tools for onion bacterial pathogens.
- At the University of Georgia, Logan Waldrop (M.A.B. student) and Morgan Hart (M.A.B. student) have been assisting PI Greg Colson with the data collection and analysis for the economics component of the project.
- In New Mexico, one undergraduate student assisted with bacterial surveys during the 2022 field season.

TRAINING AND PROFESSIONAL DEVELOPMENT

- Onion bacterial inoculation workshop, June 1, 2022, online. Attended by 32 people, including team members, graduate & undergrad students from STR regional labs and South Africa. https://youtu.be/7KaRS4MnxY4 Mike Derie and Stop the Rot project director Dr. Lindsey du Toit, presented an informal work session on inoculating onion field trials with pathogenic bacterial strains, to artificially create bacterial disease in the onions. The work session was presented to team members, graduate students and post-doctorates working on the Stop the Rot project.
- Experimental design workshop, June 8, 2022, online, on practical guidance and basic principles for good design of field trials. Attended by 29 people, including team members, graduate & undergrad students from STR regional labs and South Africa. https://youtu.be/Las-WkZZa2Y In this informal work session, Dr. Lindsey du Toit, Project Director for the Stop the Rot project, shared best practices and lessons learned in experimental design for agricultural field trials, and statistical analysis of the results. The work session was presented to team members, graduate students and post-doctorates working on the Stop the Rot project.

**How have the results been disseminated to communities of interest?**

In this reporting period, we have been actively reaching out to growers and stakeholders to: share new information and learning from the project as well as current scientific understanding of onion bacterial diseases and their management; understand growers' current state of knowledge about causes and management of bacterial diseases of onion, and identify priority concerns for growers and the onion industry regarding management of bacterial diseases.
Information has been shared with growers and stakeholders through a range of communication channels, including the Alliumnet website, research summaries, extension bulletins, articles in trade publications and presentations at growers' meetings and field days. Results were also shared at professional scientific meetings (primary venues being the American Phytopathological Society's Plant Health 2022 Conference in August 2022, and the National Allium Research Conference in March 2022).

REACHING GROWERS AND ONION INDUSTRY STAKEHOLDERS:

- Outreach to growers and onion industry stakeholders, field representatives and extension staff has occurred through informal visits with growers during field surveys, grower meetings, field days and technical workshops.

- Our Stop the Rot video playlist https://www.youtube.com/playlist?list=PLajA3BBVyv1zf2obB16bNEdQPQeLW_XB_contains several videos aimed at growers and the onion industry - introduction to rot identification, in both English and Spanish; a longer video providing an overview of bacterial diseases in onion and current management options; a short video of the experimental equipment for our field trials of post-harvest disinfection treatments; a short time-lapse video of the Red Scale Necrosis (RSN) assay; and two training videos on inoculating trials and designing field experiments.
- Outreach and dissemination of preliminary results to onion stakeholders and the industry has been conducted through a

number of informational articles in trade publications and extension newsletters (see list of publications) and websites/online alerts.

• Outreach to growers and industry stakeholders through the Stop the Rot Stakeholder Advisory Panel: Our 14-member Stakeholder Advisory Panel (SAP) brings a diverse range of expertise and experience to the project. The Panel includes growers, pathologists and onion breeders from onion growing regions across the US. Panel members are active in sharing information about the project to growers and onion industry stakeholders through their own regional and national networks in 12 states, and in bringing insights and information into the project from their networks. Our second annual meeting with the SAP was held on March 25, 2022, by videoconference. Panel members have actively participated in our monthly project team meetings by videoconference, and they continue to receive project updates, notes from the monthly meetings and our internal project team newsletters. Several panel members have also participated in team work sessions as subject matter experts.

REACHING ACADEMIC RESEARCHERS, EXTENSION PROFESSIONALS AND GRADUATE STUDENTS

• The project team now includes 24 research collaborators from 12 states, representing all 7 major U.S. onion growing regions, as well as onion bacteriologist Prof. Teresa Coutinho from South Africa. We hold monthly team videoconferences to share preliminary results and experiences and discuss recent findings. These monthly meetings of 1.5 to 2 hours have facilitated research and Extension collaborations. Almost all the project collaborators are also involved in extension services and education in their regions, which makes for efficient transfer of new information and research results from the team to extension professionals and thence to growers. Technicians and graduate students from each of the regional teams also join our monthly meetings and contribute actively to the discussions, providing feedback on methods and protocols and sharing their latest results with the full team in a collegial setting.

• Our annual project team meeting was held in Denver, CO, in March 2022, in conjunction with the National Allium Research Conference, the annual meeting of the W-4008 Multistate Onion Research Project, and the annual conference of the Colorado Fruit and Vegetable Growers Association. This allowed us to share and discuss research results with a large number of academic colleagues and onion stakeholders, both in person and online. Eighteen oral and 8 poster presentations were made at the National Allium Research Conference in Denver, CO, February 28, 2022.

• The results of Year 2 field trials in participating states have been published in 12 peer-reviewed Plant Disease Management Reports (see list of publications).

• Three articles have been published in scientific journals (see list of publications).

• Four poster presentations were shared at Plant Health 2022, the annual conference of the American Phytopathological Society.

• Posters were presented by team members at the International Conference on Plant Pathogenic Bacteria, Italy, July 2022, and at the conference of the Soil Science Society of America in April 2022.

