

**USDA-ARS**  
**U.S. Wheat and Barley Scab Initiative**  
**FY19 Performance Report**  
**Due date: July 24, 2020**

**Cover Page**

<b>Principle Investigator (PI):</b>	Pierce Paul
<b>Institution:</b>	Ohio State University
<b>E-mail:</b>	paul.661@osu.edu
<b>Phone:</b>	330-263-3842
<b>Fiscal Year:</b>	2019
<b>USDA-ARS Agreement ID:</b>	59-0206-8-187
<b>USDA-ARS Agreement Title:</b>	Fusarium Head Blight Risk Assessment, Management, and Education
<b>FY19 USDA-ARS Award Amount:</b>	\$ 102,093
<b>Recipient Organization:</b>	The Ohio State University Office of Research Office of Sponsored Programs Research Administration Building 1960 Kenny Road, 4th Floor Columbus, OH 43210
<b>DUNS Number:</b>	83-212-7323
<b>EIN:</b>	31-6025986
<b>Recipient Identifying Number or Account Number:</b>	GRT00053265 / 60067849
<b>Project/Grant Reporting Period:</b>	5/13/19 - 5/12/20
<b>Reporting Period End Date:</b>	5/12/2020

**USWBSI Individual Project(s)**

<b>USWBSI Research Category*</b>	<b>Project Title</b>	<b>ARS Award Amount</b>
MGMT	Efficacy of a New Fungicide Combined with Cultivar Resistance for FHB and DON Management in Ohio	\$ 45,613
MGMT	Improving the Accuracy of Fusarium Head Blight Predictive Models within Changing Production Environments	\$ 11,889
MGMT	Educating Soft Winter Wheat Producers on MR Varieties as the Foundation of FHB Management	\$ 10,676
EC-HQ	Obtaining Timely DON Test Results for SRWW Variety Selection: A Pilot Study	\$ 33,915
<b>FY19 Total ARS Award Amount</b>		<b>\$ 102,093</b>



Principal Investigator

07/24/2020

Date

\* MGMT – FHB Management  
FST – Food Safety & Toxicology  
GDER – Gene Discovery & Engineering Resistance  
PBG – Pathogen Biology & Genetics  
EC-HQ – Executive Committee-Headquarters  
BAR-CP – Barley Coordinated Project  
DUR-CP – Durum Coordinated Project  
HWW-CP – Hard Winter Wheat Coordinated Project  
VDHR – Variety Development & Uniform Nurseries – Sub categories are below:  
SPR – Spring Wheat Region  
NWW – Northern Soft Winter Wheat Region  
SWW – Southern Soft Red Winter Wheat Region

FY19 Performance Report  
PI: Paul, Pierce  
USDA-ARS Agreement #: 59-0206-8-187  
Reporting Period: 5/13/19 - 5/12/20

**Project 1:** *Efficacy of a New Fungicide Combined with Cultivar Resistance for FHB and DON Management in Ohio*

**1. What are the major goals and objectives of the research project?**

The overall goal of this project (as part of the FHB Integrated Management Coordinated Project [MGMT\_CP]) was to develop more robust “*best-management practices*” to provide producers with additional and more effective options for managing FHB and DON. The specific objectives were to:

- 1) Evaluate the integrated effects of fungicide treatment and genetic resistance on FHB and DON in soft red winter wheat (SRWW) and malting barley, with emphasis on a new fungicide, Miravis Ace®,
- 2) Compare the efficacy of Miravis Ace when applied at early heading or at anthesis to that of standard anthesis application of Prosaro® or Caramba®.

**2. What was accomplished under these goals or objectives?** (*For each major goal/objective, address items a-b below.*)

a) What were the major activities?

