S1053 - Multistate Research Activity Accomplishments Report

Project No. and Title: S1053

Ecological and genetic diversity of soilborne pathogens and indigenous microflora

Period Covered: 12 - 2016 to 12 -2017

Date of Report: March 15, 2017

Annual Meeting Date: August 8, 2017

Participants

Brief Summary of Minutes of Annual Meeting

Accomplishments

1. Evaluate the population genetic diversity of soilborne pathogens and antagonistic microorganisms in different growing systems and regions using traditional and metagenomic approaches.

Members of this multistate research project have continued to provide new insight into the genetic diversity of a number of soil-borne pathogens in a variety of production systems.

Work in Mississippi dealt with two soilborne fungi with different morphology and growth characteristics isolated from diseased cotton planted at the R.R. Foil Plant Science Research Center at Mississippi State by culturing infected stem tissues on potato dextrose agar (PDA) plates. The genomic DNAs were isolated from the two fungi and then used as template for a PCR-based genotyping method to identify the two species via ribosomal ITS (Internal Transcribed Spacer) DNA amplification and sequencing. The ITS genotyping indicated that the two species could be *Verticillium dahliae*, *Verticillium longisporum* or *Verticillium albo-atrum*. The two fugal species were further identified by PCR amplification of the intron 3 of the VTA2 gene which encodes a transcription activator. Only a single DNA band of 315-bp was amplified from both isolated fungi and its nucleotide sequence suggested that both fungi isolated from diseased cotton were *Verticillium dahlia*. Work was also done on another soil-borne fungal pathogen *Aspergillus flavus* which can infect corn at both pre- and post-harvest stages. *Aspergillus flavus* can produce aflatoxins B1 and B2, and ingestion of contaminated corn can damage the liver and suppresses the immune system. Recently 135 microRNA-like RNAs (milRNAs) were identified in *A. flavus* and their expression was found to be correlated with aflatoxin production conditions. This suggested that the milRNAs might play an important role in regulation of aflatoxin production and accumulation. *Aspergillus flavus* NRRL 3357 producing high levels of aflatoxin and *A. flavus* NRRL 21882 with no aflatoxin production were used to inoculate kernels of resistant (Mp719) and susceptible (Va35) maize lines, and small RNAs were isolated from infected kernels and then subjected to next generation RNA sequencing. From the RNA sequence data, 69 *A. flavus* milRNAs were identified, analyzed for differential expression, and further validated by quantitative reverse transcription PCR.

Other work in Mississippi stated that between 20 to 25% of the sweet potato crop is lost during curing and storage with another 25% lost during shipping and retailing before customer consumption. Sweet potato storage rots in Mississippi increased annually from 2005-2009. The rot also started occurring earlier in storage, becoming a late November problem instead of a

January one. In 2005-2008, the rot increased in incidence, but seldom damaged enough of the crop to cause serious economic loss. Among growers, rot incidence was erratic and with few exceptions, would occur one year but not the next. Until 2008, the most common rots were *Rhizopus stolonifera* infection, different types of Fusarium rots, circular spot, and punky rot but more recently *Macrophomina phaseolina* (MP) is considered to be one of the primary pathogen associated with tip/end rot (Stokes and Baird, unpublished data). Both fungal taxa can occur simultaneously on the same root confounding symptomologies.

