**2018 Annual Report for Multi-State Research Project S1083**

**Ecological and Genetic Diversity of Soilborne Pathogens and Indigenous Microflora**

**Reporting Period:** 01 Nov 2017 - 30 Sep 2018

The S1083 multi-state project was proposed on 2017 but officially started on October 10, 2018. Last year we were transitioning and waiting the approval of the project, therefore most of our members were not required to submit an annual report, however joined the project after it was approved. The project currently has 14 members listed, from Arkansas, Mississippi, Minnesota, Nebraska, Ohio, Oklahoma, Pennsylvania, and Tennessee. The current report includes the technical summaries submitted by new members, in addition to research conducted and the outcomes from members who reported during the period of 2017-2018.

**ARKANSAS – Dr. Alejandro Rojas and Dr. Terri Spurlock, University of Arkansas**

Dr. Spurlock was a member of previous versions of the multi-state project and a co-author of this project, however he is no longer at University of Arkansas. Dr. Alejandro Rojas joined the multi-state group in 2018 with the following is the technical summary of his project:

The execution of the proposed project will contribute unique information on a regional or national level and innovative protocols by characterizing selected soilborne plant pathogenic populations as impacted by cultural practices, such as rotations, soil amendments, and soil type by demonstrating the role of the microbial diversity and ecology of the pathogenic genera, as well as other organisms interacting with them, in suppressing the levels of disease that occurs in the field. The information generated will lead to management practices that take advantage of microbial interactions that reduce pathogen activity. A greater characterization of the pathogenic genera targeted in this project will provide that framework necessary to improve biological control as well as integrated disease management strategies. The new project will encompass two main objectives: 1. Evaluate the population genetic diversity of soilborne pathogens and antagonistic microorganisms in different growing systems and regions using traditional and metagenomic approaches and 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. Emphasis will put on the study of agricultural systems where *Rhizoctonia* and *Pythium* are major threats to crop productivity, but other pathosystems will be studied as well.

**MISSISSIPPI Dr. William Kingery and Dr. Shankar Ganapathi Shanmugam, Mississippi State University.**

Objective. Evaluate the genomic profile of Soybean Taproot Decline (soil-borne agent *Xylaria* spp.) in relation to (a) the ecology of the soil microbiome, and (b) the context of on-farm crop and soil management conditions.

A. Document agricultural management practices and history associated with Soybean Taproot Decline symptomatic fields.

Activities: A total of 18 soybean fields across six Delta counties were evaluated for the field-scale characteristics of symptomology of Soybean Taproot Decline. Evaluations were made at the R5 stage of crop development. A two-tier rating system for characterization was utilized. Field-scale distribution of symptoms were rated with the use of a 7-category system extending from no symptoms visible to symptomology present throughout. The categories included descriptors for symptoms appearing in concentration, i.e., clusters of infected plants, through symptoms distributed throughout the field. Fields were divided into four quarters with an overall rating given as the average of the four. Infection intensity percentage was measured by counting the number of infected plants per 100 plants in a linear section of row. This was done at two randomly chosen positions within each of the field quarters mentioned above.

B. Assess the soil microbiome associated with a range of Soybean Taproot Decline intensities and its progression across fields.

Activities: Two fields in the Mississippi Delta were sampled on July 26 at locations within the fields that represented three ranges of Soybean Taproot Decline intensity (0%, 1-50%, and > 50% of plants infected along one linear meter of row, i.e., infection intensity grouping of low, medium an high). From each site, soil core plugs were collected along the one meter of row, to a 10-cm depth and composited. Two additional Delta fields, each with nine georeferenced location per field were measured for percentage infection along one linear meter of row and soil sampled as described above at three dates (June, July and August). At the final sampling, all plants at each of the nine locations were collected and returned to the lab to make a final determination of Soybean Taproot Decline infection and to determine grain yield.