Two field experiments were conducted during the 2018-2019 growing seasons in Ohio - an integrated management (IM) and a uniform fungicide trial (UFT). Malting barley plots were planted in the fall, but suffered severe winterkill, preventing the trial from being completed as planned. **IM (Obj 1):** The treatments were: **1)** an untreated, inoculated check; **2)** Prosaro at anthesis; **3)** Miravis Ace at anthesis; **4)** Miravis Ace at Feekes 10.3; **5)** Prosaro at anthesis, non-inoculated; and **6)** an untreated, non-inoculated check. Treatments were applied to replicate plots of four cultivars with different levels of resistance to FHB. **UFT (Obj 2):** Plots of susceptible cultivars were subjected to ten fungicide treatments: **1)** an untreated check; **2)** Prosaro at anthesis; **3)** Caramba at anthesis; **4)** Miravis Ace at Feekes 10.3; **5)** Miravis Ace at anthesis; **6)** Miravis Ace at anthesis followed by Prosaro at 4 days after anthesis (DAA); **7)** Miravis Ace at anthesis followed by Caramba at 4 DAA; **8)** Miravis Ace at anthesis followed by Folicur at 4 DAA; **9)** Miravis Ace at 4 DAA and **10)** Prosaro at 4 DAA. In all trials, Prosaro, Caramba, Miravis Ace, and Folicur were applied at 6.5, 13.5, 13.7, and 4 fl. oz./A, respectively, along with a non-ionic surfactant and, FHB, DON, FDK, foliar diseases severity, yield, and test weight data were collected and analyzed.

b) What were the significant results?

Significant levels of scab developed in both trials, making it possible to compare treatments. **Obj 1:** All fungicide program x cultivar resistance combinations resulted in significantly lower mean FHB index (IND) and DON than the non-treated susceptible check (S\_CK). For all tested FHB resistance classes (MR, MS and S), the early application of Miravis Ace had numerically (but not always statistically) higher mean IND and DON than the anthesis application of Miravis Ace or Prosaro. The highest mean percent control of both IND and

DON relative to S\_CK was achieved when an anthesis application of Miravis Ace or Prosaro was combined with an MS or MR cultivar.

**Obj 2:** All fungicide programs resulted in significantly lower mean IND and DON than the non-treated check (CK). Two-treatment programs with Miravis Ace applied at anthesis followed by Prosaro, Caramba, or Folicur at 4 days after anthesis (DAA) resulted in the highest percent reduction in IND relative to CK. For DON, the highest percent reduction relative to CK was achieved when Miravis Ace was applied at anthesis followed by Prosaro at 4 DDA. Among single-treatment programs, Miravis Ace at anthesis was the most effective against IND, performing significantly better than Miravis at early heading, Prosaro at anthesis or Caramba at anthesis. However, for DON, efficacy was comparable among Miravis Ace, Prosaro, and Caramba when applied at anthesis. Early-heading application of Miravis Ace was the least effective single-treatment program against DON.

c) List key outcomes or other achievements.

**Obj 1:** We successfully showed that management programs that combined a Miravis Ace or Prosaro application at anthesis with an MR or MS cultivar were the most effective against both IND and DON.

**Obj 2:** We successfully showed that **1)** when applied at anthesis, Miravis Ace outperformed Prosaro and Caramba in terms of percent control of IND, however, for DON, the three treatments were comparable in their efficacy, **2)** the early heading application of Miravis Ace was among the least effective single-treatment program, particularly against DON, and **3)** all tested two-treatment programs outperformed single-treatment programs in terms of percent control relative to CK.

**3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.**

No

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

A Research Assistant and a graduate student contributed to this project. In addition to learning how to establish experiments and collect data to evaluate integrated management programs for FHB, they both learned basic data analysis and contributed to the preparation of abstracts and posters presented at the Scab Forum and the APS meeting.

FY19 Performance Report

PI: Paul, Pierce

USDA-ARS Agreement #: 59-0206-8-187

Reporting Period: 5/13/19 - 5/12/20

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

Results were disseminated by way of posters and abstracts at scientific meetings, electronic newsletter articles, and extension talks and field days.

FY19 Performance Report  
PI: Paul, Pierce  
USDA-ARS Agreement #: 59-0206-8-187  
Reporting Period: 5/13/19 - 5/12/20

**Project 2:** *Improving the Accuracy of Fusarium Head Blight Predictive Models within Changing Production Environments*

**1. What are the major goals and objectives of the research project?**

The overall project goal was to create better models for predicting Fusarium head blight (FHB).

