USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY19 Final Performance Progress Report
Due date: July 29, 2021

Cover Page

Principle Investigator (PI):	Pierce Paul
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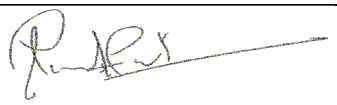
Fiscal Year:	2019
USDA-ARS Agreement ID:	59-0206-8-187
USDA-ARS Agreement Title:	Fusarium Head Blight Risk Assessment, Management, and Education
FY19 USDA-ARS Award Amount:	$ 102,093
Recipient Organization:	The Ohio State University Office of Research Office of Sponsored Programs Research Administration Building 1960 Kenny Road, 4th Floor Columbus, OH 43210
DUNS Number:	83-212-7323
EIN:	31-6025986
Recipient Identifying Number or Account Number:	GRT00053265 / 60067849
Project/Grant Reporting Period:	5/13/19 - 5/12/21
Reporting Period End Date:	5/12/2021

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
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
	FY19 Total ARS Award Amount	**$ 102,093**



07/29/2021

Principal Investigator Date

* MGMT – FHB Management
FST – Food Safety & Toxicology
R – Research
S – Service (DON Testing Lab)
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

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PI: Paul, Pierce
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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® (National),
   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® (National).
   3) Compare the efficacy of single and sequential applications of Miravis Ace, Prosaro, Caramba, and tebuconazole against FHB and DON (National).
   4) Determine the effects of rainfall timing, amount, and duration on the efficacy and residual life of Miravis Ace, Prosaro, and Caramba on wheat spikes (Ohio only).

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

   a) **What were the major activities?**
   Obj 1: (**IM_Wheat National**)**:** Field experiments were conducted in up to 22 US wheat-growing states in 2018, 2019 and 2020. The standard protocol consisted of the application of fungicide treatment programs to plots of FHB-susceptible (S), -moderately susceptible (MS), and -moderately resistant (MR) cultivars. The treatment programs 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)** Miravis Ace at anthesis followed by tebuconazole 4-6 days after anthesis.

   Obj 2 and 3 (UFT_Wheat National): Plots of susceptible cultivars were subjected to eight 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; and **8**) Miravis Ace at anthesis followed by Folicur at 4 DAA.

   Obj 4 (Ohio only): Separate plots of a susceptible wheat cultivar were treated with Miravis Ace, Prosaro, or Caramba at Feekes 10.5.1, or left untreated, after which separate groups of plots were subjected to simulated rainfall treatments of different durations (15, 30, 60, and 120 min), beginning at different times (0, 15, 30, and 60 min) after fungicide application. 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, plots were inoculated or planted after a *F. graminearum* host crop, and FHB index (IND), DON, FDK, foliar diseases severity, yield, and test weight data were collected and analyzed. Note: Barley trials were planted in Ohio in 2017-2018 and 2018-2019, but severe winterkill compromised the results in both years.

b) What were the significant results?

Obj 1 (**IM_Wheat National**)**:** Mean IND and DON were collected from 60 environments (trial x state x year combinations), representing five wheat market classes. For all tested resistance classes, all fungicide programs resulted in significantly lower mean IND than the nontreated check. For MR and S resistance classes, all treatments resulted in significantly lower mean DON than the check. However, for the MS resistance class, Miravis Ace at anthesis, Prosaro at anthesis, and Miravis Ace at anthesis followed by tebuconazole 4-6 days later had significantly lower mean DON than the Feekes 10.3-5 application of Miravis Ace and the check. Sequential application of Miravis Ace at anthesis followed by tebuconazole 4-6 days later had the lowest overall mean IND and DON. Management programs consisting of a fungicide application to an MR cultivar had the lowest overall mean IND and DON.

Obj 2 and **3 (UFT_Wheat National):** IND and DON were collected from 47 environments (trial x state x year combinations), representing different wheat market classes. All treatments had significantly lower mean IND and DON than the check. For both responses, sequential applications of Miravis Ace at anthesis followed by a DMI 4-6 days after resulted in the greatest efficacy, however, for DON, efficacy was the lowest with the early application of Miravis Ace.

Obj 4 (Ohio only): When applied with the surfactant, the performance of the Prosaro, Caramba and Miravis Ace was fairly consistent across rainfall treatments. However, efficacy was substantially lower when the fungicides were applied without the surfactant and plots were subjected to 120 min of simulated rainfall, beginning immediately after the treatments were applied.

c) List key outcomes or other achievements.

