USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY18 Performance Report
Due date: July 12, 2019

Cover Page

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Fiscal Year:	2018
USDA-ARS Agreement ID:	59-0206-8-187
USDA-ARS Agreement Title:	Fusarium Head Blight Risk Assessment, Management, and Education.
FY18 USDA-ARS Award Amount:	$ 68,178
Recipient Organization:	The Ohio State University Research Foundation Accounting Dept. 1960 Kenny Road, 4th Floor Columbus, OH 43210
DUNS Number:	07-165-0709
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Project/Grant Reporting Period:	5/13/18 - 5/12/19
Reporting Period End Date:	05/12/19

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
	FY18 Total ARS Award Amount	$ 68,178

Principal Investigator 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

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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 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? *Address items 1-4) below for each goal or objective.*

1) major activities

Three field experiments were conducted during the 2017-2018 growing seasons in Ohio; two with SRWW (IM and UFT) and one with malting barley (IM). ***Objective 1 (IM)*****:** Six treatments: **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 were applied to replicate plots of four cultivars with different levels of resistance to FHB. ***Objective 2 (UFT)*****:** 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. For Objective 1, a similar protocol was used for malting barley, with full head emergence (Feekes 10.5) as the standard and reference application time, but only Prosaro and Caramba ended up being applied. 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.

2) specific objectives

a. Evaluate the integrated effects of Miravis Ace, Prosaro, or Caramba fungicide treatments and genetic resistance on FHB and DON in SRWW and malting barley in Ohio.
b. Compare the efficacy of single and sequential applications of Miravis Ace, Prosaro, Caramba, and Folicur against FHB and DON in SRWW and malting barley in Ohio.

3) significant results

***Objective 1*:** All fungicide program x cultivar resistance combinations resulted in significantly lower mean FHB index and DON than the non-treated susceptible check. At all tested levels of FHB resistance (MR, MS and S), the early application of Miravis Ace (MIR_E) tended to have numerically (but not always statistically) higher mean FHB index and DON than the anthesis application of Miravie Ace (MIR_A) or Prosaro (PRO_A). Differences in mean FHB index and DON between Prosaro and Miravis Ace were not statistically significant when applications were made at anthesis. Mean DON (averaged across cultivars) was significantly higher for MIR_E than MIR_A or PRO_A. Similar trends to those observed for mean FDK.

***Objective 2*:** All fungicide programs resulted in significantly lower mean FHB index and DON than the non-treated check. The application of Miravis Ave at anthesis followed by Prosaro, Caramba or Folicur 4 day later resulted in the lowest overall levels of mean FHB index, FDK, and DON. Miravis Ace was not significantly different from Prosaro or Caramba for any of the measured responses when applications were made at anthesis. However, mean DON and FDK were significantly higher when Miravis Ace was applied at early heading compared to all other fungicide programs.

4) key outcomes or other achievements

We successfully showed that **1**) Miravis Ace was just as effective as Prosaro and Caramba against FHB and DON when applications were made at anthesis; **2**) a Feekes 10.3 application of Miravis Ace showed similar efficacy against FHB to that of an anthesis application of Miravis Ace, Prosaro, or Caramba, but was significantly less effective against DON than the latter three treatments; **3**) two-treatment fungicide programs involving Miravis Ace at anthesis followed by Prosaro, Caramba or Folicur four days later tended to be more effective a single-treatment programs; and **4**) an application of Miravis Ace at anthesis + a moderately resistant (MR) cultivar was just as effective a management program against FHB and DON as an anthesis application of Prosaro + an MR cultivar.

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

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

4. 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.

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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 project?

The overall project goal is 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) Identify periods within weather time series that are significantly different between FHB epidemics and non-epidemics,
3) Create variables summarizing those identified periods,
4) Use the summary variables in new logistic regression models for predicting FHB epidemics,
5) Compare the predictive performances of new models with the performances of the currently deployed models, and
6) Replace the current models with the newer versions after they have been field-tested.

2. What was accomplished under these goals? *Address items 1-4) below for each goal or objective.*

1) major activities

My lab was primarily responsible for objective 1 "*Generate data through the MGMT_CP to help validate and advance the development of FHB and DON risk prediction models*", but we work closely with Dr. DeWolf a K-State on the other objectives (see his report for details). Through the MGMT_CP experiments were conducted in 17 US wheat-growing states commonly affected by FHB (AL, DE, ID, 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 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.