Macrophomina phaseolina is an extremely important pathogen of numerous agriculture and horticultural crops causing the loss of millions of dollars annually. This pathogen is the main one associated with tip/end rot and produces the toxin botryodiplodin, which is thought to be a carcinogen. This pathogen can cause external and internal rots of crops important to Mississippi such as sweet potatoes. In the case of internal rot, which cannot be seen at the producer's level, methods to determine MP presence in presumed healthy sweet potato roots will enable the grower to ensure a quality product being sold in the market place. Portable detection equipment that can be used within warehouse pre-storage and packaging facilities could eliminate losses and prevent infected product from entering the marketplace and maintaining wholesaler and consumer confidence. In addition, the methods developed in this study can be used for MP in numerous other crops for the future. Therefore the focus of this work is to explore the development of rapid detection methods and hardware for qualitative and quantitative analysis of microbial volatile organic compounds (MVOCs) in order to identify specific chemicals unique to the MP. In recent years, metabolomics approaches have been widely used for the investigation of metabolites of biological samples for identifying biomarkers that correlate to a disease, drug toxicity, or genetic or environmental variation. Metabolites can belong to a wide variety of compound classes, such as amino acids, lipids, organic acids, nucleotides, alcohols, esters, and hydrocarbons. These compounds are very diverse in their physical and chemical properties and occur in a wide concentration range. Some of these metabolites are volatile enough for headspace sampling. Metabolic profiling and fingerprinting methods are used to elucidate a microorganism's life processes. Metabolic profiling is a determination of the chemicals and their concentrations produced by specific biosynthesis pathway of organisms. Metabolic fingerprinting is the screening approach to classify samples based on metabolite patterns or "fingerprints". The metabolomics study process often includes sample preparation, sample collection, instrumental analysis, data pretreatment, and data analysis.

Malt Extract Agar (MEA), Czapek Solution Agar (CSA), and Corn Meal Agar (CMA) were purchased from Becton, Dickinson and Company (Franklin Lakes, New Jersey). The ingredients of chemical defined agar (CDA) were mixed based on the literature. Carboxen/Polydimethylsiloxane (CAR/PDMS), Divinylbenzene/ Polydimethylsiloxane (DVB/PDMS), and DVB/CAR/PDMS SPME fibers were purchased from Sigma-Aldrich (St. Louis, MO). The analysis of collected MVOCs was performed with a GC-MS. Extracted volatiles were thermally desorbed from the SPME fiber in the injection port (at 270℃), equipped with a 78.5 mm × 6.5 mm × 0.75 mm SPME inlet liner. Thermal desorption was setup for 5 min and the SPME fiber was conditioned for 1 h at 270℃ following manufacture instructions before the next usage. The gas chromatography capillary column used for separation was a 60-m DB-1 capillary column with an internal diameter of 320 μm and a film thickness of 1 μm. Helium was used as a carrier gas with a flow velocity of 1.2 ml min-1. The following GC oven temperature program was

applied: 45℃ for 9 min, 10℃ min-1 to 85℃, hold for 3 min, 3℃ min-1 to 110℃, hold for 3 min, 3℃ min-1 to 120℃, hold for 3 min, and 10℃ min-1 to 270℃, hold for 5 min. The MS analysis was carried out in full scan mode (scan range from 35-350 amu) with ionization energy of 70 eV. Ion source and quadrupole temperatures were 230℃ and 150℃, respectively.

Extracted MVOC profiles and quantities were determined and the information was used to select the best SPME fiber for metabolic fingerprinting. Experiment precision (repeatability) was evaluated based on relative standard deviation (RSD%) of the six replicates of three SPME fiber types: CAR/PDMS, DVB/PDMS and DVB/CAR/PDMS. These fibers were evaluated in terms of their efficiency in extracting volatile metabolites emitting growth on a MEA substrate. The fungal culture was incubated for 7 d at 30℃ with initial inoculation spores concentration of 1×106 spores/ml. The SPME extraction was maintained at 30℃ for 5 hours. The extraction efficiency evaluation included two aspects, MVOC selectivity and quantity (peak area).

Three evaluated fibers showed different abilities to extract volatile metabolites. The CAR/PDMS fiber not only extracted the largest number of MVOCs, but also extracted the largest amount of MVOCs based on the total peak area of all the volatile metabolites (Figure 1B). A closer look at the data revealed MVOC functional group selectivity. Identified MVOCs were divided into 9 chemical classes including alcohols, aldehydes, furans, hydrocarbons, ketones, organic acids, organosulfur compounds, sesquiterpenes, and other compounds. Among the chemical classes, hydrocarbons were divided into hydrocarbon1 (fewer than ten carbons) and hydrocarbon2 (ten or more carbons). Other compounds include seven unknown compounds, one ether and one ester.

The CAR/PDMS fiber extracted greater amount of alcohols, furans, hydrocarbons1, hydrocarbon2 and ketones, while DVB/PDMS extracted larger amount of high molecular weight compounds containing the organosulfur compounds, sesquiterpenes and other compounds. These results agree with the literature which describes the CAR/PDMS as likely to extract low molecular weight compounds while DVB/PDMS is better at extracting high molecular weight compounds.

