USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY09 Preliminary Final Performance Report
No Cost Extension for FY10
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Cover Page

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Fiscal Year:	2009
USDA-ARS Agreement ID:	59-0206-9-071
USDA-ARS Agreement Title:	A First-Generation Model for DON Prediction and Integrated Management of FHB and DON.
FY09- USDA-ARS Award Amount:	$ 51,761

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Adjusted Award Amount
MGMT	A First-Generation Model for DON Prediction in Multiple Wheat Classes in the US.	$ 32,249
MGMT	Integrated Control and Harvesting Tactics to Minimize FHB/DON Losses in SRWW.	$ 19,512
	Total Award Amount	**$ 51,761**

Principal Investigator   Date

* MGMT – FHB Management
FSTU – Food Safety, Toxicology, & Utilization of Mycotoxin-contaminated Grain
GDER – Gene Discovery & Engineering Resistance
PBG – Pathogen Biology & Genetics
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 Winter Wheat Region
SWW – Southern Sinter Wheat Region

Project 1: *A First-Generation Model for DON Prediction in Multiple Wheat Classes in the US.*

1. **What major problem or issue is being resolved relevant to Fusarium head blight (scab) and how are you resolving it?**

Proper timing of fungicide application is critical for successful reduction of losses due to FHB and DON. Fungicides need to be applied at the right time (at anthesis) in order to be effective and when warranted (when the risks of FHB and DON are high) in order to be economical. However, this application decision has to be made well before visual symptoms of scab are observed and actual levels of DON are known. FHB risk assessment models were developed to help guide management and grain marketing decisions. The accuracy of current disease prediction models ranges from 75 to 80%. This system is now being expanded to predict the risk of DON exceeding critical thresholds. Users of the current FHB models often attempt to assess the risk of DON and make marketing decisions based on FHB predictions. However, indirect prediction of DON based on FHB is not very reliable. There is clearly a need to develop and integrate DON prediction models into the risk assessment tool.

Collaborating with researches from Kansas State University (and other institutions in previous years), data were collected from USWBSI-funded FHB variety development, uniform fungicide, and integrated management trials to refine existing FHB/DON models and to develop new models. Since, these trials were not specifically designed to generate data for the purpose of developing FHB/DON risk assessment models, extensive editing and sorting of data were required to determine their usefulness for predictive modeling, and direct communication with individual PIs was needed to gather information, such as variety resistance, flowering dates, whether or not fungicide were applied and plots were inoculated. Template MS Excel spreadsheets were develop and sent out to PI requesting a standard set of cropping, disease, DON, and weather information. Pivot table were then used to sort and organize data. Codes were then assigned for variety resistance and wheat class, and working with the De Wolf lab at KSU, predictor and response variables were generated using specialized macros and statistical software.

2. **List the most important accomplishment and its impact (i.e. how is it being used) to minimize the threat of Fusarium head blight or to reduce mycotoxins. Complete both sections (repeat sections for each major accomplishment):**

<u>**Accomplishment:**</u>

Dr. Katelyn Willyerd jointed the cereal disease epidemiology program at OSU and has made a very significant contribution to the mining of data for FHB/DON model development. A total of 2,254 unique cases were collected, of which 1,700 were rendered unsuitable for modeling. A special attempt was made to target states that had high levels of FHB in 2009. FHB and DON levels ranged from 0 to 48.6% and 0 to 48.8 ppm, respectively. These data are being used to refine existing and develop new FHB/DON risk assessment models using novel statistical approaches such as Boosted Regression. Experimental, web-based versions of DON models, with preliminary accuracy ranging from 75 to 83%, are currently being evaluated by researchers at Ohio State and Kansas State, and plans are in place to gather results from more recent FHB epidemics to further evaluate these models before making them available to the general public.

Impact:

Current web-based FHB models are available for use in 24 U.S. states to help guide fungicide use decisions. The DON modeling effort will continue using data from naturally occurring FHB epidemics in 2009 and 2010 to validate and refine the models. Ultimately, these models will be combined with current FHB models to provide a more complete assessment of the risk associated with FHB, improving the scope of this important marketing and management decision-making tool.