**OHIO – Dr. Soledad Benitez, Ohio State University**

In 2018 Dr. M. Soledad Benitez Ponce, from The Ohio State University, worked on different aspects of Objective 1 and 2 of this project. Specifically, for objective 1, the Benitez lab is working on aspects of soybean-associated microbiome responses to crop diversification, within the context of Ohio cropping systems. In 2018, two set of experiments were sampled for analysis of both bacterial and fungal communities; as well as soil and plant health measurements. The first experiment involves a three-year rotation experiment, established by collaborators in Ohio State in 2013. Therefore in 2018, two sets of three-year rotations have been completed, which could result in measurable changes in the system. This rotational system incorporates wheat into the corn-soybean rotational system and is being paired with a two-year rotation for comparison. Measurements were taken at soybean seedling stage, including soybean establishment and biomass, as well as evaluation of different pools of soil carbon, and yield. Samples for bacterial and fungal microbiome were also collected and will be analyzed next year. The second experiment involves the use of rye cover crops and the dynamics of microbiome changes in relation to timing of cover crop termination and subsequent soybean productivity. In 2018 soil samples for microbiome analysis were taken at rye establishment, and this work will continue in 2019, and potentially beyond.

For objective 2, the Benitez lab started a collaboration to evaluate the use of arbuscular mychorrhizal fungi in control of soil borne diseases of soybean. In 2018, most of the work related to this project involved protocol development and evaluation of mychorrhizal infection in soybean in the greenhouse. In the field, no effects were observed in response to the use of this particular inoculum. Mychorrhizal infections are occurring naturally in the field, with levels similar than upon application of inoculant. Future work will involve incorporating interactions between management practices and the efficacy of biological-based inoculants in the field.

**OKLAHOMA - Dr. Carla Garzon, Oklahoma State University**

In 2018 Oklahoma Agricultural Experiment Station requested a final report for the S1053 project, but including only the 2018 publications. Research progress was made regarding objective 1 of the project. Three collaborative studies were in progress relevant to the multi-state project in 2018. Electronic probes for detection of selected oomycete pathogens from metagenomic data were developed using the EDNA pipeline and validated in silico. A population genetics study of *Pyrenospora tritici-repentis* from multiple wheat fields in Oklahoma was completed. The genomes and transcriptomes of three Ophiosphaerella species were sequenced and compared to identify putative pathogenicity factors. The results of these studies were presented in oral and poster presentations at local, national and international meetings.

Publications:

Espíndola AS, Schneider W, Cardwell, KF, Hoyt PR, Marek SM, Melouk H, **Garzón CD**. **2018**. Inferring the presence of aflatoxin-producing *Aspergillus flavus* strains using RNA sequencing and electronic probes as a transcriptomic screening tool. PLOS ONE. <https://doi.org/10.1371/journal.pone.0198575>

Orquera GK, Diaz CI, Mogrovejo D, Villamarin D, Jarrín F, Oliva R, Gia J, Forbes G, Andrade-Piedra J, Molineros J, **Garzón CD**, Koch AR, Benítez MS. **2018**. Microbial-based suppression of tuber blight infection by Andean soils from four provinces in Ecuador. Plant Pathology. 67: 1562-1573. <https://doi.org/10.1111/ppa.12872>

**Garzón C** and Daughtrey M. **2018**. Who’s Doing Pythium Root Rot Now? Greenhouse Management Magazine <http://www.greenhousemag.com/article/whos-causing-pythium-root-rot-now/>

Oral and Poster Presentations

**Garzon CD**. 2018.[Status of the taxonomy of](https://apsnet.confex.com/apsnet/ICPP2018/meetingapp.cgi/Paper/11616) *[Pythium](https://apsnet.confex.com/apsnet/ICPP2018/meetingapp.cgi/Paper/11616)*[,](https://apsnet.confex.com/apsnet/ICPP2018/meetingapp.cgi/Paper/11616) *[Phytopythium](https://apsnet.confex.com/apsnet/ICPP2018/meetingapp.cgi/Paper/11616)*[,](https://apsnet.confex.com/apsnet/ICPP2018/meetingapp.cgi/Paper/11616) *[Pythiogenton](https://apsnet.confex.com/apsnet/ICPP2018/meetingapp.cgi/Paper/11616)* [and related genera.](https://apsnet.confex.com/apsnet/ICPP2018/meetingapp.cgi/Paper/11616)  6th International Oomycetes Workshop: Phytophthora, Pythium, Downy Mildews and related genera. International Congress of Plant Pathology, July 28, 2018. Boston, USA.

Proaño MF, Espindola AS, **Garzon CD**. 2018. Detection of multiple oomycetes in metagenomic data by Using E-probe Detection of Nucleic Analysis (EDNA). International Congress of Plant Pathology, Aug. 3. Boston, USA.