The objectives were to:

- 1) Generate data through the MGMT\_CP to help validate and advance the development of FHB and DON risk prediction models.
- 2) Use an ensemble modeling approach to combine multiple models to improve overall prediction accuracy.
- 3) Replace the current models with the newer versions after they have been field-tested.

**2. What was accomplished under these goals or objectives? (For each major goal/objective, address items a-b) below.)**

a) What were the major activities?

**Obj 1:** Through the MGMT\_CP, experiments were conducted in 18 US wheat-growing states commonly affected by FHB (AL, DE, ID, IL, IN, KY, MD, MI, MN, ND, NE, NY, OH, PA, SD, TN, VA, and WI). At least two commercial wheat cultivars, classified as susceptible (S), moderately of FHB epidemic. Working in collaboration with Dr DeWolf, we explored an ensemble modeling approach to combine multiple logistic regression models.

b) What were the significant results?

**Obj 1:** A total of 62 new cases (unique cultivar x trial combinations) with a range of IND levels were collected under different environmental conditions, expanding the range of conditions available in our dataset for model development.

**Obj 2:** Hierarchical cluster analysis of the FHB models indicated that there were at least 4 groups of models, based on performance. Combining multiple models into these groups captured more information and improved prediction accuracy relative to the individual models.

c) List key outcomes or other achievements.

**Obj 1:** We continue to use the MGMT\_CP as a source of very good data for FHB model development. This has allowed us to (**Obj 2**) explore novel modeling approaches such as ensembling that could ultimately lead to more accurate predictions of FHB epidemics.

FY19 Performance Report

PI: Paul, Pierce

USDA-ARS Agreement #: 59-0206-8-187

Reporting Period: 5/13/19 - 5/12/20

- 3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.**

No

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

The Research Assistant and graduate student who contributed to the MGMT\_CP learned certain basic aspects of data mining for predictive model development.

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

Results were presented at the 2019 FHB Forum (Dr. DeWolf). A manuscript is being prepared for publication.

FY19 Performance Report  
PI: Paul, Pierce  
USDA-ARS Agreement #: 59-0206-8-187  
Reporting Period: 5/13/19 - 5/12/20

**Project 3:** *Educating Soft Winter Wheat Producers on MR Varieties as the Foundation of FHB Management*

**1. What are the major goals and objectives of the research project?**

This project is aimed at strengthening the message and enhancing adoption of variety resistance (and FHB best management practices in general), particularly in soft winter wheat.

The objectives include:

- 1) Develop and fine-tune the national USWBSI List of MR varieties for the soft wheat region.
- 2) Produce a popular publication (in the format of a newsletter article and/or brochure) on the economic benefits of planting MR varieties.
- 3) Outreach to influential industry constituencies
- 4) A pilot project to generate timely DON data for variety selection and help the USWBSI evaluate whether to invest in separate or expanded DON testing of commercial winter wheat varieties.

**2. What was accomplished under these goals or objectives?** (*For each major goal/objective, address items a-b) below.*)

a) What were the major activities?

**Obj 1:** My lab (in collaboration with Dr. Sneller) came up with a list of Ohio-grown MR SRWW varieties using data collected from our 2018, 2019, and 2020 FHB screening nursery. This list was expanded by maintaining the varieties screened in 2018 and adding new varieties in 2019 and 2020. Replicate hill plots of each variety were planted in the FHB nursery, inoculated, mist-irrigated, and systematically rated for FHB and FDK. Varieties with a Truman-like or better FHB index were considered to be of moderate resistant.

**Obj 2:** Nothing new to report

**Obj 3:** Information of FHB resistance were made available to local growers through the Ohio Wheat Performance Trial (OWPT) website. A list of MR varieties was also made available for posting on Scab Smart. Stakeholders continued to access the webinars we created in early 2019 on “*Understanding the Basics of Fusarium Head Blight*” and “*Management of Fusarium Head Blight (Scab) of Wheat with Fungicides*”.

**Obj 4:** The MR varieties from *Obj.1* are being used to characterize low-DON and low-FDK varieties for use as references. Replicate spikes with a fixed level of FHB index (20%) were again tagged, hand-harvested at dry-down, and threshed, and grain samples were cleaned, ground, and tested for DON. FHB index:DON and FDK:DON ratios are being estimated as measures of resistance to DON accumulation and grain infection.