In Arkansas a disease dissimilar to other reported diseases of soybean has been found in the Mississippi River Delta. In fields where soybeans are R5, plants appear chlorotic, stunted, and when extracted from the soil, have a malformed and necrotic taproot that is often black. The estimated yield loss from affected plants was approximately 30% in 2014. The occurrence of symptomatic plants was sporadic and it was estimated that the impact to overall yield was less than 1%. However, in 2015, disease was more severe in some fields and widespread regionally. Additionally, in areas of symptomatic plants, gaps in stand were evident with mummies of dead plants between the chlorotic plants. When dead plants were extracted from the soil, the taproot was malformed and black if present. Symptoms were similar in Mississippi and Louisiana. Recently, a group of scientists from the University of Arkansas, Mississippi State University, and Louisiana State University have characterized a disease of soybean prevalent in our three states, Taproot decline (TRD). It was determined that the disease was caused by a fungus, which had not been described, in the genus *Xylaria*. Since the group began working on TRD, the disease has been identified in Tennessee and Alabama, and scientists from those states have been included on the project. However, the regional distribution of disease occurrence and overall yield loss is still not fully understood, but is becoming clearer as more information becomes available. In Arkansas,

TRD has been found as far north as Craighead County and yield loss determined to be approximately 30% on impacted plants. Additionally, some farmer and consultant reports indicate losses could be as high as 10 bu/A in fields. These estimates agree with recent loss estimates from Louisiana (Trey Price, LSU AgCenter) where 20% incidence or mortality resulted in 8 and 10 bu/A losses, respectively. From 2014-2017, six fields with TRD were marked with approximately 100 GPS points in areas from 1.75 to 8 acres in size. Taproot decline was rated at each point for incidence and in some fields for mortality as well. Aggregation statistics were calculated in GeoDa (Center for Spatial Data Science, University of Chicago, Chicago, IL). Disease distributions were clustered at all scales (P=0.05). Since yield data was only available for one field, loss was estimated using a proportional vector analysis of symptomatic plants. In ArcMap (ESRI, Redlands, CA), the semi-variograms of each location were modeled for incidence and severity and interpolated using ordinary kriging. Individual classes were created and losses assigned based on yield loss estimates. The maps were converted to vectors and areas of each polygon calculated. From the six fields, using a soybean price of $10.25, losses per acre ranged from $6.43 to $109.58 indicating the disease can be destructive in some fields and efficacious inputs to control disease profitable. Currently, we do not have repeated data from field trials suggesting seed treatment fungicides or soybean varieties could be used to manage TRD. However, some recent evidence from laboratory assays of various commercially available chemistries have been promising. Continued coordination of field research between states where TRD is found will be paramount in understanding integrated programs to manage the disease. Understanding the regional distribution, commercially available seed treatment efficacy, and varietal susceptibilities are necessary for successful management of this disease in Arkansas and the region.

In Nebraska a study provided new understanding about the spread of Fusarium in the state and the species that pose the highest threat to field crop production in Nebraska. A state-wide survey of *Fusarium* species associated with field crops was conducted with the aim i) to isolate, identify, and determine the intraspecific diversity of *Fusarium* spp. associated with root rot in corn, soybean, and wheat crops in Nebraska and ii) to determine cross-pathogenicity of recovered isolates among these crops. Plant and soil samples were collected from multiple locations and isolates were recovered. Among the isolates, 62 of which represented all morphological groups were selected and identified by sequencing of the internal transcribed spacer regions of rDNA and the beta tubulin. The pathogenicity of 28 isolates in corn, soybean, and wheat crops was evaluated. During this study, a total of 137 isolates were recovered from 20 counties in Nebraska. *F. oxysporum* was the most abundant, followed by *F. graminearum* and *F. acuminatum*, and these species are found in all geographic regions of the state. However, *F. graminearum* was the most virulent and showed the highest cross-pathogenicity to three crops – corn, soybean, and wheat.