**What do you plan to do during the next reporting period to accomplish the goals?**

OBJECTIVE A: PATHOGENOMICS TOOLS

A1. Bacterial surveys

In the next reporting period, we will complete pathogenicity testing and genus identification for bacterial strains isolated from onion crops during Years 1, 2 and 3. Regional labs will again send both representative pathogenic isolates and non-pathogenic isolates to UGA to represent the diversity found in each region. Strains sent to UGA will be identified to species using MLSA schemes, and tested for pathogenicity on onion. Metadata and results will be added to the NOBSC database and made available publicly on Alliumnet. Regional labs will plan for long-term storage and back-up of their regional collections, since the NOBSC will only include strains that are in the national collection.

A2. Pathogenomic analyses, virulence factors & bacterial community analyses

Additional strains sent to UGA for the NOBSC will be subjected to whole genome sequencing and examined to identify putative virulence factors associated with the ability to cause diseases on onion, in order to validate the virulence factors identified in the first 3 years of this project and for testing the molecular diagnostic tools being developed for onion-pathogenic strains of Pantoea spp. Results of the bacterial community analyses from asymptomatic and symptomatic bulbs collected from a field in each of GA and WA will help assess potential interactions among complex microflora associated with asymptomatic and symptomatic onion bulbs.

A3. Molecular diagnostic tools

PCR assays designed to differentiate pathogenic vs. non-pathogenic isolates of P. ananatis and P. agglomerans will be tested in Year 4 with seed, soil, water, foliar, and bulb samples sent to Woodhall's lab at the Univ. of Idaho. The PCR protocols will be modified as needed to optimize the species-specific and pathogenicity-specific assays.

A4. Phenotypic resistance screening methods

In Year 4, we will evaluate the suitability of the modified scale vs bulb assays for use in screening onion cultivars for

resistance to bacterial pathogens. Results will be compared for the bulb vs. scale assay comparison completed in CA, WA, and NY in 2022, and compared with results from cultivar field trials in each state.

OBJECTIVE B: ONION BACTERIAL DISEASE MANAGEMENT
In Year 4, the focus will be on outreach and dissemination of knowledge gained in the previous three years of field trials. A limited number of field trials will be completed, including repeated irrigation and fertility trials in WA and pesticide trials in CA that had to be abandoned in Year 3 due to very poor stand counts. We will focus on completing the data analysis of all Year 3 trials once bulbs in storage have been rated in Feb.-Mar. 2023, and publishing the results to share with growers and other stakeholders on Alliumnet, at meetings, and in various outreach materials. We plan to synthesize the trial results to highlight regional and national patterns and conclusions that should help growers make appropriate decisions about disease management options. We plan to refine a risk-based approach to decision support for growers, based on the trial results, and will be asking growers in different regions to test the prototype risk model in their onion crops in 2023.

ECONOMIC ASSESSMENTS
The potential for adoption of management recommendations based on results of these trials will be assessed annually by the SAP and stakeholders with economist Colson. Economic analyses will be developed from the results of various trials based on inputs (expenses) and outputs (marketable yield). This will include:

- Drafting academic articles reporting survey findings.

- Assisting the Extension team and grant leadership to incorporate findings from field trials into the Alliumnet website and outreach materials.
- Working with team members as field trial data become available to translate findings into cost-benefit and risk-based analyses.

OUTREACH AND EXTENSION

- In Year 4, we will direct more attention to synthesizing work from the first 3 seasons to highlight regional and national trends and patterns in bacterial diseases as well as options for management.
- Results from Year 3 work will be shared in research summaries, on Alliumnet.com, in project newsletters, trade publications, regional websites, and presentations at growers' meetings and field days.
- Plans are underway to develop more videos, "quick guides", highlights of annual project results, training and extension materials, and an interactive map of the USA with bacterial disease survey results.
- The newly redesigned Alliumnet.com website will be maintained to provide a home for national onion research collaborations, including USDA projects, National Allium Research Conference information and proceedings, links to National Onion Association meetings and events, and the W-1008, W-2008, W-3008 and W-4008 onion multi-state project reports, activities, and meeting details.

PROJECT MANAGEMENT AND COORDINATION
The third annual project team meeting is scheduled for January 5-7, 2023, in Savannah, GA, and the Stakeholder Advisory Panel videoconference is scheduled for February 3, 2023. Regular monthly videoconferences for the full team, regular meetings for the co-PIs every 2-3 months, and weekly meetings of the PD and Project Manager will continue in Year 4.

**Participants**

**Actual FTE's for this Reporting Period**

| Role | Non-Students or faculty | Students with Staffing Roles | | | Computed Total by Role |
|---|---|---|---|---|---|
| | | Undergraduate | Graduate | Post-Doctorate | |
| Scientist | 2.7 | 0.8 | 2.8 | 1.7 | 8 |
| Professional | 0.1 | 0 | 0 | 0 | 0.1 |
| Technical | 5.3 | 0 | 0 | 0 | 5.3 |
| Administrative | 0.9 | 0 | 0 | 0 | 0.9 |

**Accession No. 1020312** **Project No. WNP03104**

**Actual FTE's for this Reporting Period**

| Role | Non-Students or faculty | Students with Staffing Roles | | | Computed Total by Role |
|---|---|---|---|---|---|
| | | Undergraduate | Graduate | Post-Doctorate | |
| Other | 0.2 | 0 | 0 | 0 | 0.2 |
| Computed Total | 9.2 | 0.8 | 2.8 | 1.7 | 14.5 |

