USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY17 Final Performance Report
Due date: July 31, 2018

Cover Page

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Fiscal Year:	2017
USDA-ARS Agreement ID:	59-0206-4-018
USDA-ARS Agreement Title:	Modeling The Effects of Weather on FHB And DON and Developing Robust Strategies to Minimize Losses.
FY17 USDA-ARS Award Amount:	$ 53,871
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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Recipient Identifying Number or Account Number:	GRT00035608 BG001
Project/Grant Reporting Period:	5/13/17 - 5/12/18
Reporting Period End Date:	5/12/18

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
MGMT	Efficacy and Curative Effects of Fungicides for FHB and DON Management in Ohio.	$ 28,921
MGMT	Functional Analysis for Getting Better Weather-based Predictors of Fusarium Head Blight.	$ 10,602
MGMT	Risk-based Fungicide Decision-making for FHB and DON Management in Wheat.	$ 14,348
	FY17 Total ARS Award Amount	$ 53,871

07/31/3018

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

Project 1: *Efficacy and Curative Effects of Fungicides 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 [IM-CP]) was to develop more robust guidelines to provide producers with additional and more effective options for managing FHB and DON. The specific objectives were to:

1. Determine the efficacy and economics of integrating anthesis and post-anthesis fungicide applications and cultivar resistance to minimize losses due to FHB and DON**.**
2. Investigate the curative effect of Prosaro and Caramba on FHB and DON.

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

1) Major activities

A total of four field and three growth greenhouse experiments were conducted during the 2015-2016 and 2016-2017 growing seasons in Ohio. *Objective 1*: Fungicide treatments, consisting of **1)** an untreated check, **2)** Prosaro at 50% Feekes 10.5.1 (early anthesis); **3)** Prosaro at 50% early anthesis followed by Caramba 4 days later; **4)** Caramba at 50% early anthesis followed by tebuconazole 4 days later; **5)** Proline at 50% early anthesis followed by tebuconazole 4 days later; and **6)** an untreated, non-inoculated check, were applied to plots of susceptible, moderately susceptible, and moderately resistant cultivars. *Objective 2*: Prosaro and Caramba were applied at regular intervals between 50% early anthesis and soft dough to a moderately resistant and a susceptible cultivar in the field, and to a susceptible cultivar in the greenhouse. FHB and DON were quantified in all experiments, including systematic assessments and sampling to quantify these responses on primary and secondary tillers.

For objective 1, Ohio data were combined with those collected from collaborating PIs (IM-CP) and a preliminary quantitative synthesis was performed to estimate the overall efficacy of the different management programs.

2) Specific objectives

a. Determine the efficacy and economics of integrating sequential fungicide applications (one at anthesis and a second four days later) and cultivar resistance to manage FHB and DON**.**
b. Quantify the curative effect of Prosaro and Caramba on FHB and DON.

2) Significant results

Objective 1: All fungicide programs x cultivar combinations resulted in significantly lower mean FHB and DON than the untreated check, with two-treatment (sequential application) programs, particularly the one consisting of a Prosaro application at 50% early anthesis followed by Caramba 4 days later (Treatment 3), resulting in the highest percent control relative to the non-treated checks. However, the magnitude of this effect varied among cultivars. The highest percent control was estimated for the combination of a moderately resistant cultivar with treatment 3.

Objective 2: Early anthesis and post-anthesis treatments applied between 2 and 6 days after 50% early anthesis consistently reduced FHB and DON relative to the check, with comparable efficacy (based on percent control) on primary and secondary tillers. Treatments applied 8 or more days after anthesis were generally ineffective. The curative effect varied somewhat between fungicides and cultivars. Post-anthesis Prosaro treatments were consistently more effective than post-anthesis Caramba treatments under field conditions. Relative to the check, efficacy of curative applications was greater on the susceptible than the moderately resistant cultivar and tended to be greater for DON than FHB. There was an exponential-type temporal decline in fungicide efficacy against all measured responses.

4) Key outcomes or other achievements

We demonstrated the efficacy of two-treatment fungicide programs and the curative effects of Prosaro and Caramba, with fairly consistent results among trials. We are now in the process of completing a quantitative synthesis of data from the management coordinated project, from which we will generate summaries of the overall efficacy and economic benefit of all tested treatment program x cultivar resistance management combinations. However, our preliminary results suggest that two-treatment programs may be more warranted when susceptible cultivars are planted and disease/toxin levels are moderate; treatments applied at 2 or even 4 days after anthesis were just as or more effective than anthesis treatments; and both Prosaro and Caramba show evidence of curative effects when applied up to six days after infection, but not later.

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.

