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:	59-0206-6-015
USDA-ARS Agreement Title:	Prediction Models and Improved Pre-Harvest Estimates of Deoxynivalenol.
FY17 USDA-ARS Award Amount:	$ 86,176
Recipient Organization:	Kansas State University 10 Andrerson Hall Manhattan, KS 66506
DUNS Number:	929773554
EIN:	48-0771751
Recipient Identifying Number or Account Number:	AR9851 / GAPP603919
Project/Grant Reporting Period:	6/7/17 - 6/6/18
Reporting Period End Date:	06/06/18

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
HWW-CP	Development of Scab Resistant Wheat Cultivars for Kansas.	$ 40,455
MGMT	Continued Deployment of Prediction Models for Fusarium Head Blight.	$ 12,295
MGMT	Functional Analysis for Getting Better Weather-based Predictors of Fusarium Head Blight.	$ 33,426
	FY17 Total ARS Award Amount	$ 86,176

Erick D. DeWolf July 30, 2018
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: *Development of Scab Resistant Wheat Cultivars for Kansas.*

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

The long-term goal of this research is to develop hard red and hard white winter wheat cultivars adapted for Kansas with improved resistance to scab. Short term objectives are to: 1) test existing local cultivars for resistance, 2) test advanced breeding lines for resistance, 3) test exotic germplasm lines for resistance, 4) test the Hard Winter Wheat (Kansas, Nebraska, South Dakota, North Dakota) Scab Nursery for reaction to scab, and 5) incorporate new sources of scab resistance into the Kansas wheat breeding program.

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

1) major activities

Testing was done in misted field nurseries using soil-applied infested corn grain inoculum. Visual disease evaluation methods were used to rate the percentage spikelets infected by the pathogen and ground grain samples will be analyzed for the toxin DON. Data will be disseminated to wheat producers and used by wheat breeders as they make selections for future Kansas cultivars.

2) specific objectives

Three commercial cultivars in Kansas (Everest, Zenda, AG Robust) were identified previously in these nurseries as possible sources of resistance (generally 3 or 4 on the 1-9 scale where 1=immune and 9=highly susceptible). These cultivars had an average FHB index of <8%. In comparison, susceptible cultivars in the same tests had an average >35% FHB index. Therefore, we have identified a few sources of scab resistance already present in cultivars adapted to Kansas that can be used by producers and may be potential sources of "native" resistance for the development of future cultivars.

Both KSU wheat breeders and the USDA wheat geneticist have been involved in the project by having their breeding lines evaluated for resistance to scab. Several breeding "populations" are tested each year from which the breeders make selections of promising lines showing resistance. There were 36 advanced breeding lines (The Kansas Intrastate Nursery) tested and 48 private breeding lines screened in 2017. Greater than 40% of these lines show resistance that is comparable to the resistant check (Table 1).

Table 1. Summary of the 2017 FHB Screening in Manhattan KS

Objective	Number of lines evaluated	Number of lines statistically similar to resistant check
(1&4) Local Cultivars and Advanced breeding lines in Southern FHB, Northern FHB, and Private FHB Nurseries	Southern 36 Northern 48 Private 48	Southern 22 Northern 25 Private 13
(1&2) Advanced breeding lines for from KS	KIN 36	KIN 20

3) significant results
The cultivar Everest, a Kansas State University release that was selected previously in these nurseries for improved levels of resistance to scab. This variety "Everest" is still the top variety in KS representing more than 60% of the acres planted in regions most prone to FHB. In recent years, these nurseries have contributed to the identification of 6 new varieties from KSU and private companies with moderate levels of resistance to FHB. Farmers in KS have more options for scab management than ever before.

4) key outcomes or other achievements
Because of the scab testing efforts, a new column for reaction to "Head Scab" was added to the popular KSU extension publication *Wheat Variety Disease and Insect Ratings* for the fall, 2000 issue and has been updated in each subsequent year. For the first time, this has allowed producers in Kansas to use the reaction to scab to help select cultivars for planting. Data produced from nurseries funded by the Scab Initiative have been incorporated into this publication for 18 years becoming one of the most popular extension publications addressing wheat in the state. The information is also included in a popular extension publication *Kansas Performance Tests with Winter Wheat Varieties*, which is also widely used by wheat growers in KS. Both publications are available as "hard copy" or online.

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

This nursery has been used to train graduate students in Plant Pathology on the importance of scab in the region and methods for screening for disease resistance. This is accomplished by including students in disease ratings, and field trips designed to help our students gain practical skills in plant pathology. Six graduate students participated in these events during 2017.