**Student Count by Classification of Instructional Programs (CIP) Code**

| Undergraduate | Graduate | Post-Doctorate | CIP Code |
|---|---|---|---|
| | 2 | | 01.01 Agricultural Business and Management. |
| 1 | 2 | 1 | 01.11 Plant Sciences. |
| | 1 | | 01.12 Soil Sciences. |
| 9 | 5 | 3 | 26.03 Botany/Plant Biology. |
| | | 1 | 01.99 Agriculture, Agriculture Operations, and Related Sciences, |

**Target Audience**

Stakeholders involved in the US onion industry are the primary audience for this project. This includes onion producers (farmers), packers, shippers, and associated stakeholders engaged in various capacities in onion production, distribution, and marketing, e.g., agronomists, crop consultants, farm managers, field workers; personnel associated with agricultural supply companies (fertilizer and pesticide dealers, irrigation supply companies, etc.), seed companies, and dealers; onion breeders (public and private); and onion storage and shipping/transport personnel and companies. Public and private research and extension specialists, undergraduate students, graduate students, and postdoctorates working with diverse aspects of onion production are also a target audience for this project.

The target audiences reached during this reporting period included:

- Onion growers, packers, processors, and associated stakeholders in the 7 main onion-growing regions of the US;
- Extension professionals in the 12 onion-growing states represented in this project;
- Onion researchers from the US and other countries attended a session dedicated to Stop the Rot project results at the National Allium Research Conference in Denver, CO on March 1, 2022 (93 participants);
- The project's 14-member Stakeholder Advisory Panel represents onion farms, regional onion associations, and major vegetable seed companies (including onion breeders and plant pathologists) from across the US, with one international member. Panel members conducted further outreach to their own networks on behalf of the project. Panel members who are grower representatives include Greg Bird (President of the Michigan Onion Committee), Bob Ehn (California Garlic and Onion Research Advisory Board), Charles Hall (Executive Director of the Georgia Fruit and Vegetable Growers Association), and Michael Locati (President of the Columbia Basin Onion Research Committee. The onion seed industry is represented by Peter Rogers and Juan Carlos Brevis (Nunhems), Scott Hendricks (Bayer), and Margreet Asma (Bejo Zaden).
- Ten undergraduate students, ten graduate students and four postdoctorates have worked on research directly related to the Stop the Rot project in this reporting period. They are conducting research in Washington State, Georgia, Texas, Pennsylvania, Colorado, New Mexico, and South Africa.

We used multiple channels to reach our target audience during this reporting period, including grower meetings and field days, conferences and workshops, the Alliumnet.com website, industry newsletters, trade publications, and extension videos. Project team members also reached out directly to growers in each of the onion-growing regions to recruit growers for participation in the bacterial field surveys.

During this reporting period, the Stop the Rot project page on the Alliumnet.com website received 7,888 page views from 4,290 visits by 3,065 users. This is a significant increase from page views in the previous reporting period.

Approximately 1,100 growers, agronomists, and industry professionals were reached directly through presentations at conferences, workshops, field days, and grower meetings in this reporting period. Many of the events were shifted away from in-person to virtual format due to COVID-19 constraints across the USA and in South Africa, which made it difficult to accurately count the number of people who were reached through presentations. Approximately 4,600 people have viewed

our series of project videos to date.
Communication and outreach materials and specific activities are reported in detail in the list of products.

**Products**

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Published | 2022 | YES |

**Citation**

Manzeal Khanal, Sujan Timilsina, Bed Prakash Bhatta, Khumbuzile Bophela, Teresa Coutinho, Kimberly Cochran, and Subas Malla. (2022). Pseudomonas uvaldensis sp. nov., a bacterial pathogen causing onion bulb rot. Int. J. Syst. Evol. Microbiol. 2022;72:005311. DOI 10.1099/ijsem.0.005311

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Published | 2022 | YES |

**Citation**

Mei Zhao, Chris Tyson, Hsiao-Chun Chen, Sujan Paudel, Ron Gitaitis, Brian Kvitko, Bhabesh Dutta, Pseudomonas alliivorans sp. nov., a plant-pathogenic bacterium isolated from onion foliage in Georgia, USA, Systematic and Applied Microbiology, Volume 45, Issue 1, 2022, 126278, ISSN 0723-2020, https://doi.org/10.1016/j.syapm.2021.126278. https://www.sciencedirect.com/science/article/pii/S0723202021001016)

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Published | 2022 | YES |

**Citation**

Shin, Gi Yoon, Amy Smith, Teresa Ann Coutinho, Bhabesh Dutta, and Brian Kvitko. Validation of species-specific PCR assays for the detection of Pantoea ananatis, P. agglomerans, P. allii and P. stewartii. (2022) Plant Disease. https://doi.org/10.1094/PDIS-08-21-1810-SC

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Published | 2022 | YES |

**Citation**

du Toit, L.J., Derie, M.L., Gundersen, B., Waters, T.D., and Darner, J. 2022. Effects of bactericide and herbicide applications on bacterial leaf blight and bulb rot of onion, Pasco, WA, 2021-22. Plant Disease Management Reports 16:V150.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Published | 2022 | YES |

**Citation**

du Toit, L.J., Derie, M.L., Gundersen, B., Waters, T.D., and Darner, J. 2022. Effects of late-season cultural practices on bacterial leaf blight and bulb rot in an onion crop, Pasco, WA, 2021-22. Plant Disease Management Reports 16:V149.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Published | 2022 | YES |

**Citation**

du Toit, L.J., Derie, M.L., Gundersen, B., Waters, T.D., and Darner, J. 2022. Efficacy of disinfectants applied to onion bulbs in storage for control of bacterial bulb rots, Pasco, WA, 2021-22. Plant Disease Management Reports 16:V148.

