USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY15 Final Performance Report
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Cover Page

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Fiscal Year:	2015
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.
FY15 USDA-ARS Award Amount:	$ 72,759
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:	05/13/15-05/12/16
Reporting Period End Date:	05/12/16

USWBSI Individual Project(s)

USWBSI Research Category*	**Project Title**	**ARS Award Amount**
MGMT	Robust Integrated Management Guidelines to Minimize Losses due to FHB in Ohio.	$ 38,057
MGMT	Fate of Deoxynivalenol in Wheat after Visual Symptom Development.	$ 24,399
MGMT	Development of Prediction Models for Fusarium Head Blight and Deoxynivalenol.	$ 10,303
	FY15 Total ARS Award Amount	**$ 72,759**

Pierce Paul 07/15/2016
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: *Robust Integrated Management Guidelines to Minimize Losses due to FHB in Ohio.*

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

Goal:

Develop more robust best-management guidelines to minimize losses due of FHB and DON.

Coordinated Project Objectives:

1. Evaluate the integrated effects of fungicide and genetic resistance on FHB and DON in all major grain classes, with emphasis on different application timings and new genotypes;
2. Generate data to conduct an economic analysis of the integrated effects of fungicide and resistance on FHB/DON;
3. Generate data to advance the FHB and DON risk prediction effort.

2. What was accomplished under these goals?

1) Major activities

Two field experiments were conducted in 2015 (as was done in 2014) to evaluate the integrated effects of Prosaro and Caramba application timing, rate of active ingredient, and cultivar resistance on FHB and DON. In the first experiment, Prosaro (6.5 fl. oz./A) was applied to four cultivars with different levels of resistance to FHB (Hopewell, susceptible; Bromfield, moderately susceptible; and Truman and Malabar, both moderately resistant), and in the second, Prosaro and Caramba were applied to Hopewell and Malabar at low and high rates (6.5 and 8.2 fl. oz./A for Prosaro and 13.5 and 17 fl. oz./A, for Caramba). In both experiments, treatments were either applied at 50% anthesis or between 2 and 6 days after anthesis. All plots were inoculated at anthesis, and FHB intensity and Fusarium damaged kernel (FDK) were rated, grain yield estimated, and grain samples tested for DON.

2) Specific objectives

a. Evaluate post-anthesis applications in combination with cultivar resistance for integrated management of FHB and DON
b. Compare the efficacy of Prosaro and Caramba applied at different rates and times against FHB and DON in integrated management programs.

3) Significant results

Experiment 1: Both the main effects of cultivar and fungicide application time (treatments) on FHB index and DON were statistically significant, but the interaction was not. All treatments resulted in significantly lower mean FHB index and DON than the untreated check. Averaged across cultivars, the lowest mean levels of index were observed in plots treated at 2 days after anthesis, whereas the lowest mean levels of DON were observed in plots treated at 6 days after anthesis, however, differences between anthesis and post-anthesis treatments were generally not statistically significant. Averaged across treatments, the moderately resistant and moderately susceptible cultivars had significantly lower mean index and DON than the susceptible cultivar. Percent control of FHB index relative to the susceptible-untreated ranged from 83 to 91% when a moderately resistant was treated with Prosaro (MR-Treated), compared to 76 to 80% when the moderately susceptible cultivar was treated (MS-Treated) and 25 to 42% when the susceptible cultivar was treated (S-Treated). For DON, the corresponding ranges were 62 to 87% for MR-Treated, 66 to 70% for MS-Treated, and 32 to 40% for S-Treated.

Experiment 2: The effect of fungicide treatment (product x rate combination) on FHB index and DON was not influenced by cultivar or application time (non-significant interactions). All fungicide treatments resulted in significantly lower mean FHB index and DON (averaged across cultivars and application time) than the untreated check. Averaged across treatments and cultivars, the lowest mean levels of index and DON were observed in plots treated at anthesis, however, differences between anthesis and post-anthesis treatments were not statistically significant.