2) specific objectives

Working in collaboration with Dr DeWolf, we performed Functional Data Analyses on the master data file, identifying profiles of weather time series associated with epidemics and non-epidemics of FHB. This allowed us to generate new forms of representing weather variables as predictors of FHB, and consequently, develop new logistic regression models. A subset of the MGMT_CP data was used to compare the performance of the new models with the current models in terms of predictive accuracy.

3) significant results

We showed that FHB epidemics are associated with weather patterns covering a wider pre- and post-anthesis window than is considered in the currently deployed model.

4) key outcomes or other achievements
The new models could potentially be used to predict FHB during a wider time window to help guide pre- and post-anthesis fungicide applications for FHB and DON management.

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

The Research Associate who contributed to this project learned certain aspects of basic data mining.

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

Results were presented to wheat pathologist at the 2019 NCERA-184 annual meeting. Two manuscripts were publication in 2019 (see the publication list below).

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 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? *Address items 1-4) below for each goal or objective.*

1) major activities

Contributing to objective 1, my lab (in collaboration with Dr. Sneller) came up with an initial list of Ohio-grown MR SRWW varieties using data collected from our 2018 FHB screening nursery. Replicate hill plots of commercial SRWW 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 identified as being moderately resistant. The same set of varieties are being screened again in 2019 to evaluate the stability of the response.

For objective 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 used of grain harvesting strategies to mitigate DON.

As part of our pilot study, objective 4, we screened the MR varieties selected in objective 3 for "resistance to DON accumulation" (RDA). Replicate spikes with a fixed level of FHB index (20%) were tagged, 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 RDA. The goal is to generate an index for classifying varieties based on FHB:DON ratios. Also, as part of the pilot study, we successfully secured additional funding from USWBSI to help cover the cost of testing a fixed number of

commercial varieties from several SRWW-producing states for DON to evaluate the idea of a dedicated testing service to generate timely DON results – this will be done during the 2020 growing season.

2) specific objectives
   a. Educate stakeholder of the availability, source, and benefits of using varieties with moderate resistance to FHB.
   b. Develop a variety classification system based on both FHB and DON.

3) significant results
   We identified multiple SRWW varieties with MR for FHB based on FHB index:DON and FDK:DON ratios. These will be used as MR references for future screening and development of the list of MR SRWW varieties.

   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.

4) key outcomes or other achievements
   Of the 246 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." We believe that with **1**) educational programs on the benefits of using FHB/DON resistant varieties, **2**) a list of MR varieties (selected based on RDA ratios), and **3**) a dedicated DON testing service to generate DON results (and consequently, RDA scores) in a timely manner, we would be able to increase the adoption of MR SRWW varieties.

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

A research assistant 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.

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

Two webinars were presented as indicated about, and weblinks to recordings of the same were disseminated via email to fellow researchers, extension educators, and other stakeholders. My lab also worked closely with the SCAB SMART team to redesign the website and develop content (list of MR cultivars and fungicide efficacy charts) on best management practices for FHB.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY18 award period. 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 FY18 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 FY18 award period?** No

   If yes, how many?

3. **Have any post docs who worked for you during the FY18 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 FY18 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

   If yes, how many? 1 (my research associate was hired by FMC)

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 FY18 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

Publications, Conference Papers, and Presentations

Instructions: Refer to the FY18-FPR_Instructions for detailed instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY18 grant. Only include citations for publications submitted or presentations given during your award period (5/13/18 - 5/12/19). If you did not have any publications or presentations, state 'Nothing to Report' directly above the Journal publications section.

NOTE: Directly below each reference/citation, you must indicate the Status (i.e. published, submitted, etc.) and whether acknowledgement of Federal support was indicated in publication/ presentation. See example below for a poster presentation with an abstract:

> Conley, E.J., and J.A. Anderson. 2018. Accuracy of Genome-Wide Prediction for Fusarium Head Blight Associated Traits in a Spring Wheat Breeding Program. In: Proceedings of the XXIV International Plant & Animal Genome Conference, San Diego, CA.
> Status: Abstract Published and Poster Presented
> Acknowledgement of Federal Support: YES (poster), NO (abstract)

Journal publications.