**Accession No. 1020312** **Project No. WNP03104**

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Published | 2022 | YES |

**Citation**

du Toit, L.J., Derie, M.L., Gundersen, B., Waters, T.D., and Darner, J. 2022. Susceptibility of 12 onion cultivars to bacterial leaf blight and bulb rot in Pasco, WA, 2021-22. Plant Disease Management Reports 16:V151.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Published | 2022 | YES |

**Citation**

Dutta, B., and Tyson, C. 2022. Evaluation of digging methods on post-harvest incidence of external and internal bacterial bulb in onion, Georgia, 2021. Plant Disease Management Reports 16:V109.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Published | 2022 | YES |

**Citation**

Dutta, B., and Tyson, C. 2022. Evaluation of harvesting methods on post-harvest incidence of external and internal bacterial bulb rot in onion, Georgia, 2021. Plant Disease Management Reports 16:V108.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Published | 2022 | YES |

**Citation**

Dutta, B., and Tyson, C. 2022. Evaluation of neck-clipping length on post-harvest incidence of external and internal bacterial bulb rot in onion, Georgia, 2021. Plant Disease Management Reports 16:V107.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Published | 2022 | YES |

**Citation**

Dutta, B., Foster, M.J., and Donahoo, W.M. 2022. Evaluation of bactericides and plant defense inducers to manage internal bacterial rot of onion in Georgia, 2021. Plant Disease Management Reports 16:V044.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Published | 2022 | YES |

**Citation**

Hoepting, C.A., S. K. Caldwell and E. R. van der Heide. 2022. Evaluation of selected pesticides for control of bacterial bulb rot in onion, NY, 2021. Plant Disease Management Reports 16:V168

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Published | 2022 | YES |

**Citation**

Hoepting, C.A., S.K. Caldwell, and E.R. van der Heide. 2022. Evaluation of cultural practices to reduce bacterial bulb rot in onions that are failing to lodge, NY, 2021. Plant Disease Management Reports 16:V167.

**Accession No. 1020312** **Project No. WNP03104**

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Published | 2022 | YES |

**Citation**

Machado Burke, A., M. Uchanski, and J. Davey. 2022. Evaluation of bactericides to manage slippery skin in onion in Colorado, 2021. Plant Disease Management Reports 16:V128.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Published | 2022 | YES |

**Citation**

Sidhu, J., Dubose, J. and Fernberg J. 2022. Evaluation of bactericides for management of bacterial leaf blight and bacterial bulb rot in onions, 2021 (California). Plant Disease Management Reports 16:V026.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Aegerter, B. (2022) Stop the Rot: Update on bacterial bulb rot research. Presentation at the Annual Muck Vegetable Growers Conference in Ontario, Canada, April 7, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Rob Wilson, Kevin Nicholson, and Brenna Aegerter (2022). The influence of irrigation method (solid-set sprinkler irrigation or drip irrigation) on the incidence and severity of bacterial diseases in onions grown in Northeast California. Presentation at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Mei Zhao, Shaun Stice, Gi Yoon Shin, Teresa Coutinho, Ron Gitaitis, Brian Kvitko, and Bhabesh Dutta (2022). A novel biosynthetic gene cluster across the Pantoea species complex is important for pathogenicity in onion. Presentation at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Bhabesh Dutta, Brian Kvitko, Mei Zhao, Brendon Myers, Gaurav Agarwal, Gi Yoon-Shin, Sujan Paudel, Santosh Koirala, Bamidele Sangoyomi, and Ronald Gitaitis (2022). An overview of basic and applied research on diverse bacterial diseases on onion in Georgia. Presentation at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Gi Yoon Shin, Bhabesh Dutta and Brian Kvitko (2022). Genetic basis of HiVir, a phytotoxin gene cluster of onion pathogen Pantoea ananatis. Presentation at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

**Accession No. 1020312** **Project No. WNP03104**

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Lindsey du Toit, Brian Kvitko, Heather MacKay and the Stop the Rot project team members (2022). Surveys of bacterial pathogens in onion production regions of the U.S.: Preliminary results from 2020 and 2021. Presentation at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Brian Kvitko, Gi Yoon Shin, Amy Smith, Jo Ann Asselin, Paul Stodghill, Bhabesh Dutta (2022). A pathogenomics approach to identify virulence -associated genes of Pantoea spp. pathogenic on onion. Presentation at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Verushka Ibanez, Christopher Liakos, Jacquie van der Waals, Teresa Coutinho, Pedro Lebre (2022). Bacterial biome of storage onion bulbs sampled in Georgia and Washington States. Presentation at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