Project 2: *Integrated Control and Harvesting Tactics to Minimize FHB/DON Losses in SRWW.*

1. What major problem or issue is being resolved relevant to Fusarium head blight (scab) and how are you resolving it?

The efficacy, consistency, and economics of integrating fungicide application, cultivar resistance, and cultural practices to minimize losses due to FHB and DON vary among years and locations. More research is needed to determine the conditions under which a given combination of FHB/DON management approaches will be effective and economical. To address this issue, three years of coordinated integrated management trials were conducted between 2007 and 2009 in all major U.S. wheat growing regions commonly affected by FHB. All trials were conducted under natural field conditions, relying on natural infection to promote disease development. For most of the data collected from these trials, the levels of FHB and DON were low, making in difficult, if not impossible, to compare treatment combinations and evaluate the economic value of using the different approaches. Inoculated integrated management trials are needed to facilitate such comparisons and evaluations.

Two integrated management trials, one naturally infected and the other artificially inoculated, were conducted in Wooster, Ohio, in 2009. In the first, the design was a split-plot with 5 replicate blocks. Eight commercial soft red winter wheat (SRWW) cultivars with different levels of FHB resistance were planted as whole plots, and each whole plot was divided into three sub-plots; one treated with Prosaro (6.5 fl oz/A + 0.125% Induce), one treated with a biocontrol agent (*Cryptococcus flavescens* strain OH 182.9), and the other left untreated. A similar design was used in the second trial, in which three plots each of six SRWW cultivars with different levels of resistance to FHB were planted in four replicate blocks. One plot of each cultivar was treated with Prosaro (6.5 fl.oz/A), a second with Folicur (4 fl. oz./A) and a third was left untreated. All applications were done at Feekes 10.5.1. Prior to each fungicide application, plots were spray-inoculated with a 1:1 mixture of ascospores and macroconidia (25,000 spores/ml). In both trials, FHB intensity was visually estimated at soft dough, percent Fusarium damaged kernels (FDK) rated, and DON quantified in each sub-plot.

A third trial was conducted, using a similar experimental design, to investigate the effects of combine harvester configuration (whole plot) on percent FDK and DON, from plots with different levels of FHB (sub-plot). Plots (5-ft x 20-ft) of moderately susceptible SRWW cultivar Hopewell were established in a conventionally tilled field, with three replicate blocks. Sub-plots were spray-inoculated at anthesis with different inoculum densities (0, 1.5, 3, 4.5 and 6 x10^4 spores per mL). At soft dough (Feekes 11.2), FHB intensity was rated in each subplot. Plots were harvested using an ALMACO SPC20 plot combine harvester. Prior to harvest, the combine was calibrated on non-inoculated, disease-free plots of Hopewell. Threshing, separation and cleaning devices, along with fan speed (airflow speed and volume) were regulated to minimize excessive removal of healthy kernels. The combine settings were then adjusted relative to the default as follows: the initial default setting, **C1** = Fan speed of 1375 rpm with Shutter opening set at 2 ¾ inches; **C2** = Fan speed of 1475 rpm and Shutter opening of 2 ¾ inches; **C3** = Fan speed of 1475 rpm with Shutter opening increased to 3 ½ inches; and finally, **C4** = Fan speed of 1375 rpm and Shutter opening of 3 ½ inches. Grain harvested from each plot was visually rated for FDK (%) and samples were sent for DON analysis.

2. List the most important accomplishment and its impact (i.e. how is it being used) to minimize the threat of Fusarium head blight or to reduce mycotoxins. Complete both sections (repeat sections for each major accomplishment):

Accomplishment:

In 2009, FHB intensity was low in Ohio. Even though it rained fairly consistently during the growing season, temperatures were cooler mid-to-late May (around anthesis). Consequently, FHB and DON levels were too low to evaluate and compare treatment combinations in the non-inoculated trial. However, moderate levels of FHB developed in the inoculated trial, allowing us to evaluate fungicide and cultivar effects. The effects of fungicide and cultivar on FHB and DON were statically significant. Mean FHB index and DON in the inoculated, untreated check ranged from 1.7 to 18% and 0.8 to 15 ppm, respectively. The corresponding ranges for plots treated with Folicur were 0.8 to 13% and 0.2 to 4 ppm, and for plots treated with Prosaro, 0.7 to 9% and 0.3 to 5 ppm. Relative to the untreated susceptible check, resistance alone (without fungicide) led to 55 to 88% reduction in FHB and 83 to 88% reduction in DON. Fungicide alone (applied to the most susceptible cultivar) led to 75 to 78% reduction in index and 87 to 89% reduction in DON. Combining the most effective fungicide (Prosaro) with the most resistant cultivar (Truman) reduced FHB and DON by 90%. Fungicide and cultivar resistance also affected grain yield and test weight, with the highest mean yields (91 bu/acre) and test weights (60 lb/bu) being obtained from plots of the moderately resistant cultivars (McCormick and Truman) treated with Prosaro.