1. 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

2. 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

3. Paul, P. A., Salgado, J. D., Bergstrom, G. C., Bradley, C., Byamukama, E., Byrne, A. M., Chapara, V., Cummings, J. A., Chilvers, M. I., Dill-Macky, R., Friskop, A. J., Kleczewski, N. M., Madden, L. V., Nagelkirk, M., Stevens, J., Smith, M., Wegulo, S. N., Wise, K. A., and Yabwalo, D. 2019. Integrated effects of genetic resistance and prothioconazole tebuconazole application timing on Fusarium head blight in wheat. Plant Dis. 103:223-237.
   Status: Article published
   Acknowledgement of Federal Support: YES

4. Paul, P. A., Bradley, C. A., Madden, L. V., Dalla Lana, F., Bergstrom, G. C., Dill-Macky, R., Wise, K. A., Esker, P., McMullen, M. P., Grybauskas, A., Kirk, W., Milus, E. A., and Ruden, K. 2018. Effects of pre- and post-anthesis applications of demethylation inhibitor fungicides on Fusarium head blight and deoxynivalenol in spring and winter wheat. Plant Dis. 102:2500-2510.
   Status: Article published
   Acknowledgement of Federal Support: YES

5. Paul, P. A., Bradley, C. A., Madden, L. V., Dalla Lana, F., Bergstrom, G. C., Dill-Macky, R., Esker, P., Wise, K. A., McMullen, M. P., Grybauskas, A., Kirk, W., Milus, E. A., and Ruden, K. 2018. Meta-analysis of the effects of QoI and DMI fungicide combinations on Fusarium head blight and deoxynivalenol in wheat. Plant Dis. 102:2602-2615.
   Status: Article published
   Acknowledgement of Federal Support: YES

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

Nothing to Report

Other publications, conference papers and presentations.

Conference proceedings

1. Moraes, W. B., Schwarz, P. B., Madden, L. V., and Paul, P. A. 2018. Influence of temperature and relative humidity on mycotoxin production in wheat after Fusarium head blight symptom development. In: Canty, S., A. Hoffstetter, B. Wiermer and R. Dill-Macky (Eds.), Proceedings of the 2018 National Fusarium Head Blight Forum (p. 12-16). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
   Status: Poster Presented and Short Report published
   Acknowledgement of Federal Support: YES

2. Salgado, J. D., Edwards, J. P., Madden, L. V. and Paul, P. A. 2018. Efficacy and curative effects of fungicides for FHB and DON management. In: Canty, S., A. Hoffstetter, B. Wiermer and R. Dill-Macky (Eds.), Proceedings of the 2018 National Fusarium Head Blight Forum (p. 39). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
   Status: Poster Presented and Short Report published
   Acknowledgement of Federal Support: YES

3. Salgado et al. 2018. Efficacy of Miravis Ace for FHB and DON management across environments and grain market classes: A progress report. In: Canty, S., A. Hoffstetter, B. Wiermer and R. Dill-Macky (Eds.), Proceedings of the 2018 National Fusarium Head Blight Forum (p. 40-44). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
   Status: Poster Presented and Short Report published
   Acknowledgement of Federal Support: YES

Scholarly presentations (invited)

1. Pierce A. Paul. 2018. "*Risk Assessment and Management of Fusarium Head Blight: Lessons learned from more than a decade of research*". 9th Canadian Workshop on Fusarium Head Blight and the 4th Canadian Wheat Symposium. Winnipeg, Manitoba, Canada, November 2018.
   Status: Talk Presented
   Acknowledgement of Federal Support: YES

2. Pierce A. Paul. 2018. "*Application of Quantitative Methods to Address Applied Questions in Wheat Pathology: A case study on Fusarium Head Blight*". North Carolina State University, Department of Plant Pathology Seminar, Raleigh, NC, October 2018.
   Status: Talk Presented
   Acknowledgement of Federal Support: YES

3. Pierce A. Paul. 2018. "*Application of Quantitative Methods to Address Applied Questions in Wheat Pathology*". Purdue University, Department of Plant Pathology Seminar, West Lafayette, IN, August 2018.
   Status: Talk Presented
   Acknowledgement of Federal Support: YES