In Minnesota *Phytophthora sojae* pathotypes were isolated from 69 soybean fields in 57 counties in an ongoing study to determine the *P. sojae* pathotypes present in the state's soybean growing areas. The samples were processed to isolate *P.sojae* and also, *Phytophthora sansomeanae*, if it is present. The samples were dried, ground, a subsample placed in a small pot, flooded for 24 hours, drained and the incubated for two weeks. They were then baited with *Phytophthora* susceptible soybean variety, Sloan. After 14 days of growth, the seedlings were extracted from the soil, washed, and symptomatic tissue plated onto PBNIC medium. Mycelial growth that appeared to be *Phytophthora* when examined visually was collected and placed on media in a petri dish containing PBNIC. Isolates that appeared to be *Phytophthora* were transferred to PBNIC media and stored.

At the beginning of December 2017, 405 *Phytophthora*-like isolates had been cultured from these samples. The isolates were examined morphologically to verify their identity as either *Phytophthora or Pythium*. An additional isolate sample was plated on PDA media to determine if the isolate may be *Phytophthora sansomeana*. To distinguish *Phytophthora* from *Pythium* species isolates, isolate identity is also being confirmed using a *Phytophthora* specific PCR primer. All isolates are being retained. The *Phytophthora* isolates confirmed to be *P. sojae* will be inoculated into a differential set consisting of soybean lines representing 13 Rps genes in order to determine isolate pathotype.

2. Examine the effect of traditional or newly developed management strategies (chemical, cultural, and biological), soil physicochemical properties, or introduced biological control agents on the microbial community and its ability to suppress soilborne pathogens.

In Nebraska isolation and assessment of potential biological control agents for use in IPM was determined. New bacterial strains were identified with the ability to suppress root rot disease or promote plant growth. One of the new strains was identified as *Bacillus simplex* and very little is previously known about this species as a plant growth-promoting rhizobacteria or biocontrol agent. Thus, the discovery of this novel taxonomic group with the ability to control plant disease or enhance plant growth is a key short-term outcome. In greenhouse studies, 15-65% reduction in plant disease was achieved by using the beneficial organisms while 35-95% reduction in pathogen growth was achieved during laboratory *in vitro* assays.

In the growth promotion study, seed treatment with *Bacillus megaterium* R181, *B. safensis* R173, *B. simplex* R180, and *Paenibacillus graminis* R200 increased the growth of all test crops compared to water-treated controls. The four strains increased shoot mass by 93-126% compared to the controls and increased root mass by 127-197%. Strains differed in their responses to tests for physiological trait and there was no single physiological trait found to be predictive of growth-promotion efficacy of the bacterial strains. More than 150 potentially beneficial bacterial isolates belonging to the *Bacillus* group and 10 *Trichoderma* (fungi) isolates were collected during the project year and 20% were evaluated for growth promotion and/or antagonism against fungal pathogens *in vitro*. Selected isolates among those collected in previous years and examined *in vitro* were evaluated in 2017 in greenhouse experiments and two of the lead strains were evaluated in the field for effectiveness in controlling root rot on corn, wheat, and soybean caused by *Fusarium* spp. and *Rhizoctonia solani*. During *in vitro* inhibition tests of newly isolated bacteria and fungi against pathogenic strains of *Fusarium* spp., one strain of *Burkholderia ambifaria*, one strain of *Bacillus simplex*, and five strains of *Trichoderma* were selected as top strains.

In Mississippi 1) More than 20 bacterial isolates from various environmental niches, such as cropping soils, forest soils, and fresh vegetables were obtained. Some isolates show better antimicrobial activities than MS14. 2) A gene cluster containing two polyketide synthetase genes in the strain MS14 genome was confirmed to be involved in the biosynthesis of the antibacterial compound. Using the NRPS/PKS substrate predictor, we predicted the backbone of the antibacterial compound. Further mutation analysis using CRISP/Cas9 system showed that the two genes are involved in production of the bactericidal compound. A novel function of bacterial siderophores, which promotes production of bactericidal activity was identified. 3) Strain MS 586 was isolated from a soybean field soil in the Mississippi Delta. This bacterium exhibits unique antibacterial activity against plant pathogenic bacteria. Based on preliminary identification, it

represents a novel species of the genus *Pseudomonas*. In 2017, we collected more data to demonstrate that strain NS586 represents a novel species of *Pseudomonas*. 4) Antifungal activity of strain MS82 was characterized and it can be used for mushroom production. 5) Characterization of antimicrobial activity of endophytic bacteria. It has been revealed that some of bacterial isolates possess significant antifungal activities against the charcoal rot pathogen. Evaluation of efficacy of enhancing disease resistance and plant growth promoting activities in greenhouse is under way. A few mutants were obtained from genetic mutagenesis.