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

Reports of the phenotyping nurseries are sent to all cooperating breeding programs. These include the public wheat breeding efforts in Kansas, Nebraska, South Dakota, and North Dakota. Similar reports are sent to the breeding efforts in participating private companies (AgriPro, Limagrain, and West Bred). As noted above, the extension publications *Wheat Variety Disease and Insect Ratings* and *Kansas Performance Tests with Winter Wheat Varieties* are updated each year for access online or via paper copies by wheat producers, county agents, and crop consultants.

Project 2: *Continued Deployment of Prediction Models for Fusarium Head Blight.*

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

1. Continued deployment of the disease prediction models in 30 states including the support of the state commentary tools, FHB Alerts and the web-page information explaining the models. **2**. Continued support of a back-up system for improved system stability. **3**. Refine a version of the FHB Prediction Center for use with mobile devices (cellular-based mobile/"smart" phones and tablets). **4.** Redesign of the expert tools to allow disease specialists to record and display disease observations – for refinement in the delivery of the current and experimental models. **5.** Modification of the web-based tools to improve functionality and compatibility of the Prediction Center. **6.** Verify model inputs and improved capacity for site-specific predictions. **7.** Implement a user survey to document value of the prediction system and its impact on stakeholders.

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

1) major activities
   - Disease prediction models were delivered to stakeholders in 30 states via web-based tools. This effort included support for state commentary feature that enables local disease experts to post the assessment of disease risk and recommendations for control. This commentary is also sent to stakeholders via the FHB Alert system**.**
   - Continued support and development "behind the scenes" that enhance the stability of the web-based tools and reliability of the forecasts. This includes refinements data flow and error trapping for the weather information supporting the disease risk maps.
   - Refined protocols for additional sources of weather data that improve the accuracy and reliability of the disease risk maps in the US.

2) specific objectives
   - Continued support of mobile version of the FHB Prediction Center for use with cellular-based mobile/"smart" phones and tablets
   - Redesign of the expert tools that allow members of the modeling team to evaluate the next generation of prediction models prior to deployment were also developed this year. These tools were used extensively to develop case studies that compared current models to new models that were candidates for public use.
   - Developed case studies on new predictive models as training modules for disease experts in the US. These were presented to wheat disease specialist at scientific meetings and via conference calls to help state specialists learn to use the prediction tools more effectively.

3) significant results
   - Disease prediction models were delivered to stakeholders in 30 states via web-based tools
   - FHB Alerts distributed timely information regarding disease risk and management recommendations in key areas affected by FHB.

4) key outcomes or other achievements

Users of the FHB prediction models and the FHB Alert System were surveyed annually in 2010-2014, and then again in 2017. The survey results included input from over 1,600 respondents and indicated that 70% of these users were either farmers or farm advisors. Here are some key outcomes of the project reported to date:

- More than 85% of the users applied the information directly on their farm or used it to make recommendations about disease management to others.
- Between 2010-2017, greater than 95% of the users considered the information to be of high or moderate value for their farm operations and businesses.
- A subset of questions targeting the influence of the information suggests 91% of the users experienced moderate or great improvement in their awareness of the disease risk in their area.
- The results also showed that the information influenced the perception of disease risk for 47% of the respondents and motivated another 41% to seek advice from others.
- The 2017 survey asked growers to estimate the monetary value of the information provided to their farm or business. This survey indicates that the median monetary value of the information provided by the prediction system was $9,500 per user. Combining this figure with use statistics suggests that annual impact of the FHB prediction model exceeds $30 million. This is value is likely influenced by the decreasing value of grain in recent years.

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

The wheat scab prediction tools were the topics of a session at the International Fusarium Workshop held in Manhattan Kansas in June of 2017. This workshop had nearly 60 participants from around the world and shared some the key features and discussed ways to implement this approach on other crops.

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

Disease prediction models were delivered to thousands of stakeholders in 30 states via web-based tools including. This effort included support for state commentary feature that enables local disease experts to post the assessment of disease risk and recommendations for control. This commentary is also sent to stakeholders via the FHB Alert system**.**

Project 3: *Functional Analysis for Getting Better Weather-based Predictors of Fusarium Head Blight.*

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

The specific objectives for this project include: (1) Coordinate the collection of new observations from the IM-CP used in developing and testing future models; (2) Conduct quality checks on the new observations before including them in the expanded dataset; (3) 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; (4) Evaluate the potential value of prediction models as part of the integrated management program for FHB and DON using Bayesian decision theory.