4) Key outcomes or other achievements
All objectives were accomplished. High and low rates of Caramba and Prosaro resulted in comparable levels of FHB and DON reduction. There was no advantage to using the high rates of either Caramba or Prosaro for FHB management, regardless of whether the application was made at or after anthesis. Both fungicides performed similarly in terms of percent FHB and DON reduction at all tested application times, and post-anthesis treatments provided similar levels of FHB and DON reduction to anthesis treatments. Combining a moderately resistant cultivar with a fungicide application either at anthesis or 2-6 days after anthesis resulted in the highest percentages of FHB and DON control.

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

A Ph.D. graduate student and a post-doctoral researcher 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 both learned how to use linear mixed models to analysis data from the MGMT Coordinated Project. They both contributed to the preparation of abstracts, manuscripts, and posters presented at the scab forum and the APS meeting by the post-doc.

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

Results were disseminated by way of posters and abstracts at the 2015 scab forum and the APS annual meeting, a report posted on the USWBSI website, a talk at the International FHB Symposiums, an updated extension factsheet, electronic newsletter articles, and several in- and out-of-state extension presentations.

Project 2: *Fate of Deoxynivalenol in Wheat after Visual Symptom Development.*

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

Goal: The primary goal of this project was consistent with Goal # 3 of the MGMT Action Plan which is to "*Develop a full understanding of specific factors influencing infection and toxin accumulation that can be used to develop the next generation of scab and DON risk assessment measures.*"

2. What was accomplished under these goals?

1) Major activities
Two experiments were performed to evaluate the effects of post-symptom-expression temperature-moisture regimes on DON accumulation in FHB-affected spikes. Tillers with intact spikes showing different levels of FHB visual symptoms were used in the first experiment, whereas in the second, detached symptomatic spikes were used. In both cases, temperature and moisture treatments were initiated after visual symptom development and continued until senescence. The two experiments were performed simultaneously in walk-in growth chambers set a 20, 25, or 30ºC. Spikes were grouped into five FHB index categories (8-15, 20-40, 41-60, 61-80, 90-100%) and subjected to high (> 95%) and low (~70%) RH in experiment 1 and RH ranging from 70 to 100% (at 10% increments) in experiment 2. RH treatments were established using humidity chamber equipped with humidifiers (experiments 1) or saturated salt solutions (experiment 2). DON contamination was estimated for each treatment combination and relationships between FHB and DON were quantified. All experiments are currently being repeated.

2) Specific objectives
   a. Determine and model the effects of temperature and relative humidity on DON accumulation in spikes with known levels of FHB index.
   b. Evaluate and model relationships among post-anthesis infection, inoculum density, and DON accumulation, as influenced by temperature and relative humidity.

3) Significant results
For all temperature x RH combinations, there was a significant positive relationship between index and DON. The rate of increase in DON per unit increase in FHB index (slope) and the mean level of DON at a given level of index varied with temperature, RH, cultivar, and their interactions. For instance, in experiment 1 (intact spikes), at all three temperatures, higher slopes occurred at low (70%) than at high (>95%) RH, and slopes were higher at 20ºC than at 25 or 30ºC at high RH but not at low RH. Similarly, in experiment 2 (detached spikes), the rate of DON increase per unit increase in index at 100% RH was higher (at least numerically) at 20ºC than at 25 or 30ºC. At the high temperatures (25 and 30ºC), similar trends to those observed for intact spikes were observed for detached spikes, with higher slopes at 70 and 80% than at 90 and 100% RH. However, results from the detached spike experiment were very cultivar-dependent.

4) Key outcomes or other achievements
Post-symptom-expression moisture and temperature regime affected DON accumulation and relationships between FHB and DON. Additional experiments are correctly being conducted to better evaluate these effects and relationships, as well as the effect of post-anthesis infection and inoculum density on DON accumulation (Specific Obj. 2).