Data were successfully generated showing that for:
Obj. 1: the Integration of an early anthesis application of Miravis Ace or Prosaro or sequential application of Marais ace at anthesis followed by tebuconazole 4-6 days after resulted in the greatest efficacy again IND and DON.

Obj 2 and **3**: when applied at anthesis or at Feekes 10.3, Miravis ace was just as effective or more effective then Prosaro or Caramba against IND, however, the early Miravis Ace application was less effective against DON than the anthesis application of either Prosaro, Carambe or Miravis Ace. Two-treatment programs were the most effective against both IND and DON.

Obj 4: Prosaro, Caramba, and Miravis Ace were very rainfast once applied with Induce.

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

Greenhouse/growth chamber experiments designed to evaluate the effects of infection and fungicide application timing (relative to Feekes 10.5) on FHB development, DON contamination of grain, and fungicide efficacy against both responses in winter malting barley were compromised by university shutdowns and hiring freeze. These trials were planned for winter 2019 to early-spring 2020 and winter 2020 to early-spring 2021. COVID-related restrictions compromised research during both of these periods.

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

Post-docs, research Assistant, and graduate students who contributed to this project learned how to design experiments and collect data to evaluate integrated management programs for FHB and basic data analysis and contributed to the preparation of abstracts and posters presented at the Scab Forum and the APS meeting, and manuscripts for publication.

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, extension talks and field days, and peer-reviewed journal articles.

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.
   4) Further apply machine learning algorithms that better address non-linear relationships between weather and FHB risk; and
   5) Uses the FHB observational matrix and the predictive models to develop a suite of case studies that will help stakeholders visualize and understand weather patterns that stimulate or suppress FHB epidemics.

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

   a) What were the major activities?
   My lab was primarily responsible for **Obj 1** "*Generate data through the MGMT_CP to help advance the development of FHB and DON risk prediction models*", but we work closely with Dr. DeWolf at K-State on the other objectives (see his report for details). Through the MGMT_CP, experiments were conducted in 17, 18, and 19 US wheat-growing states commonly affected by FHB in 2018, 2019, and 2020. At least two commercial wheat cultivars, classified as susceptible (S), moderately susceptible (MS), or moderately resistant (MR), were planted in each trial. FHB index, incidence and DON data were collected from non-treated, non-inoculated plots of each cultivar in most cases and edited for inclusion in the master data file for FHB risk model development and validation.

   Obj 2: Working in collaboration with Dr DeWolf, we explored three ensemble modeling approaches (soft voting, weighted model averaging, and stacking) to combine logistic regression models. Thirty-eight logistic regression models were grouped primarily based on weather variables and time periods considered during model development and ensembles were built for each group.

   Obj 3 -5 will be the focus of FY21 and beyond.

b) What were the significant results?

Obj 1: More than 150 new cases (unique combination of cultivar resistance class x trial x year) with a range of IND levels were collected across states, years, and gain market classes. This increased our dataset for model development to more than 1,000 observations, representing a wide range of environmental conditions and associated levels of FHB. **Obj 2:** Hierarchical cluster analysis of the FHB models indicated that there were at least 4 groups of models. The three ensembling approaches were successfully used to combine models in each group into ensembles that captured more information and improved prediction accuracy relative to the individual models in several but not all cases.

c) List key outcomes or other achievements.

Obj 1: The MGMT_CP continues to be an excellent source of data for FHB model development. This has allowed us to explore novel modeling approaches such as ensembling that could ultimately lead to more accurate predictions of FHB epidemics.

Obj 2: The stacked regression ensembling approach outperformed soft voting and model averaging, resulting in a 24% increase in model accuracy (based on PR-AUC) over the original, individual models.

3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns and/or restrictions, 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 have 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 was published in early 2021.

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

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

   a) What were the major activities?

   Obj 1: Contributing to this objective, 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. Replicate hill plots of 86 commercial varieties 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. The same set of varieties screened in 2018 were screened in 2019 and 2020 to evaluate the stability of their FHB and DON response and to identify low-DON varieties. This list was expanded by adding new varieties in 2019 and 2020.