In Tennessee The efficacy of biorational products and fungicides against *Phytophthora* root rot of hydrangea and *Rhizoctonia* root rot of viburnum were assessed in separate field trials. Treatments were arranged in randomized complete block design with four replications in each trial. Plots were inoculated with *Rhizoctonia solani* agar slurry or *Phytophthora nicotianae* grown on rice grains. Mutual treatments were RootShield *PLUS*, MBI110, IT-5103, TerraClean 5.0 + TerraGrow and Empress. SoilGard, Mural and Pageant were used in the *Rhizoctonia* trial; OxiPhos, Segovis and Subdue Maxx were used in the *Phytophthora* trial. TerraClean 5.0 was drenched into the soil 24 h prior to transplanting. Rooted cuttings were dipped in TerraGrow (1 oz/10 gal) prior to planting and same plants received TerraGrow (0.4 oz/10 gal) as drench application after transplanting. Other treatments were applied as a drench after transplanting. All treatments significantly reduced root rot severities compared to the untreated, inoculated controls. The treatments most effective in reducing *Phytophthora* root rot severity were Segovis, Empress, Subdue Maxx and MBI110 and in reducing *Rhizoctonia* root rot severity were Mural, Empress, Pageant and TerraClean 5.0 + TerraGrow.

The efficacy of fungicides against *Phytophthora* root rot of dogwood was assessed in a greenhouse trial. Treatments (RootShield *PLUS*, MBI110, Empress Intrinsic, Mural, Pageant Intrinsic, Segovis and Subdue Maxx) were applied as drench applications using a measuring cup at 200 ml treatment per plant 5 days before inoculation. Plants were inoculated by placing a single rice grain colonized for 10 days by *P. cinnamomi* at four opposite sides in the root zone of each plant. Non-treated, inoculated and non-treated, and non-inoculated plants served as controls. Plant root systems were assessed for root rot severity using a 1 to 5 scale based on percentage of the root with visible rot symptoms. The median value of each range was used for data analysis. *Phytophthora* root rot severity was moderate to high; the final mean root rot severity was 69.3% in the non-treated, inoculated dogwood plants. All treatments significantly reduced *Phytophthora* root rot severity compared to the non-treated, inoculated control. Plants treated with Segovis, Empress Intrinsic, Subdue Maxx and MBI1 had significantly less *Phytophthora* root rot than the other treatments. Segovis, Empress Intrinsic and Mural treatments significantly increased plant root weight compared to the other treatments and non-treated, inoculated control.

The efficacy of fungicides against *Phytophthora* aerial blight of vinca was assessed in a greenhouse trial. Treatments (Segovis 1.67 SC at 1 and 2 fl oz/100 gal) were applied as a drench application using a measuring cup at 200 ml treatment per plant 7, 14 and 21 days before inoculation (DBI) on 26, 19 and 12 Jun 2017, respectively. Plants were inoculated by placing a single rice grain colonized for 10 days by *P. nicotianae* at four opposite sides in the root zone of each plant on 3 Jul 2017. Non-treated, inoculated and non-treated, and non-inoculated plants served as controls. Plants were assessed four times starting on 17 Jul and ending on 28 Aug for symptom severity using a 1 to 5 scale based on the percentage of foliage with visible

symptoms. The median value of each range was used for data analysis. *Phytophthora* aerial blight pressure was moderate to high; the final mean disease severity was 66.1% in the non-treated, inoculated control vinca plants. Both rates of Segovis significantly reduced *Phytophthora* aerial blight severity compared to non-treated inoculated control throughout the evaluation period regardless of the application timing. There were no significant differences in disease severity between low and high rates of Segovis applications on 17 and 31 Jul. The high and low rates of Segovis applied 7 and 14 days before inoculation significantly reduced *Phytophthora* aerial blight severity compared to the high and low rates of Segovis applied 21 days before inoculation on 14 and 28 Aug. The high rate of Segovis applied 7 and 14 days before inoculation and the low rate of Segovis applied 7, 14 and 21 days before inoculation significantly increased plant weight compared to the high rate of Segovis applied 21 days before inoculation and the non-treated, inoculated control.