James Woodhall, Miranda Harrington, Ben Wood, Gi Yoon Shin, and Brian Kvitko (2022). Developing nucleic acid amplification tests for onion pathogenic bacteria. Presentation at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Mei Zhao, Michael Derie, Timothy Waters, Bhabesh Dutta, and Lindsey du Toit (2022). Evaluation of resistance screening methods for bacterial diseases of onion. Presentation at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Gabriel LaHue, Tessa Belo, Michael Derie, Bhabesh Dutta, Erik Feibert, Beth Gugino, Christy Hoepting, Jennie Mazzone, Stuart Reitz, Timothy Waters, Rob Wilson, and Lindsey du Toit (2022). Reducing the risk of onion bacterial diseases through irrigation and nitrogen management. Presentation at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Brenna Aegerter, W. M. Donahoo, Jane Davey, Michael Derie, Lindsey du Toit, Bhabesh Dutta, Eric Feibert, M. J. Foster, Christy Hoepting, Antoinette Machado, Claudia Nischwitz, Stuart Reitz, Jaspreet Sidhu, Mark Uchanski, Timothy Waters, and James Woodhall (2022). Evaluation of bactericides and plant defense

inducers to manage bacterial rots of onion in seven states in the U.S. Presentation at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Lindsey du Toit, Michael Derie, Christy Hoepting, and Bhabesh Dutta (2022). Evaluation of late-season cultural practices for managing onion bacterial bulb rots. Presentation at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Timothy Waters, Mark Uchanski, Lindsey du Toit, Michael Derie, and Jane Davey (2022). Evaluation of post-harvest treatments for control of bacterial rots in onions. Presentation at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Kirti Rajagopalan, Ananth Kalyanaraman, and Hossein Noorazar (2022). Predictive modeling of bacterial disease risk in onion bulb crops. Presentation at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Greg Colson, Lindsey J. du Toit, Bhabesh Dutta, and Christy Hoepting (2022). Economic assessments of management strategies for onion bacterial rots. Presentation at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Lindsey du Toit and Heather MacKay (2022). Stop the Rot: Overview of research to combat onion bacterial diseases with pathogenomic tools and enhanced management strategies. Presentation at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Belo, T., du Toit, L., Waters, T., Derie, M., Schacht, B., & LaHue, G. (2021). Combating Onion Bacterial Diseases Through Nitrogen Fertility Management. Poster presented at 2021 ASA, CSSA, SSSA International Annual Meeting, Salt Lake City, 7-10 November 2021.

**Accession No. 1020312** **Project No. WNP03104**

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

MacKay, H., du Toit, L., Aegerter, B., Colson, G., Coutinho, T., Dutta, B., Gugino, B., Hoepting, C., Kvitko, B., LaHue, G., Malla, S., Nischwitz, C., Reitz, S., Sidhu, J., Uchanski, M., Waters, T., Wilson, R., Woodhall, J., Asma, M.(presenting author). 2022. Combating onion bacterial diseases with pathogenomics tools and enhanced management strategies: Research objectives and progress towards reducing crop losses. Poster presentation at 14th International Conference on Plant Pathogenic Bacteria, July 2022, Assisi, Italy.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Gi Yoon Shin, Bhabesh Dutta and Brian Kvitko. Genetic Basis Of Hivir-Mediated Red Onion Scale Necrosis, A Phytotoxin Gene Cluster Of Pathogenic Pantoea Ananatis. Poster presentation at American Phytopathological Society Plant Health 2022 Conference, Pittsburgh, August 6-10, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Ram Neupane, Jennie Mazzone, Christine Hoepting, Beth Gugino. Identification And Pathogenicity Of Bacteria Isolated From Symptomatic Onion Leaves And Bulbs In Pennsylvania And New York In 2020 And 2021. Poster presentation at American Phytopathological Society Plant Health 2022 Conference, Pittsburgh, August 6-10, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Benjamin B. Wood, Mackade Murdock, and James Woodhall. A Survey Of Bacterial Species Associated With Onion Rots In The Treasure Valley Of Southwest Idaho And Eastern Oregon. Poster presentation at American Phytopathological Society Plant Health 2022 Conference, Pittsburgh, August 6-10, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Lindsey du Toit, Heather MacKay, Gi Yoon (Gina) Shin, Brian Kvitko, Brenna Aegerter, Christopher Cramer, Beth Gugino, Christine Hoepting, Subas Malla, Claudia Nischwitz, Stuart Reitz, Mark Uchanski, James Woodhall, Bhabesh Dutta. Distribution And Pathogenicity Of Bacteria Collected In Surveys Of Onion Crops Across Production Regions In The U.S. In 2020 And 2021. Poster presentation at American Phytopathological Society Plant Health 2022 Conference, Pittsburgh, August 6-10, 2022

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Pedro Lebre, Verushka Ibanez, Christopher Liakos, Jacqui van der Waals, and Teresa Coutinho (2022). The metavirome of onion bulbs in the U.S.A. Poster presented at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

**Accession No. 1020312** **Project No. WNP03104**

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Lindsey du Toit, Brian Kvitko, Heather MacKay and the Stop the Rot project team members (2022). Surveys of bacterial pathogens in onion production regions of the U.S.: Preliminary results from 2020 and 2021. Poster presented at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Verushka Ibanez, Christopher Liakos, Jacqui van der Waals, Teresa Coutinho, and Pedro Lebre (2022). A study on the bacterial inhabitants of storage onions: Identity and function. Poster presented at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Pedro Lebre, Verushka Ibanez, Christopher Liakos, Jacqui van der Waals, and Teresa A. Coutinho (2022). The metavirome of onion bulbs symptomatic and asymptomatic for bacterial bulb rots sampled from Georgia and Washington States in the U.S.A. Poster presented at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Christy Hoepting and Emma van der Heide (2022). Influence of variety on bacterial bulb rot of onion in New York State. Poster presented at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Christy Hoepting and Emma van der Heide (2022). Influence of applied nitrogen on bacterial bulb rot in muck-grown onion in New York. Poster presented at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Brenna Aegerter, W. M. Donahoo, Jane Davey, Michael Derie, Lindsey du Toit, Bhabesh Dutta, Eric Feibert, M. J. Foster, Christy Hoepting, Antoinette Machado, Claudia Nischwitz, Stuart Reitz, Jaspreet Sidhu, Mark Uchanski, Timothy Waters, and James Woodhall (2022). Evaluation of bactericides and plant defense inducers to manage bacterial rots of onion in seven states in the U.S. Poster presented at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