   Obj 2. Nothing to report

   For **Obj. 3**, we developed and presented a two-part webinar series entitled "*Management of Fusarium Head Blight (Scab) of Wheat"*. The first part, "*Understanding the Basics of Fusarium Head Blight*", presented by Christina Cowger and Pierce Paul on February 11, 2019, covered the epidemiology of FHB, management with cultural practices and resistant varieties, and risk forecasting. The second part was presented on February 18, 2019 by Carl Bradley and Pierce Paul on "*Management of Fusarium Head Blight (Scab) of Wheat with Fungicides*". This session focused on fungicide decision-making, efficacy, and timing, as well as the use of grain harvesting strategies to mitigate DON.

b) What were the significant results?

Obj 1: We identified multiple SRWW varieties with MR for FHB based on FHB index. These will be used as MR references for future screening and development of the list of MR SRWW varieties.

Obj 3: Our webinars were well attended. The first had 929 registrants, with 81% being from the United States (43 states), 18% from Canada (9 provinces), and the rest from Brazil, South Africa, China, Switzerland, and other countries. A total of 343 of the registrants were live. Similar numbers were reported for the second webinar; there were 912 registrants (231 live), with 81% from the US, 17% from Canada and 2% from other countries.

c) List key outcomes or other achievements.

Obj 1: We 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 these are stable and resistant to DON accumulation.

Obj 3: Of the 246 webinar registrants who responded to a survey after the live sessions, 64% found the program to be "very valuable" and 31% found it to be "somewhat valuable."

3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns and/or restrictions, 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 part-time student) in my lab contributed to variety resistance screening. Several of the slides used for the webinars were developed from work done by past students, post-docs, and research associates in my lab.

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

Two webinars were presented as indicated about, and web links to recordings of the same were disseminated via email to fellow researchers, extension educators, and other stakeholders (the links are still available). My lab also worked closely with the SCAB SMART team to redesign the website and develop content (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?**
   This was a pilot project to generate timely DON data for variety selection. 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 these three items below.)*

   a) What were the major activities?

   As part of the pilot study, the 86 commercial SRWW varieties screened in 2018, including the MR varieties selected in Project 3, were screened for "resistance to DON accumulation" (RDA). Replicate spikes with known levels of FHB were hand-harvested at dry-down (15% moisture) and threshed, and grain samples were cleaned, ground, and tested for DON. FHB index:DON and FDK:DON ratios were estimated as measures of resistance to DON accumulation. The goal was to generate an index for classifying varieties based on FHB:DON ratios. The plan was to collect samples from participating SRWW states, but the funds for this project became available way too late (June-July 2019) for grain samples to be collected and processed and varieties characterized and ranked in 2019. In addition, FHB levels were low is most participating states.

   b) What were the significant results?

   The same 86 commercial SRWW varieties were screened in 2018, 2019 and 2020 for FHB resistance, spikes were harvested, and grain samples will be used to generate data to assess the stability of IND, DON and FDK reactions.

   c) List key outcomes or other achievements.

   Samples are available for characterizing of Low-DON MR varieties. These will be useful references for screening other varieties.

3. **Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns and/or restrictions, 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 in 2020, including collect and process grain samples of commercial varieties from the FHB nursery in Ohio and variety trials in 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 work hours prevented these tasks from being completed. Spike samples were collected but not processed or

tested for DON as these time-consuming and labor-intensive tasks were impossible to accomplish in a timely manner with the COVID-related restrictions.

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

A research assistant learned how to screen SRWW for reference low-DON MR varieties. A recently hired post-doc (part-time) will analyze and process grain samples, characterize variety reaction based on ratios of IND, DON and FDK, and preparate reports.

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

No. Results will eventually be published in the Ohio County Journals and Ohio Wheat Performance Trial webpage.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the **FY19 award period (5/13/19 - 5/12/21)**. 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?**
   ☐Yes ☒No
   If yes, how many? Click to enter number here.

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?**
   ☐Yes ☒No
   If yes, how many? Click to enter number here.

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?**
   ☐Yes ☒No
   If yes, how many? Click to enter number here.

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?**
   ☐Yes ☒No
   If yes, how many? Click to enter number here.