Project 2: *Functional Analysis for Getting Better Weather-based Predictors of Fusarium Head Blight.*

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

The overall goal of this project was to create better models for predicting Fusarium head blight (FHB). The specific objectives were to:

1. Identify periods within weather time series that are significantly different between FHB epidemics and non-epidemics,
2. Create variables summarizing the identified periods,
3. Use the summary variables in new logistic regression models for predicting FHB epidemics,
4. Compare the predictive performances of new models with the performances of the currently deployed models, and eventually
5. 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

As was the case in the first year of this project, additional data were collected for the forecasting effort from field experiments conducted in 17 US wheat-growing states (AL, DE, ID, IN, KY, MD, MI, MN, ND, NE, NY, OH, PA, SD, TN, VA, and WI) as part of the FHB IM-CP. At least three 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 several of the trials and edited for inclusion in the master data file for FHB risk model development and validation.

Working closely with Dr. De Wolf and his team at Kansas State, we completed functional data analysis to quantify associations between weather time series relative to anthesis and FHB epidemics (a manuscript is in press - Phytopathology first look). For each field plot location, daily time series were generated for dewpoint (d), pressure (p), relative humidity (rh), temperature (t), vapor pressure deficit (vpd), and temperature-dewpoint depression (tdd) for periods from 120 days pre-anthesis to 20 days post-anthesis. Functional mean curves, standard deviations, and derivatives (1st and 2^{nd}) were generated and compared for FHB epidemics relative to non-epidemics.

2) Specific objectives

Functionally model weather-based time series data linked to FHB epidemics (FHB disease index $\geq$ 10%) and non-epidemics (FHB disease index < 10%).

3) Significant results

For most of the tested weather variables, the mean curves for epidemic began separating from those of non-epidemics about 40 days pre-anthesis, with the greatest separation occurring close to anthesis. The most consistent separations between the epidemic and non-epidemic curves were seen with daily averages of moisture-related variables and variables representing daily variation in temperature.

4) Key outcomes or other achievements

Results from the functional data analyses suggest that FHB predictor variables could be summarized for periods extending to as many as 40 days pre-anthesis, much earlier than the 15-days pre-anthesis window used in current models. Functional data analysis has improved our understanding of relationships between weather and FHB epidemics, providing us with additional options for modeling relationships between weather and FHB that could potentially improve the accuracy of FHB predictions.

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 as an abstract with a poster at the 2017 Scab Forum. A manuscript was recently accepted for publication in Phytopathology (first look).

Project 3: *Risk-based Fungicide Decision-making for FHB and DON Management in Wheat.*

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

The overall goal of this project was to facilitate the practical utilization of the web-based FHB risk assessment system for fungicide application decision-making. The specific objectives were to:

1. Evaluate criteria for using the web-based risk assessment tool to make fungicide application decisions for FHB management.
2. Develop risk-based fungicide application guidelines for FHB management.

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

1) Major activities

FHB and DON data were again collected from Prosaro-treated and non-treated, naturally-infected plots of susceptible, moderately susceptible, and moderately resistant wheat cultivars planted at five locations in Ohio, as well as several locations in Michigan, North Carolina, Wisconsin, Kentucky, Nebraska, Tennessee, North Dakota, Virginia, South Dakota, Indiana, Minnesota, Delaware, and Vermont.

2) Specific objectives

The specific objective was to determine if the efficacy of Prosaro against FHB and DON was influenced by whether the application was made under low, moderate, high, or consistently moderate-high risk predictions. Finding will be used to develop risk-based fungicide application guidelines for FHB management.

3) Significant results

The success of this project is totally dependent on the availability of a wide range of FHB index data collected under a range of risk scenarios (based on predictions made by the risk tool). Unfortunately, the risk of FHB was low across most of the locations from which data were collected in 2016. We are still in the process of collecting and analyzing data from 2017. In addition, we are still awaiting data from a few PIs who opted to establish the trials after funding was approved; meaning that they conducted the first set of experiments in 2017 and the second set in 2018.

4) Key outcomes or other achievements

Once we collect mean FHB and DON data from Prosaro-treated and non-treated plots, we will estimate percent control for both responses to determine under which risk scenario(s) the overall mean efficacy was greatest. Summaries of pre-anthesis relative humidity will be plugged into the risk model equations to estimate FHB risk at the time of fungicide application at each of the locations in which the trials were conducted.

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

A Ph.D. graduate student is being trained as part of this project. He is learning how to use decision theory to evaluate fungicide efficacy against FHB and DON when application decisions are made under low, moderate, and high FHB risk.

4. How have the results been disseminated to communities of interest?
Results have not yet been disseminated.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY17 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 FY17 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 FY17 award period?** No

   If yes, how many?

3. **Have any post docs who worked for you during the FY17 award period and were supported by funding from your USWBSI grant taken faculty positions with universities?**

   If yes, how many? No

4. **Have any post docs who worked for you during the FY17 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?