Based on the outcome of the pathogenicity study from 2016 research results, selected cover crops were evaluated for their ability in controlling soilborne diseases in greenhouse and farm trials. The experiments were established as greenhouse trials in topsoil with pre-existing populations of *R. solani* or *P. nicotinanae* and on-farm with prevalent *R. solani* pressure. Selected biofumigants were direct seeded into the soil and flowering plants were incorporated 15 cm deep into the same pots or beds and covered with polythene for 14 days/1 month. Volatile compounds released during the biofumigation process were collected at different time intervals. In the greenhouse trial, the biofumigated pots of hydrangea or viburnum plants were grown and roots evaluated for disease severity. In the on-farm trial flowering cherry (*Prunus serrulata* 'Kwanzan') cuttings were planted two weeks after the incorporation of each treatment. Data were analyzed using Minitab statistical software. In greenhouse study, mustard (*Sinapis alba),* purple top forage turnips (*B. rapa),* astro arugula (*E. vesicaria* spp. *sativa),* mighty mustard (*B. juncea),* dwarf essex rape (*B. napus),* amara mustard (*B. carinata)* and oriental mustard (*B. juncea)* cover crops were effective in controlling *R. solani* and *P. nicotianae* pathogens. Amara mustard, astro arugula and purple top forage turnips were effective in controlling soilborne pathogens under field conditions.

The effectiveness of a cover crop mix (wheat and crimson clover) for management of wood-boring insects and soilborne pathogens (*P. nicotianae* and *R. solani*) was assessed in nursery production. There were four treatments; no insecticide + herbicide, insecticide + herbicide, cover crop + insecticide, and cover crop only. The experiment was established as a randomized complete block design with four replications. Soil was sampled from field plots before and after incorporation of the cover crop mix. Greenhouse bioassays were conducted using red maple seeds in 4-in pots. Pots were amended with *P. nicotianae* or *R. solani* inoculum. Non-inoculated pots served as controls. Stand and vigor data were recorded four months after seeding. Fluorescent *Pseudomonads* were determined using selective media. The lowest level of damping off was observed in the cover crop treatments for both pathogens. The observed level of damping off was also lowest in cover crop incorporated soils. Plant vigor was greater in the cover crop treatments. There were no significant differences in *Pseudomonad* colony numbers among treatments, but colonies numerically increased in cover crop incorporated soils. These results indicate that cover crops can provide nursery growers with some quantifiable protection against subsequent outbreaks of soilborne diseases.

In Arkansas Southern root-knot nematode, *Meloidogyne incognita*, is responsible for substantial yield losses on soybeans grown in the Mississippi Alluvial Plain. Evidence suggests nematicide seed treatments, ILeVO (fluopyram) and Avicta (abamectin), have decreased reproduction and root galling by root-knot nematodes (RKN) but yield protection in fields with higher nematode pressure is unclear. The objective of this work was to determine the efficacy of these seed treatment nematicides compared to Telone II (1,3-dichloropropene) applied site-specifically. In 2016, a field near Backgate, AR was confirmed to have a population of RKN. Prior to planting, three strips of Telone II were applied with a coulter rig. Armor DK4744 soybeans were planted without any nematicide, with ILeVO, with Avicta, or within Telone II in adjacent strips of equal size, replicated three times. Data was collected at ten georeferenced locations within each strip and yield data was provided by a yield monitor. Populations of RKN were significantly less at harvest in the Telone II than ILeVO and strips lacking nematicide (P=0.05). Yield was significantly greater in the Telone II strips than all other treatments, while ILeVO and Avicta were not different than strips lacking nematicide (P=0.001). The distribution of RKN at harvest was uniform (P=0.08) suggesting Telone II would be economically beneficial as a whole-field application when a susceptible soybean is planted. In 2017, the same field in Backgate, AR was used in a similar design; Armor 46-D08 soybeans were planted without any nematicide, with ILeVO, with Avicta, within Telone II applied in 2016 (residual Telone II), and within Telone II applied in 2017. Data was collected at ten new georeferenced locations within each strip and yield data was provided by a yield monitor. Yield for both Telone II and residual Telone II strips were significantly greater than all other treatments, and the ILeVO and Avicta strips were significantly greater than soybeans planted with no nematicide (P=0.05). This suggests that all nematicide treatments tested provided yield protection as a whole-field application when a susceptible soybean is planted rather than applied site-specifically.