**Accession No. 1020312** **Project No. WNP03104**

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Joe LaForest, Sarah Jean Swain, and Heather MacKay (2022). ALLIUMNET.COM website redesign to support collaborative onion research and extension. Poster presented at the National Allium Research Conference, Denver, CO, February 28-March 1, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Belo T. and LaHue G.T. (co-presenters), du Toit L., Waters T., Derie M., and B. Schact. 2021. Combatting onion bacterial diseases through irrigation management. Pacific Northwest Vegetable Association Annual Conference and Trade Show, Kennewick, WA, November 16th, 2021.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Websites | Published | 2022 | YES |

**Citation**

The Alliumnet website www.alliumnet.com has been updated regularly with new content generated during the reporting period. The site contains information resources for researchers, extension staff, and producers on the management of onion pests and diseases, links to current and recently completed research projects funded by federal and other grants, information on upcoming research meetings and conferences, and archives of previous research meetings. The Alliumnet website is developed, maintained, and hosted by the Southern IPM Center and the Center for Invasive Species and Ecosystem Health at the University of Georgia.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2021 | YES |

**Citation**

du Toit, L. 2021. Stop the Rot: How can the results benefit you? Presentation at the Pacific Northwest Vegetable Association Annual Conference and Trade Show, Kennewick, WA, November 16th, 2021.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2021 | YES |

**Citation**

Belo T., LaHue G.T. du Toit L., Waters T., Derie M., and B. Schact. 2021. “Combatting onion bacterial diseases through nitrogen fertility management”. Presentation at the Pacific Northwest Vegetable Association Annual Conference and Trade Show, Kennewick, WA, November 16th, 2021.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2021 | YES |

**Citation**

Woodhall, J. 2021. Stop the Rot: Diagnostic and bacterial survey results for Washington, Idaho and Oregon. Presentation at the Pacific Northwest Vegetable Association Annual Conference and Trade Show, Kennewick, WA, November 16th, 2021.

**Accession No. 1020312** **Project No. WNP03104**

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Gugino, B. 2022. Identification and management of common foliar and bulb diseases of onion. Presentation at the 2022 Mid-Atlantic Fruit and Vegetable Convention Proceedings, Pennsylvania Vegetable Growers Association, Richfield, PA, February 1st, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Conference Papers and | Published | 2022 | YES |

**Citation**

Aegerter, B., Wilson, R., Sidhu, J., Putman, A. 2022. Stop the Rot: Combating onion bacterial diseases with pathogenomic tools and enhanced management strategies. Presentation at the California Garlic and Onion Symposium, February 7th, 2022.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Other | Published | 2021 | YES |

**Citation**

Wohleb, C.H., Waters, T.W., du Toit, L.J., and LaHue, G. 2021. Washington State University Extension Onion Alert, 1 September 2021. https://mailchi.mp/wsu/wsu-onion-alert-sept1-2021-1305808?e=72ba613792

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Other | Published | 2021 | YES |

**Citation**

du Toit, L. and Waters T. 2021. To disinfect or not? Can postharvest applications of disinfectants reduce bacterial bulb rots in storage? Article in Onion World Magazine, July/August 2021, pp. 6 - 9. https://issuu.com/columbiamediagroup/docs/onion_world_july-august_2021/6

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Other | Published | 2021 | YES |

**Citation**

Belo T., LaHue G.T., du Toit L., and T. Waters. 2021. When to water? How do irrigation frequency and final irrigation timing influence onion bacterial diseases? Onion World Magazine. December 2021. pp. 6 – 8. https://issuu.com/columbiamediagroup/docs/onion_world_december_2021?fr=sNDA4ZDI1Mjg1MDI

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Other | Published | 2022 | YES |

**Citation**

Dutta, B. & Zhao M. 2022. Getting to the Root Cause of Rot: Progress in the Stop the Rot Project in Georgia. Onion World Magazine, February 2022, pp. 16 – 17. https://onionworld.net/2022/01/26/getting-to-the-root-cause-of-rot/

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Other | Published | 2022 | YES |

**Citation**

MacKay, H., du Toit, L. & Hoepting, C. 2022. Stop the Rot Halftime Report: News from the Stop the Rot Project on Onion Bacterial Diseases. Onion World Magazine, March/April 2022, pp. 16 - 17. https://issuu.com/columbiamediagroup/docs/onion_world_march-april_2022/16

**Accession No. 1020312** **Project No. WNP03104**

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Other | Published | 2022 | YES |

**Citation**

MacKay, H. & du Toit, L. 2022. Stop the Rot Year 3 Highlights: Global study of bacterial rot yields interesting results with production practices. National Onion Association Newsletter, Volume XL, Issue 3, April 2022, pp. 6 – 7.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Other | Published | 2022 | YES |

**Citation**

MacKay, H., du Toit, L. & Havey, M. 2022. A Collaborative Effort: Joint Allium Research Meeting Showcases Latest Research on Onion Production, Pests and Diseases. Onion World Magazine, May/June 2022, pp. 14 – 16. https://onionworld.net/2022/05/13/a-collaborative-effort-joint-allium-research-meeting-showcases-latest-research-on-onion-production-pests-diseases/

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Other | Published | 2022 | YES |