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 FY17 award period. All columns must be completed for each listed germplasm/cultivar. Use the key below the table for Grain Class abbreviations. *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 FY17-FPR_Instructions for detailed instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY17 grant. Only include citations for publications submitted or presentations given during your award period (5/13/17 - 5/12/18). 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.

Journal publications.
None

Books or other non-periodical, one-time publications.
None

Other publications, conference papers and presentations.
Salgado, J. D. **Paul**, **P. A.,** Ames, K. A., Bergstrom, G. C., Bradley, C. A., Byamukama, E. Z., Cummings, J. A., Chapara, V., Chilvers, M., Dill-Macky, R., Friskop, A. J., Gautam, P., Kleczewski, N. M., Madden, L. V., Milus, E. A., Nagelkirk, M., Ransom, J., Ruden, K. R., Stevens, J., Wegulo, S. N., Wise, K. A., and Yabwalo, D. 2017. A multi-state coordinated project to evaluate integrated management strategies for Fusarium head blight and deoxynivalenol in wheat. (Abstr.) Phytopathology 107:S5.6.
Status: Abstract Published and Talk Given
Acknowledgement of Federal Support: YES

Salgado, J. D., Ames, K. A., Bergstrom, G. C., Bradley, C. A., Byamukama, E. Z., Cummings, J. A., Chapara, V., Chilvers, M., Dill-Macky, R., Friskop, A. J., Gautam, P., Kleczewski, N. M., Madden, L. V., Milus, E. A., Nagelkirk, M., Ransom, J., Ruden, K. R., Stevens, J., Wegulo, S. N., Wise, K. A., and Yabwalo, D., and **Paul, P. A.** 2017. Robust Management Programs to Minimize Losses due to Fusarium Head Blight and Deoxynivalenol in Wheat. In: S. Canty, B. Wiermer and D. Van Sanford (Eds.), *Proceedings of the 2017 National Fusarium Head Blight Forum* (pp. 26-27). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
Status: Abstract Published and Talk Given
Acknowledgement of Federal Support: YES

Salgado, J. D., Bergstrom, G., Bradley, C., Bowen, K., Byamukama, E., Byrne, A., Collins, A., Cowger, C., Cummings, J., Chapara, V., Chilvers, M. I., Dill-Macky, R., Friskop, A., Kleczewski, N., Madden, L. V., Marshall, J., Mehl, H., Nagelkirk, M., Stevens, J., Smith, D., Smith, M., Wegulo, S. N., Wise, K. A., and Yabwalo, D., Young-Kelly, H. and **Paul, P. A.** 2017. Efficacy of Two-treatment Fungicide Programs for FHB Management: A Multi-State

Coordinated Project. In: S. Canty, B. Wiermer and D. Van Sanford (Eds.), *Proceedings of the 2017 National Fusarium Head Blight Forum* (pp. 20-25). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
Status: Short Report Published
Acknowledgement of Federal Support: YES

Bradley, C. A, Madden, L. V. and **Paul, P. A.** 2017.Multi-state research on the effect of Quinone outside inhibitor fungicides on DON contamination in wheat grain. In: S. Canty, B. Wiermer and D. Van Sanford (Eds.), *Proceedings of the 2017 National Fusarium Head Blight Forum* (pp. 6). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
Status: Abstract Published and Talk Given
Acknowledgement of Federal Support: YES

De Wolf, E., Shah, D., **Paul, P.**, Madden, L., Crawford, S., Hane, D., Canty, S., Van Sanford, D., Imhoff, K., Miller, D., and Knight, P. 2017. Impact of prediction tools for Fusarium head blight in the US, 2009-2017. In: S. Canty, B. Wiermer and D. Van Sanford (Eds.), *Proceedings of the 2017 National Fusarium Head Blight Forum* (pp. 11). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
Status: Abstract Published and Poster Presented
Acknowledgement of Federal Support: YES

Mills, K. B., Salgado, J. D., Madden, L. V., and **Paul, P. A.** 2017. The spray before the storm: assessing the rainfastness of caramba for control of fusarium head blight. In: S. Canty, B. Wiermer and D. Van Sanford (Eds.), *Proceedings of the 2017 National Fusarium Head Blight Forum* (pp. 16). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
Status: Abstract Published and Poster Presented
Acknowledgement of Federal Support: YES

Moraes, W. B., Madden, L. V., and **Paul, P.A.** 2017. Effects of sample size on fusarium head blight index estimation and its relationship with deoxynivalenol accumulation in wheat. In: S. Canty, B. Wiermer and D. Van Sanford (Eds.), *Proceedings of the 2017 National Fusarium Head Blight Forum* (pp. 17). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
Status: Abstract Published and Poster Presented
Acknowledgement of Federal Support: YES