In the third trial, mean FHB index increased with inoculum density, ranging from 7% in the check to 35% in plots inoculated with 6 x10^4 spores/ml. Averaged across all disease levels (inoculum densities), combine harvester configuration C3 yielded the lowest mean percent FDK and DON and the highest mean test weight (TW). The difference between C1, the default setting, and C3 was statistically significant for FDK and TW but not for DON. C3 consistently resulted in lower FDK and DON and higher TW than the other configurations; however, the differences were not statistically significant at all levels of FHB. C3 and C4 resulted in the highest percent (29 to 65%) reduction in FDK relative to C1 at all levels of disease. For DON, C3 resulted in the highest percent (14 to 46%) reduction relative to C1 at the three highest index levels.

Impact:

Inoculations can be used to evaluate treatment combinations in FHB integrated management trials. At the levels of disease and DON observed in 2009, either fungicide or resistance could have been used alone to successfully reduce FHB and DON and increase grain yield and test weight. These results will serve as the basis for establishing future inoculated integrated management trials. Findings from trials with different levels of disease will be use to better determine when it is most effective and economical to use a single strategy or a combination of strategies to manage FHB and DON. Results from trial 3 suggest that modifying combine configuration to discard scabby, lightweight kernels could improve grain quality by reducing the FDK and DON levels of harvested grain. However, for the configurations tested, the effects varied with disease levels. C3 proved to be the most consistent configuration across all tested levels of disease, and could be integrated with fungicide treatment and cultivar resistance to minimize losses due to FHB.

Include below a list of the publications, presentations, peer-reviewed articles, and non-peer reviewed articles written about your work that resulted from all of the projects included in the grant. Please reference each item using an accepted journal format. If you need more space, continue the list on the next page.

Publications:

***Peer-reviewed Articles**:*

1. Kriss, A. B., Paul. P. A., and Madden, L. V. 2010. Relationship between yearly fluctuations in Fusarium head blight intensity and environmental variables: A windowpane analysis. Phytopathology 100: 784-797.

2. Paul, P. A., Hershman, D. E., McMullen, M. A., and Madden, L. V. 2010. Effects of Triazole-based fungicides on wheat yields and test weights as influenced by Fusarium head blight intensity. Phytopathology 100:160-171.

3. Sneller. C. H., Paul. P. A., and Guttieri, M. 2010. Prevalence of resistance to Fusarium head blight in Eastern US soft red winter wheat. Crop Sci. 50:123-133.

4. Madden, L. V., and Paul, P. A. 2009. Assessing heterogeneity in the relationship between wheat yield and Fusarium head blight intensity using random-coefficient mixed models. Phytopathology 99:850-860.

Proceedings:

1. Paul, P. A., Madden, L. V., and Willyerd, K. 2009. Integrated management of FHB and DON: a 2009 update. In: Canty, S. M., A. Clark, J. Mundell, E. Walton, D. Ellis, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2009 Dec 7-9; Orlando, FL. Lexington, KY: University of Kentucky. pp. 71-72.

2. Willyerd, K., Madden, L., Bergstrom, G., Bradley, C., Grybauskas, A., Hershman, D., McMullen, M., Ruden, K., Sweets, L., Wegulo, S., Wise, K., and Paul, P. 2009. Integrated management of FHB and DON in small grains: 2009 coordinated trials. In: Canty, S. M., A. Clark, J. Mundell, E. Walton, D. Ellis, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2009 Dec 7-9; Orlando, FL. Lexington, KY: University of Kentucky. pp. 95-99.

3. Salgado, J. D., Wallhead, M. W., Madden, L. V. and Paul, P. A. 2009. Effect of varying combine harvester configurations on Fusarium damaged kernels (FDK) and deoxynivalenol accumulation in wheat grain harvested from plots with different levels of Fusarium head blight. In: Canty, S. M., A. Clark, J. Mundell, E. Walton, D. Ellis, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2009 Dec 7-9; Orlando, FL. Lexington, KY: University of Kentucky. pp. 75-79.

4. Kriss, A. B., Madden, L. V., and Paul, P. A. 2009. Multi-state assessment using window pane analysis confirming weather variables related to Fusarium head blight epidemics. In: Canty,

S. M., A. Clark, J. Mundell, E. Walton, D. Ellis, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2009 Dec 7-9; Orlando, FL. Lexington, KY: University of Kentucky. pp. 60.