FY19 Performance Report

PI: Paul, Pierce

USDA-ARS Agreement #: 59-0206-8-187

Reporting Period: 5/13/19 - 5/12/20

b) What were the significant results?

We were again able to screen for and identify commercial SRWW varieties that will be added to our standard list of MR varieties (*Obj 1*: this list has to be updated annually because of the high turnover). In addition, by maintaining and screening a core set of MR varieties over three years, we will be able to identify those with a stable resistance reaction, both in terms of FHB index and DON contamination. This is important for coming up with a list of reference low-DON MR varieties against which future varieties can be compared (*Obj. 4*).

c) List key outcomes or other achievements.

We have identified a core set of Ohio-grown MR varieties. Once we are done processing the grain samples collected in 2019 and 2020, we will be able to determine which of there are stable and resistant to DON accumulation.

**3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.**

No

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

A research assistant in my lab contributed to variety resistance screening and will also assist with the identification of, and eventually publish on, low-DON MR varieties.

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

My lab worked closely with the Scab Smart team to redesign the website and develop content (including a list of MR varieties and fungicide efficacy charts) on best management practices for FHB.



**Project 4: *Obtaining Timely DON Test Results for SRWW Variety Selection: A Pilot Study***

**1. What are the major goals and objectives of the research project?**

The goal of this project was to explore the prospect of adding the OSU DON testing unit to the UWBSI DON testing service to generate timely DON results for commercial SRWW in Ohio and other states.

The specific objective was to generate DON data for publication in OWPT reports to assist with the selection and adoption of moderately resistant varieties for planting.

**2. What was accomplished under these goals or objectives? (For each major goal/objective, address items a-b) below.)**

a) What were the major activities?

Eighty-six commercial varieties were planted in the FHB screening nurseries in the fall of 2018, but the funds for this project became available way too late (June-July 2019) for grain samples to be collected and processed, varieties characterized and ranked based on DON, and results published in time for growers to make decisions regarding cultivar selection.

b) What were the significant results?

Spikes were harvested from the nursery at the end of the 2019 wheat season and threshed, and grain samples are being processed.

c) List key outcomes or other achievements.

Low-DON MR varieties are being characterized. These will be useful references for screening other varieties as the project continues.

**3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.**

Yes. The plan was to complete the proposed activities, including collect and process grain samples of commercial varieties from nurseries in Ohio and participating SRWW-producing states between May and July and prepare reports for delivery to growers between July and August 2020. However, university shutdown, hiring freeze (no interns were hired in my lab in 2020), and reduced workhours prevented these tasks from being completed. Grain sampling, processing, and DON analysis are time-consuming and labor-intensive tasks that are impossible to accomplish in a timely manner with the current set of COVID-related restrictions.

FY19 Performance Report

PI: Paul, Pierce

USDA-ARS Agreement #: 59-0206-8-187

Reporting Period: 5/13/19 - 5/12/20

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

A research assistant and post-doctoral researcher (recently hired) will assist with the collection and analysis of grain samples, characterization of variety reaction, and preparation of reports.

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

There is nothing to report at this time. Results will eventually be published in the Ohio County Journals and Ohio Wheat Performance Trial webpage.

FY19 Performance Report  
PI: Paul, Pierce  
USDA-ARS Agreement #: 59-0206-8-187  
Reporting Period: 5/13/19 - 5/12/20

## **Training of Next Generation Scientists**

**Instructions:** Please answer the following questions as it pertains to the FY19 award period (5/13/19 - 5/12/20). The term “support” below includes any level of benefit to the student, ranging from full stipend plus tuition to the situation where the student’s stipend was paid from other funds, but who learned how to rate scab in a misted nursery paid for by the USWBSI, and anything in between.