FY19 Final Performance Progress Report
PI: Paul, Pierce
USDA-ARS Agreement #: 59-0206-8-187
Reporting Period: 5/13/19 - 5/12/21

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 (5/13/19 - 5/12/21)**. 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	FHB Rating (0-9)	Year Released
N/A	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
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Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year

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

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Publications, Conference Papers, and Presentations

Instructions: Refer to the 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 - 5/12/21**) 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. See example below for a poster presentation with an abstract:

Winn, Z.J., Acharya, R., Lyerly, J., Brown-Guedira, G., Cowger, C., Griffey, C., Fitzgerald, J., Mason R.E., and Murphy, J.P. (2020, Dec 7-11). Mapping of Fusarium Head Blight Resistance in NC13-20076 Soft Red Winter Wheat (p. 12). In: Canty, S., Hoffstetter, A. and Dill-Macky, R. (Eds.), *Proceedings of the 2020 National Fusarium Head Blight Forum*. https://scabusa.org/pdfs/NFHBF20_Proceedings.pdf.
Status: Abstract Published and Poster Presented
Acknowledgement of Federal Support: YES (Abstract and Poster)

Journal publications.

Shah, D.A., Paul, P.A., De Wolf, E.D., and Madden, L.V. 2019. Predicting plant disease epidemics from functionally - represented weather series. Phil. Trans. R. Soc. B. 374:20180273.
Status: Article Published
Acknowledgement of Federal Support: YES

Shah, D.A., De Wolf, E.D., Paul, P.A. and Madden, L. V. 2019. Functional data analysis of weather variables linked to Fusarium head blight epidemics in the United States. Phytopathology 109:96-110.
Status: Article Published
Acknowledgement of Federal Support: YES

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* 110:1632-1646.
Status: Article Published
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: Article Published
Acknowledgement of Federal Support: YES

Shah, D. A., De Wolf, E. D., Paul, P. A. and Medden, L. V. 2021. Accuracy in the prediction of disease epidemics when ensembling simple but highly correlated models. PLOS Computational Biology | https://doi.org/10.1371/journal.pcbi.1008831
Status: Article Published
Acknowledgements of Federal Support: YES

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

Nothing to Report

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, B. Wiermer and R. Dill-Macky (Eds.), Proceedings of the 2019 National Fusarium Head Blight Forum (p. 11). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
Status: Talk and abstract
Acknowledgement of Federal Support: YES

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, B. Wiermer and R. Dill-Macky (Eds.), Proceedings of the 2019 National Fusarium Head Blight Forum (p. 12). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
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, B. Wiermer and R. Dill-Macky (Eds.), Proceedings of the 2019 National Fusarium Head Blight Forum (p. 18). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
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, B. Wiermer and R. Dill-Macky (Eds.), Proceedings of the 2019 National Fusarium Head Blight Forum (p. 20). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.

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, B. Wiermer and R. Dill-Macky (Eds.), Proceedings of the 2019 National Fusarium Head Blight Forum (p. 25). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.

Status: Poster Presented and Short Report published
Acknowledgement of Federal Support: YES

Moraes, W. B., Madden, L. V., and **Paul, P. A.** 2019. 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

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, J. M., 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
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National Fusarium Head Blight Forum (p.29). East Lansing, MI: U.S. Wheat & Barley Scab Initiative.
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Bucker Moraes, W., Ng, S. J., Madden, L. V. and Paul, P. A. 2020. Rainfastness of fungicides for Fusarium head blight management in soft red winter wheat. In: Canty, S., A. Hoffstetter, and R. Dill-Macky (Eds.), Proceedings of the 2020 National Fusarium Head Blight Forum (p.30). East Lansing, MI: U.S. Wheat & Barley Scab Initiative.
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Luis, M. J., 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., Langston, D. B., Madden, L., Marshall, J., Mehl, H., Moraes, W., Nagelkirk, M., Rawat, N., Smith, D., Telenko, D., Wegulo, S., Young-Kelly, H., and Paul, P. A. 2020. Fusarium head blight management coordinated project: integrated management trials 2018-2020. In: Canty, S., A. Hoffstetter, B. Wiermer and R. Dill-Macky (Eds.), Proceedings of the 2019 National Fusarium Head Blight Forum (p. 38-43). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
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Statue: Short paper published
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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.
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Pierce A. Paul. 2020. "*Fungicides and Integrated Management of Head Scab and Vomitoxin in Wheat with Emphasis on Miravis Ace: A 2020 Update*". 2020 National Fusarium Head Blight Forum. Virtual, December 2020.

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