BIOAg Project Report

Report Type: FINAL

Title: Development of a USDA NIFA SCRI proposal to combat onion bacterial diseases across the US

Principal Investigator(s) and Cooperator(s): Lindsey du Toit, WSU Professor & Extension Plant Pathologist; Louisa Winkler, Postdoctoral Research Associate; 24 collaborators from 12 states and from the University of Pretoria in South Africa.

Abstract:

This BIOAg grant was used to support a postdoctorate, Dr. Louisa Winkler, to assist Dr. Lindsey du Toit, WSU Professor of Plant Pathology, prepare a 12-state, 20-person collaborative, multi-disciplinary proposal on onion bacterial diseases to the USDA NIFA Specialty Crops Research Initiative in March 2018. The submitted proposal, which requested ~$3.5 million, ranked in the 'highly recommended for funding' category (2nd highest category), placing 39th out of 109 full proposals submitted. However, the proposal was not funded. Feedback from the grant review panel was used to revise the pre-proposal (Stakeholder Relevance Statement) during fall 2018, which was submitted in December 2018. The pre-proposal was accepted for submission of a full proposal. The full proposal was revised over winter and spring of 2019 based on panel feedback from the original submission, including expanding the team to 24 members from 12 states and one other country (a phytobacteriologist at the Univ. of Pretoria, South Africa, to increase the phytobacteriology expertise on the team). The proposal was submitted in late April 2019 (deadline was postponed a month because of the federal government shutdown and the reinstated requirement for 100% cost-share on SCRI proposals). The proposal was rated 'Outstanding', ranked in the top 13 of 101 proposals submitted, and was funded at $4,044,300 (Award No. 2019-51181-30013). The project start date was modified by NIFA to 1 Sep. 2019. Subcontracts with 11 institutions are being implemented although funding has not yet been received from NIFA because of the relocation of NIFA headquarters to Kansas City, MO in fall 2019. Multiple conference calls to initiate plans for the project have taken place in fall 2019. The first team meeting will be on 3-4 Feb. 2020 at the University of Georgia campus in Athens, with the Stakeholder Advisory Panel members joining by videoconference. A Project Manager, Dr. Heather MacKay, was hired in Nov. 2019 to help Dr. du Toit manage the project.

Project Description:

Onion bulb crops are grown on 140,000 acres annually in the US at a farmgate value of $925 million (USDA NASS). Dry bulb storage crops represent ~70% of the acres. Bacterial diseases cause substantial losses in onion crops in fields and in storage. US onion growers and packers commonly lose 10-40% of the harvested crop to bacterial rots. In the western US alone, annual losses to bacterial bulb rots in storage is >$16 million. The losses represent wasted farmland, fuel and other inputs, and economic strain for producers and packers. Disposal of culled onions adds expenses and potential environmental hazards, e.g., buried onions can contaminate groundwater. Losses to bacterial bulb rots have increased in the past 10 years, highlighting the limited understanding of the pathogens. More than 15 bacterial species are known pathogens of onion but it can be difficult to

detect accurately the specific causal agent of rots in a region or field. Infected bulbs usually are asymptomatic at harvest, with rot developing in storage after production and storage expenses have been incurred, and preventing detection of infected plants in fields by scouting. Furthermore, multiple bacterial species can be isolated from a plant or bulb, complicating efforts to determine the primary causal agent vs. secondary colonizers. Field-validated assays capable of differentiating potential pathogenic bacterial species, including non-pathogenic vs. pathogenic strains of a species, do not yet exist. Available molecular assays are time-consuming since bacteria must first be isolated into pure cultures. Most detect only one or a few potential bacterial pathogens of onion, and none effectively distinguishes non-pathogenic vs. pathogenic strains of a species. Identifying virulence factors of different bacterial pathogens, e.g., by whole genome sequencing with comparative genomics, is needed to develop robust diagnostic tools. At present, no commercial onion cultivar is resistant to bacterial rot pathogens. Molecular diagnostics will facilitate developing effective phenotypic screening methods, enabling breeding for bacterial rot resistance. Resistant cultivars will reduce losses in production and the need for cull disposal.

Today, growers and packers use a plethora of strategies to try and manage bacterial diseases, with very limited efficacy owing to lack of clarity about sources of inoculum and other environmental, host, and epidemiological factors. Growers attempt sanitation, bactericide applications (with very limited protective effects and no curative efficacy), field and postharvest curing of bulbs, and disposal of symptomatic bulbs by burial, maceration, and incorporation into soil. A coordinated, multi-state effort is needed to determine the relative efficacy of these practices and how to optimize management strategies based on understanding how environmental conditions and production practices impact the pathogens and host in different regions of onion production in the US.