- 1. Did any graduate students in your research program supported by funding from your USWBSI grant earn their MS degree during the FY19 award period?**

No

**If yes, how many?**

- 2. Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY19 award period?**

No

**If yes, how many?**

- 3. Have any post docs who worked for you during the FY19 award period and were supported by funding from your USWBSI grant taken faculty positions with universities?**

No

**If yes, how many?**

- 4. Have any post docs who worked for you during the FY19 award period and were supported by funding from your USWBSI grant gone on to take positions with private ag-related companies or federal agencies?**

No

**If yes, how many?**

FY19 Performance Report  
 PI: Paul, Pierce  
 USDA-ARS Agreement #: 59-0206-8-187  
 Reporting Period: 5/13/19 - 5/12/20

### Release of Germplasm/Cultivars

**Instructions:** In the table below, list all germplasm and/or cultivars released with full or partial support through the USWBSI during the FY19 award period. All columns must be completed for each listed germplasm/cultivar. Use the key below the table for Grain Class abbreviations.

*NOTE: Leave blank if you have nothing to report or if your grant did NOT include any VDHR-related projects.*

Name of Germplasm/Cultivar	Grain Class	FHB Resistance (S, MS, MR, R, where R represents your most resistant check)	FHB Rating (0-9)	Year Released

Add rows if needed.

**NOTE:** List the associated release notice or publication under the appropriate sub-section in the 'Publications' section of the FPR.

**Abbreviations for Grain Classes**

- Barley - BAR
- Durum - DUR
- Hard Red Winter - HRW
- Hard White Winter - HWW
- Hard Red Spring - HRS
- Soft Red Winter - SRW
- Soft White Winter - SWW

FY19 Performance Report  
PI: Paul, Pierce  
USDA-ARS Agreement #: 59-0206-8-187  
Reporting Period: 5/13/19 - 5/12/20

## **Publications, Conference Papers, and Presentations**

**Instructions:** Refer to the FY19-FPR\_Instructions for detailed more instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY19 grant award. Only citations for publications published (submitted or accepted) or presentations presented during the **award period (5/13/19 - 5/12/20)** should be included. If you did not publish/submit or present anything, state ‘Nothing to Report’ directly above the Journal publications section.

**NOTE:** Directly below each citation, you **must** indicate the Status (i.e. published, submitted, etc.) and whether acknowledgement of Federal support was indicated in the publication/presentation.

### **Journal publications.**

Madden, L.V., and Paul, P.A. 2020. Is disease intensity a good surrogate for yield loss or toxin contamination? A case study with Fusarium head blight of wheat. *Phytopathology* (Accepted) - <https://doi.org/10.1094/PHYTO-11-19-0427-R>

Status: Published online – first look

Acknowledgement of Federal Support: YES

Anderson, N.R., Freije, A.N., Bergstrom, G.C., Bradley, C.A., Cowger, C., Faske, T., Hollier, C., Kleczewski, N., Padgett, G.B., **Paul, P.A.**, Price, T., and Wise, K. A. 2020. Sensitivity of *Fusarium graminearum* to metconazole and tebuconazole fungicides before and after widespread use in wheat in the United States. *Plant Health Progress* 21:85-90.

Status: Published

Acknowledgement of Federal Support: YES

### **Books or other non-periodical, one-time publications.**

None

### **Other publications, conference papers and presentations.**

#### ***Conference proceedings***

De Wolf, E., Shah, D., **Paul, P.**, and Madden, L. 2019. “Application of model ensembles to the prediction of Fusarium head blight.” In: Canty, S., A. Hoffstetter, H. Campbell and R. Dill-Macky (Eds.), *Proceedings of the 2019 National Fusarium Head Blight Forum* (p. 11). Milwaukee, WI; December 8-10. University of Kentucky, Lexington, KY.

Status: Take and abstract

Acknowledgement of Federal Support: YES

FY19 Performance Report

PI: Paul, Pierce

USDA-ARS Agreement #: 59-0206-8-187

Reporting Period: 5/13/19 - 5/12/20

De Wolf, E., Shah, D., **Paul, P.**, Madden, L., Crawford, S., Hane, D., Canty, S., Dill-Macky, R., Van Sanford, D., Imhoff, K., and Miller, D. 2019." Impact of prediction tools for Fusarium head blight in the US." In: Canty, S., A. Hoffstetter, H. Campbell and R. Dill-Macky (Eds.), *Proceedings of the 2019 National Fusarium Head Blight Forum* (p. 12). Milwaukee, WI; December 8-10. University of Kentucky, Lexington, KY.