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. The student is learning how to conduct experiments to study the biology and epidemiology of FHB as well as how to use statistical techniques to model relationships between FHB and DON as influenced by temperature and RH. The student had the opportunity to prepare a short manuscript and present a poster at the 2015 scab forum.

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

Preliminary results were published in the proceedings of and presented on a poster at the 2015 scab forum.

Project 3: *Development of Prediction Models for Fusarium Head Blight and Deoxynivalenol.*

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

   Goal: Improve the prediction accuracy of the current FHB risk assessment tool by incorporating new variables and observations gathered from the Integrated Management Coordinated Project.

2. **What was accomplished under these goals?**

   1) Major activities
      Field experiments were established in 12 US wheat-growing states (AR, DE, IL, IN, MD, MI, MN, ND, NE, NY, OH and SD) as part of the FHB Integrated Management Coordinated Project and used to obtain data for the FHB forecasting effort. 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 from non-treated, non-inoculated plots of each cultivar were collected, edited, and added to the master data file for FHB risk model development and validation.

      Working closely with Dr. De Wolf and his team at Kansas State, 865 observations collecting between 1982 and 2014 were used to further explore weather variables as predictors of FHB epidemics (>10% index). For instance, FHB and DON data were aligned with daily temperatures beginning 120 days pre-anthesis to 20 days post-anthesis and profiles associated with epidemics and non-epidemics were identified. A temperature of 11°C was used as a cut-off for classifying epidemics and non-epidemics and estimating overall classification rates.

   2) Specific objectives
   a. Coordinate the collection of new observations from the IM-CP used in developing and testing future models;
   b. Conduct quality checks on the new observations before including them in the expanded dataset;
   c. Improve the prediction accuracy of models for FHB and DON by (i) including predictors from time periods not considered by the current models, and (ii) by using functional data analysis to identify signal locations within the expanded time series;
   d. Evaluate the potential value of prediction models as part of the integrated management program for FHB and DON using Bayesian decision theory.

   3) Significant results
      FHB index and DON data were collected from 27 environments representing 15 soft red winter, two soft white winter, three hard red winter, and seven hard red spring wheat market classes. Through direct communication with PIs and the aid of google map and addresses, latitude and longitude coordinates were collected for each environment and added to the data matrix and subsequently used to obtain weather data.

We identified three periods during which there was a separation of temperature profiles between epidemic and non-epidemic: 84 to 72 days pre-anthesis, 42 to 23 days pre-anthesis, and from 7 days pre-anthesis to 10 days post-anthesis. Using a temperature of 11°C as a cut-off for classifying epidemics and non-epidemics resulted in an overall correct classification rate of 72%. Non-epidemics were correctly classified 88% of the time, but epidemics were correctly classified only 29% of the time.

4) Key outcomes or other achievements
We successfully identified temperature summaries for much earlier time windows (e.g. 84 to 72 days pre-anthesis) than the 7-day pre-anthesis window used in the existing FHB forecasting system as useful predictors of FHB epidemics. Functional data analysis is being further explored to identify additional predictors of FHB epidemics.

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

A post-doc who contributed to this project received training on certain aspects of basic datamining.

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

Results were presented at the 2015 scab forum as an abstract.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY15 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 FY15 award period?**

   If yes, how many? No

2. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY15 award period?**

   If yes, how many? No

3. **Have any post docs who worked for you during the FY15 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 FY15 award period and were supported by funding from your USWBSI grant gone on to take positions with private ag-related companies or federal agencies?**

   If yes, how many? No

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 FY15 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

Refer to the FY15-FPR_Instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY15 grant. If you did not have any publications or presentations, state 'Nothing to Report' directly above the Journal publications section.