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

1) major activities

Coordinated the collection of new observations from 2016- 017 growing seasons and preliminary data from 2018 with cooperators from Ohio State University and members of the IM-CP.

2) specific objectives

- The current FHB data set contains 629 non-epidemic and 236 epidemic cases. All resistance classes are represented: Very Susceptible (126), Susceptible (378), Moderately Susceptible (166), and Moderately Resistant (195). We have also updated the weather time series associated with each of the 865 observations. This new weather data matrix covers a much longer pre-anthesis period (for winter wheat, all the way back to the September of the prior year) than the weather used in previous efforts.
- Completed functional data analysis of the new data sets and began translating these results in to a new generation predictive models for FHB in the US. This includes the incorporation of novel weather-based predictors identified as potentially FHB modeling groups in Europe, and South America.

3) significant results

The analysis continues to support the role of relative humidity and other similar measures of moisture in the development of FHB epidemics. However, the expanded data set and functional approach also gave us important insights on novel representations of environment and time periods that may also be important if we are to improve the accuracy of the predictions. These new predictors include representations of temperature, rainfall, and barometric pressure.

The expanded data sets and functional data analysis has identified that it may be possible to identify FHB epidemics 3-4 weeks prior to the crop growth stages critical disease management. This is significantly earlier that the current prediction models that make predictions just days prior to the critical growth stages. We are now in the process of developing and testing models based on these extended time periods. We are also looking at ways to combine multiple predictive models to further improve accuracy and stability of the predictions.

4) key outcomes or other achievements

These results will serve as the foundation for improved disease prediction models that could provide more timely estimates of disease risk for stakeholders. This information will enable growers to better determine when and if fungicide applications are needed to suppress the risk of FHB and DON.

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

None to report

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

Presentations and posters and scientific meetings and stakeholders. Publication on the functional analysis in Phytopathology that is now “in press”. The predictive models currently in use by Fusarium Prediction Center deliver forecasting models where developed as part of this project. These web-based tools provide daily estimate of disease risk to thousands of small grain producers and influence the production of wheat on more than 3 million acres of wheat and barley.

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?** Yes.

   If yes, how many?
   One M.S. Student

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?**

   If yes, how many?
   One Ph.D. Student

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?** No

   If yes, how many?

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?

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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.*

Nothing to Report

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 (6/7/17 - 6/6/18). 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.

Shah, D.A., De Wolf, E.D., Paul, P.A. and Madden, L. V. 2018. Functional data analysis of weather variables linked to Fusarium head blight epidemics in the United States. Phytopathology: In Press and First Look: https://doi.org/10.1094/PHYTO-11-17-0386-R.
Status: Journal Publication
Acknowledgement of Federal Support: Yes

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

Other publications, conference papers and presentations.

DeWolf, E.D., Davis, M.A., Bockus, W.W., Fritz, A.K., Zhang, G and Baenzinger, P.S. 2017. Reaction of Kansas, Nebraska winter wheat accession to Fusarium head blight (FHB), 2016. *Plant Disease Management Reports* 11:CF037.
Status: Technical Report
Acknowledgement of Federal Support: Yes

DeWolf, E.D., Davis, M.A., Bockus, W.W., Zhang, G., Fritz, A.K., Baenzinger, P.S., Marais, G. and Sehgal, S.K. 2017. Reaction of North Dakota, South Dakota and Montana winter wheat accession to Fusarium head blight (FHB), 2016. *Plant Disease Management Reports* 11:CF038.
Status: Technical Report
Acknowledgement of Federal Support: Yes

Lingenfelser, J., De Wolf, E., Fritz, A., Knapp, M., Lollato, R., Miller, R., Watson, S., Whitworth, J., Adee, E., Cramer, G., Esser, A., Kimball, J., Larson, M., Haag, L., Mengarelli, L., Schlegel, A., Seaman, Zhang, G., C., Chen, M., Chen, R., Knapp, L., King, A. and Knopf, J. 2017. Wheat Performance Tests with Winter Wheat Varieties: Report of Progress. Kansas Agricultural Experiment Station; No. 1135.
Status: Technical Report
Acknowledgement of Federal Support: No

De Wolf, E.D., Shah, D., Paul, P.A., Madden, L.V. 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. Wiemer 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: Meeting Presentation
Acknowledgement of Federal Support: Yes (abstract), Yes (poster)