Status: Poster Presented and Abstract

Acknowledgement of Federal Support: YES

Moraes, W.B., Schwarz, P.B., Madden, L.V. and **Paul, P. A.** 2019. "Pre-Harvest rainfall and harvesting strategy effects on the quality of FHB affected grain." In: Canty, S., A. Hoffstetter, H. Campbell and R. Dill-Macky (Eds.), *Proceedings of the 2019 National Fusarium Head Blight Forum* (p. 18). Milwaukee, WI; December 8-10. University of Kentucky, Lexington, KY.

Status: Poster Presented and Short Report published

Acknowledgement of Federal Support: YES

**Paul, P.A.**, Ng, S. J., Bergstrom, G., Bissonnette, K., Bowen, K., Bradley, C., Byamukama, E., Chilvers, M., Collins, A., Cowger, C., Darby, H., DeWolf, E., Dill Macky, R., Esker, P., Friskop, A., Kleczewski, N., Koehler, A., Madden, L., Marshall, J., Mehl, H., Moraes, W., Nagelkirk, M., Rawat, N., Smith, D., Telenko, D., Wegulo, S., and Young-Kelly, H. 2019. "Fusarium head blight management coordinated project: integrated management trials 2018-2019." In: Canty, S., A. Hoffstetter, H. Campbell and R. Dill-Macky (Eds.), *Proceedings of the 2019 National Fusarium Head Blight Forum* (p. 20). Milwaukee, WI; December 8-10. University of Kentucky, Lexington, KY.

Status: Poster Presented and Short Report published

Acknowledgement of Federal Support: YES

**Paul, P.A.**, Ng, S.J., Bergstrom, G., Bissonnette, K., Bowen, K., Bradley, C., Byamukama, E., Chilvers, M., Collins, A., Cowger, C., Darby, H., DeWolf, E., Dill Macky, R., Esker, P., Friskop, A., Kleczewski, N., Koehler, A., Madden, L., Marshall, J., Mehl, H., Moraes, W., Nagelkirk, M., Rawat, N., Smith, D., Telenko, D., Wegulo, S., and Young-Kelly, H. 2019. "Fusarium head blight management coordinated project: uniform fungicide trials 2018-2019." In: Canty, S., A. Hoffstetter, H. Campbell and R. Dill-Macky (Eds.), *Proceedings of the 2019 National Fusarium Head Blight Forum* (p. 25). Milwaukee, WI; December 8-10. University of Kentucky, Lexington, KY.

Status: Poster Presented and Short Report published

Acknowledgement of Federal Support: YES

Moraes, W.B., Madden, L.V., and **Paul, P.A.** 2029. Post-anthesis rainfall effects on the efficacy of tebuconazole + prothioconazole against Fusarium head blight and deoxynivalenol in wheat. *Phytopathology* 109:S2.35.

Status: Poster and abstract

Acknowledgement of Federal Support: YES

FY19 Performance Report

PI: Paul, Pierce

USDA-ARS Agreement #: 59-0206-8-187

Reporting Period: 5/13/19 - 5/12/20

Salgado, J.D., Ng, S.J., Bergstrom, G.C., Bradley, C.A., Bowen, K.L., Byamukama, E., Byrne, A., Collins, A.A., Cowger, C., Cummings, J., Chapara, V., Chilvers, M., Dill Macky, R., Darby, H.M., Friskop, A.J., Kleczewski, N.M., Madden, L.V., Marshall, JM., Mehl, H. L., Nagelkirk, M., Stevens, J., Smith, D.L., Smith, M.J., Wegulo, S.N., Wise, K.A., Yabwalo, D., Young-Kelly, H.M., and **Paul, P.A.** 2019. Effects of two-treatment fungicide programs on grain yield and quality of Fusarium head blight-affected wheat. *Phytopathology* 109:S2.65.

Status: Poster and abstract

Acknowledgement of Federal Support: YES

***Scholarly presentations (invited)***

**Pierce A. Paul.** 2019. “*Updated insights on efficacy and timing of fungicides from Multi-state efforts*”. 2019 National Fusarium Head Blight Forum. Milwaukee, WI. December 2019.