Journal publications.
None

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

1. Dill-Macky, R., Van Sanford, D.A., De Wolf, E.D., and **Paul, P. A.** 2015. *Fusarium* head blight of wheat: progress and challenges. Program and Abstracts of the 9th International Wheat Conference: 41-42.
   Status: Abstract published
   Acknowledgement of Federal Support: Yes

2. Salgado, J., Madden, L. V., and **Paul, P. A.** 2015. Spike colonization, fungal spread and deoxynivalenol accumulation in Fusarium head blight susceptible and resistant wheat cultivars. Phytopathology 105:S4.122.
   Status: Abstract published
   Acknowledgement of Federal Support: Yes

3. Kriss, A. B., **Paul, P. A.**, and Madden, L. V. 2015.Use of climate patterns in prediction of *Fusarium* head blight epidemics. Phytopathology 105:S4.171.
   Status: Abstract published
   Acknowledgement of Federal Support: Yes

Other publications, conference papers and presentations.
Conference Papers:

1. **Paul, P.A.,** Salgado. J. D., Ames, K., Bergstrom, G., Bradley, C., Byamukama, E, Cummings, J., Chilvers, M., Dill-Macky, R., Friskop, A., Gautam, P., Kleczewski, N., Madden, L.V., Nagelkirk, M., Ransom, J., Ruden, K., Wegulo, S., Wise, K. 2016. More than a decade of coordinated research to develop integrated management programs for Fusarium head blight of wheat. In: E. M. Del Ponte, G. C. Bergstrom, W. Pavan, A. Lazzaretti, and J. M. C. Fernandes (Eds.), Annals of The 5th International Symposium on Fusarium Head Blight and 2nd International Workshop on Wheat Blast (pp. 81). Universidade de Passo Fundo, Passo Fundo, RS, Brazil.
   Status: Abstract published and talk presented
   Acknowledgement of Federal Support: Yes (during presentation)

2. Moraes, W. B., Rios, J. A., Madden, L. V., and **Paul, P. A.** 2015. Influence of temperature and relative humidity on DON production in wheat after Fusarium head blight symptom development. In: S. Canty, A. Clark, S. Vukasovich and D. Van Sanford (Eds.), Proceedings of the 2015 National Fusarium Head Blight Forum (pp. 16-20). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Inititiative.
   Status: Short paper published and poster presented
   Acknowledgement of Federal Support: Yes

3. Salgado. J. D., Ames, K., Bergstrom, G., Bradley, C., Byamukama, E, Cummings, J., Chapara, V., Chilvers, M., Dill-Macky, R., Friskop, A., Gautam, P., Kleczewski, N., Madden, L.V., Milus, E., Nagelkirk, M., Ransom, J., Ruden, K., Stevens, J., Wegulo, S., Wise, Yabwalo, D., and **Paul, P.A.** 2015. Robust management programs to minimize losses due to FHB and DON: a multi-state coordinated project. In: S. Canty, A. Clark, S. Vukasovich and D. Van Sanford (Eds.), *Proceedings of the 2015 National Fusarium Head Blight Forum* (pp. 24-29). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
   Status: Short paper published and poster presented
   Acknowledgement of Federal Support: Yes

4. Shah, D.A., De Wolf, E.D., **Paul, P.A.**, and Madden, L.V. 2015. A functional exploration of temperature as a predictor of Fusarium head blight epidemics. In: S. Canty, A. Clark, S. Vukasovich and D. Van Sanford (Eds.), *Proceedings of the 2015 National Fusarium Head Blight Forum* (pp. 30). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
   Status: Abstract published
   Acknowledgement of Federal Support: Yes

Presentations:

1. **Pierce A. Paul. "*More than a decade of coordinated research to develop integrated management programs for Fusarium head blight of wheat*"**. 5th International Symposium on Fusarium Head Blight and 2nd International Workshop on Wheat Blast. Florianopolis, Santa Catarina, Brazil. April, 2016.
   Status: Abstract published and talk presented
   Acknowledgement of Federal Support: Yes (during presentation)

2. **Pierce A. Paul**. ***"Practical and Economic aspects of Decision making in Plant Disease Management"***. 48th Congress of the Brazilian Phytopathological Society. Sao Pedro, Sao Paulo, Brazil. August, 2015.
   Status: Abstract published and talk presented
   Acknowledgement of Federal Support: Yes (during presentation)