In winter 2017-18, with funding from the WSU CSANR BIOAg program, Lindsey du Toit WSU Professor of Plant Pathology, received a BIOAg Planning Grant to prepare a USDA NIFA SCRI proposal for submission in March 2018 with assistance of Dr. Louisa Winkler (independent research consultant) to help develop, manage, and collate the full SCRI proposal with 20 collaborators from 12 states, to ensure timely submission of a high quality proposal. The pre-proposal (Stakeholder Relevancy Statement) for this SCRI grant was submitted on 5 Dec. 2017, and was approved for submission of a full proposal, which was submitted in March 2018. “Stop the rot: Combating onion bacterial diseases with pathogenomic tools and enhanced management strategies” was the title of the proposal. The objective of this project is to advance scientific understanding of onion bacterial diseases and provide the industry with more effective mitigation tools. The project integrated research and extension efforts addressing the three components of the disease triangle: pathogen, host, and environment; and accounted for farm- and industry-level economic assessments. Objective 1: Utilize comparative genomics to identify virulence factors of different onion bacterial pathogens to develop diagnostic tools and phenotypic resistance screening methods for onion bacterial diseases. Activities include annual surveys of onion crops in six primary regions of onion production in the US, and assembly of a national library of curated bacterial pathogen strains to facilitate searching for diagnostic targets and virulence determinants. Hypotheses underlying Objective 1 include: 1a. Rapid, robust, and regionally-specific detection assays for bacterial pathogens are crucial for mitigation strategies; 1b. Comparative bacterial genomics will identify virulence factors to develop practical diagnostic tools for onion bulb rot pathogens; 1c. Phenotypic resistance screening methods will speed the breeding of disease resistant onion cultivars; 1d. Economic assessment of bacterial disease impacts on US onion production will clarify opportunities to enhance profitability. Objective 2: Identify production practices, environmental factors, and inoculum sources that favor bacterial disease outbreaks in order to develop environmentally- and economically-viable management programs. Activities include coordinated field trials in six US onion production regions to evaluate locally relevant irrigation,

fertility, and cultural practices as well as pesticide programs for the impacts on bacterial diseases, and to explore economic implications of each. Hypotheses underlying Objective 2 were: 2a. Epidemiological studies will reveal how production practices, environmental factors, and inoculum sources impact bacterial diseases; 2b. Combined with knowledge generated by Objective 1, enhanced strategies to reduce bulb rots will be identified; 2c. Adoption of data-driven recommendations by onion producers/packers will limit economic losses from bulb rots; 2d. Economic and stakeholder assessments of enhanced management strategies will improve onion production efficiency and productivity.

Outputs

See the Logic Model below for the 'Stop the Rot' project that summarizes short, medium, and long-term outputs and outcomes.

Feedback received from the NIFA SCRI review panel for a full grant proposal titled "Stop the rot: Combating onion bacterial diseases with pathogenomic tools and enhanced management strategies" that was originally submitted in Mar. 2018 (described in more detail in the progress report submitted a year ago) was used to revise the pre-proposal for submission in Nov. 2018. That pre-proposal was accepted in late Jan. 2019 for submission of a full proposal, which was submitted in Apr. 2019. The full proposal was evaluated by the review panel as 'Outstanding', ranked in the top 13 of 101 proposals submitted, and was funded at $4,044,300 (Award No. 2019-51181-30013).

The project start date was set by the SCRI Program Manager to 1 Sep. 2019, and runs through 31 Aug. 2023. WSU subcontracts with 11 institutions are being implemented. However, funding has not yet been received from NIFA because the relocation of NIFA headquarters to Kansas City, MO in fall 2019 has delayed processing of funding for all SCRI projects this round.

Multiple team conference calls to initiate the project were organized in fall 2019. The first team meeting will be on 3-4 Feb. 2020 at the University of Georgia campus in Athens, with the Stakeholder Advisory Panel members joining by videoconference. There will be hands-on training in some of the field and lab methods for the survey component of the project.

A Project Manager, Dr. Heather MacKay, was hired in Nov. 2019 to help Dr. du Toit manage the project.