**Citation**

Schattenberg, P. 2022. Novel species of pathogenic bacteria of onion identified in Texas. AgriLife Today, May 9, 2022. https://agrilifetoday.tamu.edu/2022/05/09/novel-species-of-pathogenic-bacteria-of-onion-identified-in-texas/

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Other | Published | 2022 | YES |

**Citation**

LaHue, G. 2021. Two critical pieces of the puzzle: Irrigation and nitrogen management impacts on bacterial bulb rot. WSU Onion Alert, September 1, 2021.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Other | Published | 2022 | YES |

**Citation**

du Toit, L. & Waters, T. 2021. To disinfect or not? Can postharvest applications of disinfectants reduce bacterial bulb rots in storage? WSU Onion Alert, September 1, 2021.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Journal Articles | Published | 2022 | YES |

**Citation**

Wilson, R., Nicholson, R. and Aegerter, B. 2022. The influence of irrigation method on bacterial diseases of onion in northeast California, 2021. Plant Disease Management Reports 16:V154.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Theses/Dissertations | Accepted | 2022 | YES |

**Citation**

Lliakos, Christopher. 2022. Bacterial microbiome of healthy and diseased storage onion bulbs from Washington State, USA. M.Sc. Thesis, Department of Biochemistry, Genetics and Microbiology, University of Pretoria, South Africa.

**Accession No. 1020312** **Project No. WNP03104**

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Theses/Dissertations | Published | 2022 | YES |

**Citation**

Belo, T.R.D. 2022. Reducing the risk of onion bacterial diseases through irrigation and nitrogen fertility management. M.S. Thesis. Department of Crop and Soil Sciences. Washington State University.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Theses/Dissertations | Published | 2022 | YES |

**Citation**

Machado Burke, Antoinette. 2022. Evaluation of Bactericides and Plant Defense Inducers in the Presence and Absence of Onion Pathogens Pantoea SPP. and Burkholderia gladioli in Colorado. M.S. Thesis. Department of Horticulture and Landscape Architecture, Colorado State University. https://mountainscholar.org/handle/10217/235581

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Theses/Dissertations | Other | 2022 | YES |

**Citation**

Ibanez, Verushka. (In prep. 2022). Bacterial microbiome of healthy and diseased storage onion bulbs from Georgia, USA. M.Sc. Thesis, Department of Biochemistry, Genetics and Microbiology, University of Pretoria, South Africa.

| Type | Status | Year Published | NIFA Support Acknowledged |
|---|---|---|---|
| Other | Published | 2022 | YES |

**Citation**

Pennsylvania Vegetable Disease Update and Pennsylvania Vegetable and Berry Current Issues are written weekly and biweekly and distributed via a listserv, posted on the Penn State Extension website and are further distributed by the Pennsylvania Vegetable Marketing and Research Program newsletter that is mailed, faxed or emailed to all PA vegetable growers who participate in the check-off program. Diseases of onion were included in articles between May 2022 and September 2022.

**Other Products**

**Product Type**

Survey Instruments

**Description**

A survey was developed and delivered to project team members and the stakeholder advisory panel in March 2022 to: (a) assess the quality and value of the “Stop the Rot” annual Stakeholder Advisory Panel videoconference; (b) gather opinions and suggestions for management of information, documents, and other elements of the grant project; and (c) help plan future meetings. Results from the survey were communicated to the grant leadership and factored into team planning and activities.

**Product Type**

Educational Aids or Curricula

**Description**

Onion bacterial inoculation workshop, June 1, 2022, online. Attended by 32 people, including team members, graduate & undergrad students from STR regional labs and South Africa. https://youtu.be/7KaRS4MnxY4 Mike Derie and Stop the Rot project director Dr. Lindsey du Toit, presented an informal work session on inoculating onion field trials with pathogenic bacterial strains, to artificially create bacterial disease in the onions. The work session was presented to team members, graduate students and post-

doctorates working on the Stop the Rot project.

**Product Type**

Educational Aids or Curricula

**Description**

Experimental design workshop, June 8, 2022, online, on practical guidance and basic principles for good design of field trials. Attended by 29 people, including team members, graduate & undergrad students from STR regional labs and South Africa. https://youtu.be/Las-WkZZa2Y In this informal work session, Dr. Lindsey du Toit, Project Director for the Stop the Rot project, shared best practices and lessons learned in experimental design for agricultural field trials, and statistical analysis of the results. The work session was presented to team members, graduate students and post-doctorates working on the Stop the Rot project.

**Product Type**

Protocols

**Description**

“Stop the Rot Project Standardized Bacterial Survey Protocols for Season 3” is a set of standardized protocols for field collection and processing of onion samples, isolation and identification of bacterial strains, testing of pathogenicity and virulence of bacterial strains. The protocols are accompanied by electronic data entry forms to facilitate the preparation of a centralized project database on onion bacterial isolates. These standardized approaches and methods for sampling, isolating, and testing virulence on onion are the foundation for improving our understanding of onion bacterial pathogens in different regions of production across the USA, over the three field seasons of surveying/sampling during this project.

