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:	59-0206-6-015
USDA-ARS Agreement Title:	Prediction Models and Improved Pre-Harvest Estimates of Deoxynivalenol.
FY18 USDA-ARS Award Amount:	$ 110,797
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:	6/7/18 - 6/6/19
Reporting Period End Date:	06/06/19

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
HWW-CP	Development of Scab Resistant Wheat Cultivars for Kansas.	$ 48,350
MGMT	Continued Deployment of Prediction Models for Fusarium Head Blight.	$ 12,373
MGMT	Improving the Accuracy of Fusarium Head Blight Predictive Models within Changing Production Environments.	$ 35,134
MGMT	Integrated Management of Fusarium Head Blight in Kansas.	$ 14,940
	FY18 Total ARS Award Amount	$ 110,797

Erick D. DeWolf 7/10/19

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?

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, and Montana) 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

Until involvement in the USDA Scab Initiative, there was little effort to identify sources of scab resistance in Kansas breeding programs. The Initiative has resulted in the development of accurate and efficient field testing nurseries that are providing useful ratings for current cultivars in Kansas and advanced breeding lines. This screening effort now includes entries from winter wheat breeding programs throughout the Great Plains region. The long-term goal of the research is to develop, deploy, and advertise winter wheat cultivars adapted for Kansas with improved levels of resistance to scab.

2) specific objectives

The FHB phenotyping nurseries allow dissemination of information to growers on the reaction of current commercial cultivars, selection by breeders for scab resistance in their breeding lines, and identification of additional sources of resistance from other breeding efforts in the region that can be incorporated into Kansas breeding lines. Kansas has also taken the lead in organizing a Hard Winter Wheat Scab Screening Nursery for the hard winter wheat breeding programs of Kansas, Nebraska, South Dakota, and North Dakota. This latter nursery provides valuable data on the reaction of hard winter wheat cultivars to scab in their area of adaptation.

3) significant results

In 2009, Kansas State University released the first hard red winter wheat cultivar adapted to Kansas selected for improved levels of resistance to scab. This variety "Everest" is still a top variety in KS representing more than 60% of the acres planted in regions of the state most prone to FHB. KSU released a new variety, Zenda, with moderate levels of resistance to FHB in 2016, several private breeding programs have also released varieties with improved resistance to FHB including Bob Dole, WB4268, and SY Benefit. The screening nurseries supported by the USWBSI were essential in the development of these varieties.

4) key outcomes or other achievements

Because of the scab testing efforts, wheat farmers in Kansas have access to quality information about wheat varieties reaction to FHB. This information is released in the popular KSU extension publications "*Wheat Variety Disease and Insect Ratings, 2019"*

and "*Kansas Performance Tests with Winter Wheat Varieties*". Both publications are available as "hard copy" or online.

Wheat varieties like Everest are among the most popular varieties in Kansas representing more than 60% of the acres planted in areas of the state most prone to FHB. The adoption of this cultivar has significantly lowered the susceptibility of the state's wheat crop to scab; 22% lower statewide and 40% lower in the eastern part of the state where scab is prevalent. The release of 4 new varieties with moderate or intermediate levels of resistance by KSU and private breeding programs means that wheat growers in Kansas have more tools than ever before to manage this troublesome disease.

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

The FHB screening nursery provides training opportunities for graduate students within the Applied Wheat Pathology Lab to gain hands-on experience in the operation and rating of these multi-disciplinary projects. Students are involved in every aspect of the project from planting, harvest and processing the diseased grain.

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, Montana, and North Dakota. Similar reports are sent to the breeding efforts in participating private companies.

Information about current wheat varieties is released via KSU extension publications "*Wheat Variety Disease and Insect Ratings, 2019"* and "*Kansas Performance Tests with Winter Wheat Varieties*". Both publications are available as "hard copy" or online.

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

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

Our specific objectives for this grant period were: 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. Refine and maintain a version of the FHB Prediction Center for use with mobile devices (cellular-based mobile/"smart" phones and tablets). 3. Redesign the expert tools used to test experimental models before public deployment. 4. Modification of the web-based tools to improve functionality and compatibility of the Prediction Center. 5. Implement a user survey to document value of the prediction system and its impact for stakeholders.

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

1) major activities
   a. Disease prediction models were delivered to 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 with text saved to the USWBSI blog site.
   b. Continued support and development "behind the scenes" data bases and weather resources that enhance the stability of the web-based tools and reliability of the forecasts.
   c. Redesign of the expert tools that allow us to test new models
   d. Upgrade of the web-based user interface for the Prediction Center. This includes upgrades in web browser compatibility and access via mobile devices.
   e. Conducted user survey for the 2018 growing season.

2) specific objectives
   a. Testing of the FHB prediction models for state in the Pacific Northwest region including ID, and MT where the disease has emerged as a problem in recent years. Most technical issues were addressed for expanding the system to consider these areas and plans are in place now to work with colleagues in these states to evaluate the model predictions.
   b. Much of the foundation of the new user interface was completed in this grant period. We are now working through the last rounds of testing and expect deployment of the new tools in 2020. This upgrade will address browser and mobile device compatibility.
   c. Update the overall survey of users to provide impact information for the USWBSI.
   d. Developed case studies on new predictive models as training modules for disease experts in the US. These were presented to wheat disease specialists NCERA-184 meeting (March 2019), which reaches most key scientists in most FHB prone regions of the US.