5. Schisler, D. A., Boehm, M. J., Paul, P., and Dunlap, C. A. 2009. Colonization of wheat heads by Fusarium head blight antagonist *Cryptococcus flavescens* OH 182.9 when applied alone or in combination with prothioconazole and the treatment effect on FHB disease development in field grown wheat. In: Canty, S. M., A. Clark, J. Mundell, E. Walton, D. Ellis, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2009 Dec 7-9; Orlando, FL. Lexington, KY: University of Kentucky. pp. 80-84.

6. De Wolf, E., Knight, P., Miller, D., Paul, P., and Madden, L., 2009. Evaluating the use and potential impact of Fusarium head blight prediction models in the U.S., 2009. In: Canty, S. M., A. Clark, J. Mundell, E. Walton, D. Ellis, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2009 Dec 7-9; Orlando, FL. Lexington, KY: University of Kentucky. pp. 40.

7. Sneller, C, Paul, P., Guttieri, M., Herald, L., and Sugerman, B. 2009. Report on the 2008-09 Northern Uniform Winter Wheat Scab Nurseries (NUWWSN and PNUWWSN). In: Canty, S. M., A. Clark, J. Mundell, E. Walton, D. Ellis, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2009 Dec 7-9; Orlando, FL. Lexington, KY: University of Kentucky. pp. 148-153.

Abstracts

1. Kriss, A. B., Madden, L. V., Paul, P. A. 2009. Multi-state assessment using window pane analysis confirming weather variables related to Fusarium head blight epidemics. Phytopathology 99:S67.

2. Kriss, A. B., Madden, L. V., Paul, P. A. 2009. More than 40 years of observations from Ohio confirm the importance of relative humidity and precipitation for Fusarium head blight epidemics. Phytopathology 99:S67.

3. Li., C., Paul, P. , Guttieri, M. , Madden, L., and Sneller, C. 2009. A PCR-based Approach to Characterizing Resistance Responses of Soft Red Winter Wheat Cultivars to *Fusarium graminearum* Infection. Phytopathology 99:S72.

4. Odenbach, K. J., Guttieri, M. J., Sneller, C. H., Madden, L. V., and Paul, P. A. 2009. Association between post-anthesis infection and deoxynivalenol accumulation in grain from spikes without visual symptoms of Fusarium head blight. Phytopathology 99:S96.

5. Nita, M., DeWolf, E., Paul, P., Madden, L., Stein, J., Ali, S., and Wegulo, S. 2009. Prediction of deoxynivanenol accumulation for Fusarium head blight of wheat using empirical and mechanistic modeling approaches. Phytopathology 99:S94.

6. Schisler, D. A., Boehm, M.J., and Paul, P. 2009. Variants of antagonist *Cryptococcus flavescens* OH 182.9 with improved efficacy in reducing Fusarium head blight in greenhouse and field environments. Phytopathology 99:S115.

Presentations

Larry Madden. *"Contemporary approaches to plant disease forecasting: A case study with Fusarium head blight of wheat."* Federal University of Vicosa, Brazil, Video linked Presentation 04/26/2010.

Larry Madden. *"The cost of decision making in plant pathology: case study with Fusarium head blight."* China Agricultural University, Beijing, China. March, 2010.

Larry Madden. *"The cost of decision making in plant pathology: case study with Fusarium head blight."* Qingdao Agricultural University, Chengyang, Qingdao, China. March, 2010.

Pierce Paul. "*Deoxynivalenol Accumulation in Healthy-looking Wheat Grain"* USDA ARS Soft Wheat Quality Laboratory – The 57th Research Review Conference. Wooster, OH. 03/10/2010.

Pierce Paul, Larry Madden, and Katelyn Willyerd. "*Integrated Management of FHB and DON: A 2009 Update."* - 2009 National Fusarium Head Blight Forum. Orlando, FL. 12/07/2009.

Pierce Paul. "*Evaluating Tends and Relationships in the Wheat-Fusarium graminearum-Deoxynevalenol System*" Iowa State University - Department Seminar Series. Ames, IA. 10/20/2009.

Pierce Paul. "*A Quantitative Synthesis of Trends and Relationships in the Wheat-Fusarium Head Bligh-Deoxynivalenol System"* Purdue University - Department Seminar Series. West Lafayette, IN. 09/30/2009.