**Product Type**

Databases

**Description**

Bacterial survey data submitted by each of the 12 participating state teams are being compiled into a centralized database for use by the project team. The database now contains results from two full years of field surveys. Results from the third and final year of surveys will be added in the next reporting period. Crop and environment data were recorded for each location and onion sample when the samples were collected. Field data are connected to each strain through unique, anonymized sample and field codes. The database will be used to populate a public searchable platform for the National Onion Bacterial Strain Collection

**Product Type**

Physical Collections

**Description**

Regional onion bacterial strain collections: Each of the regional labs for this project has stored all the bacterial isolates collected during surveys in the state(s) in that region. This includes a regional lab at each of: 1) Washington State University (du Toit) for isolates from Washington and California; 2) University of Idaho (Woodhall) for isolates from Idaho and Oregon; 3) Utah State University (Nischwitz) to store isolates from Utah, Colorado, and New Mexico; 4) Texas A&M University (Malla) for isolates collected from Texas; 5) Pennsylvania State University (Gugino) for isolates collected from Pennsylvania and New York; and 6) University of Georgia (Dutta) for isolates collected in Georgia.

**Product Type**

Physical Collections

**Description**

National Onion Bacterial Strain Collection (NOBSC): A subset of the strains stored and characterized at each regional lab is being used to populate the NOBSC to represent the diversity of bacterial strains associated with onion crops across the USA. Each regional lab, therefore, also serves as a backup repository for part of the NOBSC collection. Bacterial strains collected from the fields and storage facilities surveyed in 12 states each of three seasons will be added to the NOBSC over the duration of this project. At the end of Year 3,

the collection contained 1,278 curated strains.

**Product Type**

Other

**Description**

Update on fungal and bacterial diseases in onion at the Georgia Regional Onion Growers Meeting, September 1, 2021. (PI Dutta)

**Product Type**

Other

**Description**

Results of the project were presented to Idaho and Eastern Oregon growers at the Idaho Onion growers association and Malheur county onion growers association combined meeting, November 16, 2021. (PI Woodhall)

**Product Type**

Other

**Description**

Update on management of onion diseases in Georgia at the Tattnall County Annual Winter Grower Meeting, January 7, 2022. (PI Dutta)

**Product Type**

Other

**Description**

Identification and management of common foliar and bulb diseases of onion, at the Keystone Family Farms Onion Meeting, PA, January 24, 2022. (PI Gugino)

**Product Type**

Other

**Description**

Onion disease update, featuring bacterial diseases, at the Idah--Malheur County Onion Growers Meeting, February 1, 2022. (PI Woodhall)

**Product Type**

Other

**Description**

Update on "Stop the Rot" project at the Utah Onion Association meeting, February 8, 2022. (PI Nischwitz)

**Product Type**

Other

**Description**

Update on managing common diseases of onion, at the Sugar Valley Vegetable Growers Meeting, PA, March 4, 2022. (PI Gugino)

**Product Type**

Other

**Description**

Stop the Rot bactericide trial self-guided tour/open house, CO, September 1, 2021.

**Product Type**
Other

**Description**
New Mexico State University Onion Field Day, June 29, 2022.

**Product Type**
Other

**Description**
Update on "Stop the Rot" project at the WA Onion Field Day, August 25, 2022.

**Changes/Problems**

Rising input costs and labor costs
The costs of fertilizer, irrigation equipment and labor have increased sharply in this reporting period. In Oregon, Co-PI Reitz noted that input costs were greater than planned but he was able to access additional funding support from companies interested in the 2022 bactericide trials, and from the Idaho-Eastern Oregon Onion Growers Association for the 2022 irrigation and fertility trials. In Colorado, Co-PI Uchanski's labor costs were higher than planned, but we were able to transfer a small amount of surplus funds from Co-PI Aegerter's budget in California to cover the Colorado wages shortfall in 2022.

Risk-based modeling: access to commercial production data
Access to production data from growers and packers has been very limited as stakeholders are reluctant to share proprietary crop information in a highly competitive market. In addition, growers do not always have detailed environmental data records, particularly for soil moisture status which we hypothesize is one of the most important risk factors in bacterial disease development. This has continued to affect the ability of the team to develop and evaluate bacterial disease risk models as originally planned. In this reporting period, therefore, we have been collecting more data from our field trials in NY and UT especially, including deploying additional sensors to monitor environmental conditions in the trial plots. In the next reporting period, we will incorporate these results into a simple risk assessment tool for growers to test in the field and provide feedback to the team.

Environment-related problems

- Irrigation/fertility trials in Washington State during 2022 were abandoned due to poor stands from record cold and windy conditions in April after planting. The trials will be repeated in the next reporting period.
- Bactericide trials in Kern County, CA, were abandoned due to poor stands, and will be repeated in the next reporting period.

COVID19 impacts

- In Idaho and Utah, the pandemic resulted in significantly increased costs and delays in the delivery of supplies associated with PCR assays and nitrile gloves, and to delays in sample analysis in fall and winter 2021.
- In Georgia, supply chain issues caused PI Kvitko's lab to change cryovial suppliers and formats several times.
- In Washington State, COVID increased travel expenses for field research, particularly during periods of intense labor needs, e.g., during harvest of field trials and when evaluating onion bulbs in storage, because of not being able to share hotel rooms.

Grant administration capacity
Subcontractors to Washington State University (WSU) on this project have all reported that their grant administration offices are short-staffed with high turnover. This is making it slow, if not impossible in some cases, for WSU to get the data and supporting information needed for required reporting to NIFA, such as effort certifications, and to keep subcontractor cost-share reporting up to date.

Other changes

Robert Sakata (CO) and Kerrick Bauman (WA) stepped down from the SAP; Mr. Sakata is no longer an active onion grower, and Mr. Bauman cited time constraints.

No-cost extension request

Due to delays for COVID issues, delays in receiving funding, some weather-related problems, we plan to request a one-year no-cost extension (NCE). This will allow us to complete all field trials as planned and prepare the final results for dissemination.