Proaño MF, Espindola AS, Marek SM, Schneider W, **Garzon CD**. 2018. Detection of multiple oomycetes in metagenomic data by using E-probe Detection of Nucleic Analysis (EDNA). 18th Oomycete Molecular Genetics Network Annual Meeting. Shandong Agricultural University. Apr. 8-12. Shandong, China.

Suarez S, **Garzon** CD, Hunger RM, Marek SM. 2018. Characterization of tan spot fungus populations from wheat in Oklahoma. 511-P. International Congress of Plant Pathology, Boston, USA.

Graf Grachet N, Couger M, Young CA, Hartson S, **Garzon CD**, Marek SM, Walker NR. 2018. The genomes of Ophiosphaerella spp. reveal new insights into the bermudagrass spring dead spot pathosystem. 578-P. International Congress of Plant Pathology, Boston, USA.

Graf-Grachet N, Couger M, Young C, Harston S, **Garzon CD**, Marek S, and Walker N. 2018. The genomes of *Ophiosphaerella* spp. reveal new insights into the bermudagrass spring dead spot pathosystem. 3rd OSU Soil Biology Symposium. Stillwater OK. Apr. 27.

Proaño MF, Espíndola AS, and **Garzon CD**. 2018. Detection of multiple oomycetes in metagenomic data by using E-probe Detection of Nucleic Analysis (EDNA). 3rd OSU Soil Biology Symposium. Stillwater OK. Apr. 27.

Suarez S, Marek S, Hunger R, **Garzon CD**. 2018. Characterization of the Tan Spot fungus populations on wheat in Oklahoma. 3rd OSU Soil Biology Symposium. Stillwater OK. Apr. 27.

**TENNESSEE – Dr. Fulya Baysal-Gurel,**

The primary impacts of this project were: 1) provide information regarding how specific management strategies, such as biofumigant cover crops or compost amendments, can suppress plant pathogens and increase the abundance of antagonist populations, and 2) provide the nursery industry with improved, efficacious, cost-effective, sustainable and environmentally friendly recommendations for soil-borne disease management.

1. Evaluate the efficacy of chemical and biorational products for controlling soil-borne diseases with different application methods, intervals and reduced-rate applications in ornamentals.

Phytophthora and Rhizoctonia root rot diseases are two destructive diseases of woody ornamentals with a wide host range. The efficacy of biocontrol products and fungicides against Phytophthora root rot of hydrangea cultivars and Rhizoctonia root rot of *Viburnum odoratissimum* were assessed in a separate greenhouse and field experiments with different treatments. Randomized complete block experimental design with four replications was used for all trials and non-treated, non-inoculated and inoculated pots/plots served as controls. For the *Phytophthora* study, pots/plots were inoculated with *P. nicotianae* grown on rice grains. Treatments were RootShield *PLUS+*, MBI110, IT-5103, OxiPhos, TerraClean 5.0 + TerraGrow program, Segovis, Empress Intrinsic and Subdue Maxx for *Phytophthora* study. All of the treatments particularly Segovis, Empress Intrinsic, Subdue Maxx, TerraClean 5.0 + TerraGrow program, and MBI110 significantly reduced Phytophthora root rot severity compared to the non-treated inoculated control in both greenhouse and field experiments. Except for RootShield *PLUS+*, all treatments significantly increased the plant fresh weight and root weight. For the *Rhizoctonia* study, treatments were RootShield *PLUS+*, MBI110, SoilGard, IT-5103, TerraClean 5.0 + TerraGrow program, Mural, Empress Intrinsic and Paegant Intrinsic.Pots/plots were inoculated with *Rhizoctonia solani* agar slurry. In both greenhouse and field experiments, all of the treatments significantly reduced Rhizoctonia root rot severity. Mural, Empress Intrinsic, Paegant Intrinsic and TerraClean 5.0 + TerraGrow program not only showed significantly less Rhizoctoniaroot rot but also numerically increased plant fresh weight and root weight compared to the other treatments and non-treated, inoculated control. This study will help nursery producers make proper management decisions by using recommended fungicides and biocontrol products of this study in a rotation or alone to manage Phytophthora and Rhizoctonia root rot diseases of woody ornamentals.