An article on this funding was written by Denise Keller, Editor of *Onion World* (Columbia Publishing), and published on pages 24-26 of the Nov. 2019 edition of *Onion World*. The article is titled 'Stop the Rot. Combating Onion Bacterial Diseases':
https://issuu.com/columbiamediagroup/docs/onion_world_november_2019?fr=sMjE1NTQ3OTUxMA

A presentation on onion bacterial diseases, including the plans for this project, was given at the Pacific Northwest Vegetable Association Annual Convention & Trade Show in Kennewick, WA on 20 Nov. 2019 by du Toit. The presentation, titled 'Bacterial rots of onion: Knowledge gaps and the USDA SCRI project' was attended by ~200 onion growers, agronomists, research and extension personnel, consultants, processors, packers, and other stakeholders.
https://pnva.org/wp-content/uploads/2019/10/2019-PNVA-Program-10-2-19.pdf

Impacts

See the Logic Model below for the 'Stop the Rot' project that summarizes short, medium, and long-term outputs and outcomes.

Short-Term: A 4-year, USDA NIFA SCRI grant was received for $4,044,300 for a coordinated, nation-wide research and extension effort to address bacterial diseases impacting onion production.
Intermediate-Term: This proposal will enable the 24 collaborators from 12 states and South Africa, together with key onion stakeholders from across the US, to make significant advances in understanding the etiology, epidemiology, and management of bacterial diseases in onion production.
Long-Term: This project will contribute to onion production in the USA that is more sustainable practically, economically, and environmentally.

Additional funding applied for/secured:

The 4-year, 24-collaborator, USDA NIFA SCRI grant detailed above was procured for $4,044,300.

Graduate students funded:

WSU PhD student co-advised by Dr. Gabriel LaHue, soil scientist, and Dr. Lindsey du Toit, plant pathologist.
Colorado State University MS student working with Drs. Mark Uchanski and Michael Bartolo, horticulturalists.
Pennsylvania State University graduate student working with Dr. Beth Gugino, plant pathologist.
University of Pretoria, South Africa, PhD student advised by Dr. Teresa Coutinho, phytobacteriologist, and Drs. Brian Kvitko and Bhabesh Dutta at the Univ. of Georgia.
University of Georgia graduate student advised by Dr. Greg Colson, economist.

Recommendations for future research:

None at this stage. Grateful for the BIOAg Planning Grant that enabled me to hire Dr. Louisa Winkler to help with collating all the documents needed for such a large, nation-wide proposal with 12 institutions.

(See Logic Model on last page of this report)

Logic model: Stop the rot: Combating onion bacterial diseases with pathogenomic tools and enhanced management strategies

Situation: Bacterial diseases of onion occur across the U.S. and are some of the most difficult diseases of onion to manage because of a lack of effective, rapid detection methods, poor understanding of the genetic basis of pathogenicity and epidemiology of the complex of bacterial pathogens of onion, and the need for commercially viable onion cultivars that are resistant to bacterial pathogens.

INPUTS	**OUTPUTS**		**OUTCOMES**		
	Activities	***Participation***	***Short (knowledge)***	***Medium (actions)***	***Long (conditions)***
• University personnel with complementary skills in Allium research & extension • In-kind, regional resources from onion industry • Established network with regional & national onion industries, incl. the National Onion Association (NOA) • Stakeholder Advisory Panel, seed companies	• Survey onion crops yearly for pathogens • Sequence genomes of *P. agglomerans* & *P. ananatis* • Develop rapid diagnostic tools & phenotypic screens for host resistance • Test IPM practices in 8 onion regions • Predictive modeling • Share results: field days, Alliumnet; Nat. Allium Res. Conf., NOA, & W-3008; journal & extension articles • Train students & postdocs	• Onion growers & packers • Regional onion associations • NOA • Onion seed companies • Private & public onion breeders, pathologists, horticulturists, entomologists • Economists • Computer scientists & data modelers • Crop consultants	• Awareness of regional bacterial pathogens of onion • Standardized assays for bacterial isolations & virulence screening • Identification of bacterial virulence factors on onion • Onion phenotypic resistance screening methods developed • Access to national collection of onion bacterial pathogens • Awareness of effective & economical IPM practices for onion bacterial diseases	• Increased use of new, rapid diagnostic tools for bacterial diseases • Adoption of phenotypic resistance screening tools by onion breeding programs • Adoption of more effective IPM practices for bacterial pathogens in onion bulb & seed crops • Increased understanding of economic & social factors affecting adoption of IPM practices	• New onion cultivars with resistance to important bacterial pathogens • Reduced losses to bacterial diseases during production, storage & transport • More sustainable onion production • Increased economic stability in rural U.S., where onion crops are a critical commodity
Assumptions: Pathogenomic tools enable identification of virulence factors associated with bacterial pathogens of onion, which enable development of effective methods to screen for host resistance and economical management practices.			**External Factors:** Need for a greater understanding of the fundamental biology and genetics of regional bacterial species that cause diseases in onion crops; local and regional weather conditions and disease pressure affect the success of field trials.		