PUBLICATIONS / PRESENTATIONS

Scientific articles:

Sharma, S., Zaccaron, A., Ridenour, J., Allen, T., Conner, K., Doyle, V., Price, T., Sikora, E., Raghuwinder, S., Spurlock, T., Tomaso-Peterson, M., Wilkerson, T., Bluhm, B. Draft genome sequence of *Xylaria* sp., the causal agent of taproot decline of soybean in the Southern United States. Journal of Biotechnology. (submitted 2017)

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Peng Deng, Adam Foxfire, Jianhong Xu, Sonya M. Baird, Jiayuan Jia, Keren H. Delgado, Ronald Shin, Leif Smith and Shi-En Lu*. 2017. Siderophore product ornibactin is required for the bactericidal activity of Burkholderia contaminans MS14. Applied and Environmental Microbiology. 83(8), e00051-17.

Ma, Lin, Xiaoqiang Wang, Peng Deng, Sonya M. Baird, Youzhou Liu, Shaoxuan Qu, and Shi-En Lu*. 2017. The PafR Gene Is Required for Antifungal Activity of Strain MS82 against Mycogone perniciosa. Advances in Microbiology 7 (04): 217.

Abstracts/Posters

B. Boney, T. Spurlock, J. Rupe, and A. Tolbert. Site-Specific Efficacy of Nematicides in Soybean. Arkansas Crop management Conference 2017, Fayetteville, AR

Spurlock, T., Kirkpatrick, T. Understanding the phytobiome; using strip trials and spatial analysis to determine concomitant maladies in soybean fields. SSDW 2017, Pensacola, FL.

Stetina, T., Tzanetakis, I., Rothrock, C., Spurlock, T. Transmission of mycoviruses of *Rhizoctonia solani* and effects on fungal growth. APS Annual Meeting 2017, San Antonio, TX.

Boney, B., Spurlock, T., Allen, T., Francis, P., Rupe, J., Stark, R., Tolbert, A. Management of plant-parasitic nematodes in soybean using site-specific methods. 2017. APS Southern Division, College Station, TX. Phytopathology 107:S3.2

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Akinrinlola, R., Adesemoye, A. O., and Yuen G. Y. 2017 Bacillus strains as plant growth-promoting agents for the Great Plains agricultural region. Oral presentation during the Annual

Meeting of the North Central Region of the American Phytopathological Society, which held at Champaign, IL. June 14-16, 2017.

Kodati, S., Eskelson, M. J., and Adesemoye, A. O. 2017. Cross-pathogenicity of *Rhizoctonia* spp. isolated from multiple hosts to corn, soybean, and wheat. Oral presentation during the Annual Meeting of the North Central Region of the American Phytopathological Society, holding at Champaign, IL. June 14-16, 2017.

Parikh, L., Eskelson, M., and Adesemoye, A. O 2017. Biological control of Fusarium root rot on row crops in the Great Plains using PGPR and *Trichoderma* species. Poster presentation during the Annual Meeting of the American Phytopathological Society, APS, San Antonio, Texas. August 5-9, 2017.

Kodati, S., Gambhir, N., Everhart, S., and Adesemoye, A. O 2017. Prevalence and pathogenicity of *Rhizoctonia* spp. from soybean in Nebraska. Poster presentation during the Annual Meeting of the American Phytopathological Society, APS, San Antonio, Texas. August 5-9, 2017.

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Baysal-Gurel, F. 2017. Identification of boxwood diseases and pests. November 2017. TSU-18-0042(B)-4a-61065.