The efficacy of fungicides against Phytophthora root rot of dogwood was assessed in greenhouse trial. One drench application was made for each treatment at 200 ml per plant 5 days before inoculation. Control plants were drenched with only water. Plants were inoculated by placing a single rice grain that had been colonized for 10 days by *Phytophthora cinnamomi* at four opposite sides of the root zone of each plant. Non-treated, inoculated and non-treated, non-inoculated plants served as controls. Plant root system was assessed for root rot severity using a 1 to 5 scale based on percentage of the root with visible rot symptoms: 1=0% (healthy), 2=1-25%, 3=26-50%, 4=51-75%, and 5=76-100%. The median value of each range was used for data analysis. Phytophthora root rot severity was moderate to high; the final (28 Nov) mean root rot severity was 69.3% in the non-treated, inoculated control dogwood plants. All treatments significantly reduced Phytophthora root rot severity and resulted in greater root fresh weight compared to the non-treated, inoculated control. Segovis, Empress Intrinsic, Subdue Maxx and MBI-110 were significantly more effective than RootShield *PLUS*+ and Pageant Intrinsic at preventing root rot severity. Segovis, Empress Intrinsic, and Mural treatments had numerically greater root fresh weight compared to the non-treated, non-inoculated control and statistically greater root fresh weight compared to the non-treated, inoculated control.

2. Develop improved soil-borne disease management strategies based on cultural approaches for suppression of *Rhizoctonia* and (or) *Phytophthora* spp. and other soil-borne pathogens. The goal of this research was to improve soilborne disease management through the use of soil solarization alone and in combination with biofumigant cover crop incorporation (such as mustard, mighty mustard, turnip, radish and astro arugula**)**, and also good quality compost and mustard meal amendment. The experiments were established as field experiment, which had pre-existing populations of *Rhizoctonia solani* or *Phytophthora nicotinanae* and an on-farm experiment with prevalent *R. solani, Fusarium solani*, *F. oxysporum*, *Pythium rosratifingens* and *Phytopythium vexans*. The experiments were conducted as a randomized complete block design with four and three replications, respectively. In both field and on-farm experiments both solarization alone or in combination with biofumigant cover crop incorporation significantly reduced root rot diseases compared to the non-treated controls. In on-farm experiments, there were no significant differences among 6-weeks soil solarization alone and 2-weeks solarization in combination with biofumigant cover crop incorporation in root rot disease severity. Furthermore, in field experiments there were no significant differences among 6-weeks soil solarization alone and 2 or 4-weeks solarization in combination with biofumigant cover crop incorporation in root rot disease severity. Cover crop usage in combination with soil solarization and organic inputs could be alternative approaches to control soilborne diseases.

3. Characterize the associations between microbial community profile and soil-borne disease suppression expressed in different soil-borne disease management strategies. Soil samples taken from 4 weeks and 2 weeks biofumigation greenhouse trials experiments were stored at 4oC refrigerator until they were cultured. Soil samples were processed and serial diluted. Stock solution and 10-1 serial dilution was cultured on *Rhizoctonia,* *Phytophthora,* and *Pseudomonas* spp.selective or semi-selective media. *Rhizoctonia* and *Pseudomonas* plates were incubated for 48 hr-72hr and *Phytophthora* for 5 days under dark conditions at 25 oC inside the incubator. Randomly selected colonies were re-culture on respective media and identified using DNA sequencing. DNA extraction was performed using PowerLyzer®UltraClean® microbial DNA isolation kit according to the MOBIO laboratories Inc. protocol and DNA quantification was done by using NanoDrop 2000c. PCR was conducted using ITS1 and ITS4 primers. Gel electrophoresis was done and positive PCR products were purified sent to Eurofins genomics for DNA sequencing. Colony counts were expressed as colony forming units (CFU) per gram of dried soil. In the Brassicaceae treated pots of both trials, the highest number of fungi CFU log values in *R. solani* selective medium were recorded, before incorporation of cover crops to the pots. Initial higher fungal colonies started to reduce after 24h of biofumigation and continuous reduction was observed during the biofumigation time interval in both experiments, except for radish at 4 weeks after biofumigation in first trial. Before incorporation of the green manure, initial fungal populations in the *R. solani* selective medium of all the treatments were similar to inoculated control. Twenty-four hours after cover crop incorporation, significantly highest fungal populations were recorded in inoculated non-biofumigated controls compared to all cover crops of both 4 weeks and 2 weeks biofumigation trials, respectively. After twenty-four hours sampling, until the end of the trials, all Brassicaceae-incorporated soils showed significantly lower fungal populations compared to inoculated non-biofumigated controls but significantly higher colony counts than non-inoculated non-biofumigated controls in both trials. In both of the trials, significantly lower numbers of *Phytophthora* colony forming units on PARPH medium were recorded in non-inoculated non-biofumigated control treatments before incorporation of the green manure. Twenty-four hours after the incorporation of the cover crops, all the treatments except radish had significantly lower CFU log values compared to the inoculated control. In the 4 weeks trial and in the 2 weeks biofumigation trial CFU log values of radish and turnips amended soils were not significantly different from the inoculated non-biofumigated control while the other cover crop amended treatments had significantly lower CFU values. Astro arugula, amara mustard, mustard (*S. alba)* and dwarf essex rape *Brassica* incorparated soil samples had significantly lower CFU values than other cover crops four weeks after biofumigation in 4 weeks trial and there were no significant differences in the CFU values among these cover crops soils and the non-inoculated non-biofumigated control. At the end of the 4 weeks biofumigation trial, the CFU values for all the cover crop incorporated soils increased and values were significantly higher than non-inoculated non-biofumigated control, but still statistically lower than inoculated non-biofumigated control soil. Soil samples taken from astro arugula and mustard (*S. alba)* amended pots, 2-weeks after biofumigation in the 2 weeks trial had the lowest log value of *Phytophthora* compared to the other cover crops and there was no significant differences in the CFU values among these cover crops soils and non-inoculated non-biofumigated control soil. Amara mustard and dwarf essex rape *Brassica* incorporated soil samples 10-weeks after biofumigation in the 2 weeks trial had the lowest log value of *Phytophthora* compared to the other cover crops. There were no significant differences among the cover crops incorporated soils and control soils (non-inoculated non-biofumigated control and inoculated non-biofumigated control) in the CFU values of fluorescent *Pseudomonads* in both trials under the disease pressure given by both tested soilborne pathogens. A negative relationship was recorded between the fluorescent *Pseudomonads* colony log values and disease severity percentages for both of the tested soilborne pathogens in 2 weeks trial.