3) significant results
   a. Disease prediction models were delivered to stakeholders in 30 states via web-based tools for the 2018 season and the 2019 season is currently in progress.
   b. FHB Alerts distributed timely information regarding disease risk and management recommendations in key areas affected by FHB.

4) key outcomes or other achievements
   a. The forecasting models supported by the USWBSI had more than 3,200 users in 2018. The FHB Alert System, which sends timely notification of disease risk to farmers and farm advisors, had over 1,100 users.

   b. More than 95% of the users of the forecasting models and FHB Alert System considered the information to be of high or moderate value to their farm or business.

   c. Users of the FHB forecasting models and FHB Alert System reported that the median value of this information was $11,890.

   d. User surveys between 2012-2018 indicate that the value of the disease forecasting models and the FHB Alert System is $58 million annually.

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

Disease specialists in the US received training on the FHB forecasting models and progress development of new models. NCERA-184 meeting (March 2019).

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 ((3,200 users). 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 and archived on the USWBSI blog site.

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Project 3: *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 are to (i) identify periods within weather time series that are significantly different between FHB epidemics and non-epidemics, (ii) create variables summarizing those identified periods, (iii) use the summary variables in new logistic regression models for predicting FHB epidemics, (iv) compare the predictive performances of new models with the performances of the currently deployed models, and (v) 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

a. Completed the Functional Data Analysis examining weather time series that are important for predicting epidemics of FHB.
b. Developed new variables representing weather patterns that favor disease development and the outbreaks of disease.
c. Developed new logistic regression models based on the new variables and time periods recommended by the functional data analysis. Compared the predictive capabilities of these new models with the best available models currently available.
d. Testing new models during the 2019 growing season.

2) specific objectives

Improved the prediction accuracy of forecasting models over currently deployed models for FHB with models developed and tested with over 900 location years of information collected by the integrated management CP.

3) significant results

We identified weather patterns that begin to 3 to 4 weeks prior to the growth stages when fungicides may be needed to suppress the development of FHB epidemics. This is significantly earlier than the current prediction models that make predictions just days prior to the critical growth stages. We have integrated these new variables into predictive models and are testing models with observations from the 2019 growing season.

4) key outcomes or other achievements

These results are 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. They also help growers avoid unnecessary fungicide

applications, reduce the cost of crop production and help preserve the environments in rural communities.

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

Disease specialists in the US received training on the FHB forecasting models and progress development of new models. NCERA-184 meeting (March 2019).

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

Presentations and posters and scientific meetings and stakeholders. Prediction models currently in use by Fusarium Prediction Center deliver forecasting models to thousands of wheat and barley producers in the US.

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Project 4: *Integrated Management of Fusarium Head Blight in Kansas.*

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

This project established integrated management studies for Fusarium head blight (FHB) in Kansas. The objectives for this project include: 1) Demonstration of Integrated Management for FHB in Kansas environments and locally adapted varieties; 2) Contribution of Kansas observations to overall integrated management and disease forecasting projects in the US.

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

1) major activities

Field trials were conducted at two locations in Kansas with a history of problems with FHB. At each location, the experiments included three varieties planted in a replicated complete block design with a split-plot arrangement. Wheat variety was the whole plot and 6 combinations of fungicide and inoculum as the sub-plots. Treatments include control plots and the fungicides Prosaro®, Marivs Ace® applied at rates recommended and timings recommended by the MGMT-CP. The trial were replicated at least 4 times at each location and weather data collected on site. The plots were rated for disease incidence and severity during the soft dough stage of development. Grain was harvested to calculate yield and test weight. Sub samples of the grain were collected to assess the percentage of Fusarium damaged kernels and DON.

2) specific objectives

Verify the integrated management approach with wheat varieties locally adapted for growing conditions in Kansas.

3) significant results

Dry conditions and hot temperatures limited the development of FHB in 2018 at both locations. Yield, FDK and DON all supported observations of low disease and minor differences among varieties. In contrast, the 2019 growing season was characterized by above normal levels of rainfall and cool temperatures. Incidence of FHB on susceptible varieties in the trials were generally >30%. Plots were harvested and plans are in place to complete observations of FDK and DON as directed by the protocols.

4) key outcomes or other achievements

Collection of observation of integrated management for FHB in contrasting years provide helpful data for local programing in Kansas and contribute valuable data to the national level projects on management and disease forecasting.

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

Mentoring graduate student on application of FHB treatments, inoculation methods and rating for disease (1 Master's student).

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

Kansas specific observations facilitate local programs addressing FHB management for wheat growers in Kansas. Plans are in place to expand programing efforts on FHB in 2020 using the data collected over the last two years.

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?**
   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 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**
Vendada	HWW	MS	6	2018

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 (6/7/18 - 6/6/19). 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.

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

Books or other non-periodical, one-time publications.
Nothing to Report

Other publications, conference papers and presentations.

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. 2018. Wheat Performance Tests with Winter Wheat Varieties: Report of Progress. Kansas Agricultural Experiment Station; No.1143.
Status: Extension Publication, published
Acknowledgement of Federal Support: NO

De Wolf, E.D., Lollato, R. and Whitworth, J. R. 2018. Wheat variety disease and insect ratings, 2018. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. Pub. No. MF991.

Status: Extension Publication, published

Acknowledgement of Federal Support: NO