Liyanapathiranage, P. Sustainable management of soilborne diseases in nursery production. MS Thesis. Nashville, TN. 12/09/2017.

Kirkpatrick, T. Spurlock, T., Patton, A. Bateman, R., Moseley, D. MP481 Controlling Nematodes on Golf Courses. 2017.

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Presentations / Professional Meetings

Spurlock, T. N. Precision AG and Remote Sensing. Farm Bureau Officers and Leaders Conference. 24 July, 2017. Hot Springs, AR. (invited)

Spurlock, T. N., Nematicide use in Arkansas. DowAgrosciences Telone II meeting. 20-21 February 2017. College Station, TX. (invited)

Spurlock, T. N. Identification and Management of Soilborne Diseases of Soybean. 2017. Tri-state Soybean Forum, Dumas, AR (invited)

Boney, B., Spurlock, T., Allen, T., Francis, P., Rupe, J., Stark, R., Tolbert, A. Management of plant-parasitic nematodes in soybean using site-specific methods. 2017. APS Southern Division, College Station, TX. (poster)

Spurlock, T., Kirkpatrick, T. Understanding the phytobiome; using strip trials and spatial analysis to determine concomitant maladies in soybean fields. SSDW 2017, Pensacola, FL. (oral)

Stetina, T., Tzanetakis, I., Rothrock, C., Spurlock, T. Transmission of mycoviruses of Rhizoctonia solani and effects on fungal growth. APS Annual Meeting 2017, San Antonio, TX. (poster)

Baysal-Gurel, F. Soil borne diseases of woody ornamentals in nursery production systems. Multistate Project S-1053- Ecological and Genetic Diversity of Soil-borne Pathogens and Indigenous Microflora Annual Meeting, McMinnville, TN, October 20 and 21, 2016 (speaker and host).

Liyanapathiranage, P. and Baysal-Gurel, F. Sustainable Management of Soil-borne Diseases in Nursery Production. S-1053- Ecological and Genetic Diversity of Soil-borne Pathogens and Indigenous Microflora Annual Meeting, McMinnville, TN, October 20 and 21, 2016 (speaker).

Kabir, Md N. and Baysal-Gurel, F. Effect of Biopesticides on *Phytophthora* Root Rot Disease of Oakleaf Hydrangea. S-1053- Ecological and Genetic Diversity of Soil-borne Pathogens and Indigenous Microflora Annual Meeting, McMinnville, TN, October 20 and 21, 2016 (speaker).

Liyanapathiranage, P. Pathogenicity of *Rhizoctonia solani* and *Phytophthora nicotiane* to biofumigation cover crops (*Brassica* spp.) Departmental seminar. Nashville, TN. 4/6/2017.

Liyanapathiranage, P. Sustainable management of soilborne diseases in nursery production. MS Thesis Defense Seminar. Nashville, TN. 07/11/2017.

Baysal-Gurel, F. Fungicide resistance management. Departmental seminar. Nashville, TN. 11/16/2017.

Kabir, Md N. Enhancing the detection process, prevention and sustainable management of soilborne diseases in Tennessee nursery production. Departmental seminar. Nashville, TN. 11/16/2017.

Baysal-Gurel, F. Tennessee Nursery Field Day. Research updates. McMinnville, TN. June 20, 2017 (Organizer and presenter).

Baysal-Gurel, F. TDA Boxwood blight training. McMinnville, TN. September 20, 2017 (Presenter).

Baysal-Gurel, F. Boxwood disease training. McMinnville, TN. November 9, 2017 (Organizer and presenter).

Baysal-Gurel, F. Identification and management of diseases and pests of ornamental crops workshop. Cukurova University, Adana, Turkey, 11-14 April, 2017 (Trainer) (42 students).

Baysal-Gurel, F. A fungus among us. Junior Master Gardener Camp, McMinnville, TN, July 2017 (Trainer).

Baysal-Gurel, F. Plant diseases. 2017 TN Master gardener classes. TSU NRC, McMinnville, TN, 1/17/2017 (Invited speaker).

Baysal-Gurel, F. Garden diseases and their management. McMinnville Garden Club. McMinnville TN, 1/10/2017 (Invited speaker).