**Baysal-Gurel, F.**, Liyanapathiranage, P. Mullican, J. 2018. Biofumigation: opportunities and challenges for control of soilborne diseases in nursery production. Plant Health Progress. <https://doi.org/10.1094/PHP-08-18-0049-RV> P. 1-6.

**Baysal-Gurel, F.**, Kabir, N. 2018. Comparative performance of fungicides and biocontrol products in suppression of Rhizoctonia root rot in viburnum. Journal of Plant Pathology & Microbiology Vol:9 Issue:9 DOI: 10.4172/2157-7471.1000451.

Addesso, K., **Baysal-Gurel, F.**, Oliver, J., Ranger, C., O’Neal, P. 2018. Interaction of a Preventative Fungicide Treatment and Root Rot Pathogen on Ambrosia Beetle Attacks during a Simulated Flood Event. Insects 2018, 9, 83; doi:10.3390/insects9030083.

**Baysal-Gurel, F.,** Simmons, T., and Kabir, Md N. 2018. Evaluation of biorational products and fungicides for the control of Phytophthora root rot of Hydrangea in field condition, 2017. Plant Disease Management Report OT026. Online publication. The American Phytopathological Society, St. Paul, MN.

**Baysal-Gurel, F.,** Simmons, T., and Kabir, Md N. 2018. Evaluation of biorational products and fungicides for the control of Phytophthora root rot of hydrangea in greenhouse condition, 2017. Plant Disease Management Report OT021. Online publication. The American Phytopathological Society, St. Paul, MN.

**Baysal-Gurel, F.,** Simmons, T., and Kabir, Md N. 2018. Evaluation of biorational products and fungicides for the control of Rhizoctonia root rot of viburnum in greenhouse condition, 2017. Plant Disease Management Report OT020. Online publication. The American Phytopathological Society, St. Paul, MN.

**Baysal-Gurel, F.,** Simmons, T., and Kabir, Md N. 2018. Evaluation of biorational products and fungicides for the control of Rhizoctonia root rot of viburnum in field condition, 2017. Plant Disease Management Report OT025. Online publication. The American Phytopathological Society, St. Paul, MN.

Kabir, Md N., and **Baysal-Gurel, F.** 2018. Effect of fungicides and biorational products on *Phytophthora* root rot of hydrangea cultivars. SNA Research Conference Vol. 62 2018. Pathology and Nematology Section. Page (Accepted)(Oral presentation PhD second place).

Brown, M., **Baysal-Gurel, F.,** Oliver, J., and Addesso, K. 2018. Evaluation of fungicides and biofungicides for control of *Phytophthora cinnamomi* on flood-stressed flowering dogwoods. SNA Research Conference Vol. 62 2018. Pathology and Nematology Section. Page (Accepted) (Oral Presentation MS second place).

**Baysal-Gurel, F.,** Brown, M., Oliver, J., Addesso, K. 2018. Comparative performance of fungicides, biofungicides, and host plant defense inducers in suppression of Phytophthora root rot in flowering dogwood during simulated flood events. International Soilborne Oomycete Conference. December 4-6, 2018. Islomorada, FL.

Brown, M., **Baysal-Gurel, F.,** Oliver, J., Addesso, K. 2018. Managing Phytophthora root rot on flood stressed woody ornamental plants. ICPP meetingJuly 29-August 3, 2018 Boston, MA.

Kabir, Md. N., and **Baysal-Gurel, F.** 2018. Comparison of concentration methods to facilitate the successful recovery and early detection of *Phytophthora* speciesfrom Tennessee nursery irrigation water.The 40th Annual University-Wide Research Symposium, 2018. April 2-6, 2018. Nashville, TN.

Kabir, Md. N., Simmons, T. and **Baysal-Gurel, F.** 2018. Development of integrated pest management approach to control *Phytophthora* root rot in field grown hydrangeas. The 40th Annual University-Wide Research Symposium, 2018. April 2-6, 2018. Nashville, TN.

Brown, M., Baysal-Gurel, F., Oliver, J., Addesso, K. Control of *Phytophthora cinnamomi* on flood stressed woody ornamental plants using preventive and curative fungicides.The 40th Annual University-Wide Research Symposium, 2018. April 2-6, 2018. Nashville, TN.

**Baysal-Gurel, F.,** and Liyanapathiranage, P. 2018. Sustainable Management of Soil-borne Diseases in Nursery Production. Our Farms, Our Future Conference. Apr 3-5, 2018. St. Louis, Missouri (Poster presentation- SSARE travel award).

Kabir, Md. N., Simmons, T. and **Baysal-Gurel, F.** 2018. Control of *Phytophthora* root rot disease of hydrangea using biorational products and fungicides**.** 9th International IPM Symposium. Mar 19-22, 2018. Baltimore, MD.

**Baysal-Gurel, F**. 2018. Controlling Rhizoctonia root rot on viburnum in the greenhouse and in the field. Chase Digest October 2018 Issue Volume 6(10).

**Baysal-Gurel, F**. 2018. Phytophthora root rot control on dogwood and vinca. Chase Digest June 2018 Issue Volume 6(6).

Kabir, N. Enhancing the detection process, prevention and sustainable management of soilborne diseases in Tennessee nursery production. PhD Thesis. Nashville, TN. 12/08/2018. (Major advisor: Fulya Baysal-Gurel)

Brown, M. Prevention of ambrosia beetles and phytophthora root rot with stress-mitigating fungicides. MS Thesis. Nashville, TN. 12/08/2018. (Co-advisor: Fulya Baysal-Gurel)

**Other Products**

Data and Research Materials were collected for Objectives 1 and 2.

Kabir, N. Enhancing the detection process, prevention and sustainable management of soilborne diseases in Tennessee nursery production. PhD Thesis Defense seminar. Nashville, TN. 06/27/2018. (Major advisor: Fulya Baysal-Gurel)

Brown, M. Prevention of ambrosia beetles and phytophthora root rot with stress-mitigating fungicides. MS Thesis Defense seminar. Nashville, TN. 06/27/2018. (Co-advisor: Fulya Baysal-Gurel)

**Baysal-Gurel, F.** 2018. Biofumigation: opportunities and challenges for control of soilborne diseases in nursery production. Seminar. University of Georgia, Athens, GA. Aug 27, 2018.

**Baysal-Gurel, F.** TSUNRC Plant Pathology Program updates.IPPS tour. McMinnville, TN. October 21, 2018.

**Baysal-Gurel, F.** Boxwood Diseases and their management.Tennessee Nursery Field day. McMinnville, TN. July 24, 2018.

**Baysal-Gurel, F.** Boxwood Diseases and their management.MTNA Field day.McMinnville, TN. June 14, 2018.

**Baysal-Gurel, F.** Boxwood Disease Landscaper Workshop.Murfreesboro, TN. February 9, 2018.