USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY12 Final Performance Report
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Cover Page

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Fiscal Year:	FY12
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.
FY12 USDA-ARS Award Amount:	$ 63,586*

USWBSI Individual Project(s)

USWBSI Research Category**	**Project Title**	**ARS Award Amount**
MGMT	Managing FHB and DON with Fungicide, Resistance, and Grain Harvesting Strategies.	$ 29,367
MGMT	Development of Prediction Models for Fusarium Head Blight.	$ 13,513
MGMT	Influence of Variable Pre-anthesis Rainfall Patterns on FHB and DON in Wheat.	$ 20,706
	Total ARS Award Amount	**$ 63,586**

Principal Investigator   Date

* Award Amount does not include additional funding awarded in September of 2012 earmarked for other PIs at same institution

** 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 Soft Winter Wheat Region
  SWW – Southern Soft Red Winter Wheat Region

Project 1: *Managing FHB and DON with Fungicide, Resistance, and Grain Harvesting Strategies.*

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

The application a triazole fungicide such as Prosaro as part of an integrated management program that includes host resistance and cultural practices may provide up to 70% reduction of Fusarium head blight (FHB) and deoxynivalenol (DON) in wheat. However, under conditions of high relative humidity and frequent rainfall during anthesis (Feekes 10.5.1) and early grain, FHB infection and DON contamination of grain cannot be avoided. Moreover, when conditions are most favorable for FHB and fungicide applications are most warranted, producers often find it difficult to treatment fields at the recommended Feekes 10.5.1 growth stage due to the physical limitations of spraying in the rain and driving equipment in soggy fields. Thus, this research was conducted to address two major questions pertaining to the management of FHB/DON: 1 - efficacy of post-anthesis fungicide applications to provide producers with options for using fungicides when inclement weather prevents treatments from being made at anthesis and 2 - efficacy of using grain harvesting strategies to compliment fungicide application and genetic resistance as a way of minimizing losses due to FHB and increasing grain quality.

In 2012, two field experiments was conducted; one to evaluate the effect of Prosaro application after anthesis on FHB and DON and the other to determine the value of varying combine harvester configurations (as part of an integrated management strategy) in an effort to improve the quality of grain harvested from FHB-affected fields. For the first experiment, two SRWW cultivars (one moderately resistant and the other susceptible to FHB) were planted as whole plots in a randomized complete block design, with three replicate blocks. Four fungicide treatments (an untreated check, and Prosaro [6.5 fl oz/acre + NIS] applied at anthesis and 2, 4 and 6 days post-anthesis) were applied to different sub-plots of each cultivar, and all plots were spray inoculated with a spore suspension of *Fusarium graminearum* approximately 36 hours after the anthesis treatment. For the second experiment, plots of two moderately resistant and two susceptible cultivars were treated with Prosaro (6.5 fl oz/A + NIS) at anthesis and then 36 hours after spray-inoculated with a spore suspension of *F. graminearum*. In both experiments, non-inoculated, non-treated plots were used as checks, FHB intensity was rated at soft dough, and Fusarium damaged kernels (FDK), DON, grain yield, and test weight were quantified at harvest. Two different combine harvester configurations (C1, the default, and C2, modified to increase air flow through the combine) were used to harvest different subsets of the plots of each cultivar x fungicide treatment combination in the second experiment.

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>

Due to hot drought-like conditions in 2012, FHB and DON levels were low in both experiments (in spite of the inoculations). However, for Experiment 1, significant differences were still observed between fungicide-treated plots and the untreated checks. Both anthesis and post-anthesis treatments reduced FHB index and DON relative to the check, in both the resistant and the susceptible cultivars. Mean differences in index and DON between the treatment applied at anthesis and those applied at 2, 4 and 6 days after anthesis were not significant. However, in some cases, applications made at 2 or even 4 days after anthesis resulted in numerically lower levels of FHB and DON than those made at anthesis. For Experiment 2, mean FHB index and DON varied among cultivars and fungicide and inoculation treatments, with inoculated, untreated plots of susceptible cultivars having the highest levels of disease and toxin. Among inoculated plots, the lowest mean levels of disease and toxin and the highest mean test weights and yields were observed when fungicide treatment and cultivar resistance were integrated. Modifying the combine harvester configuration to blow out diseased, lightweight kernels resulted in lower FDK and DON and higher test weight than the default configuration, but this effect was only statistically significant for test weight. For both experiments, the 2012 results were comparable to those observed in 2011.

Impact:

Practical limitations such as frequent rainfall have prevented widespread adoption of FHB management recommendations. This project addressed a few of those limitations, with two years of results that could serve as the basis for improving management recommendations. In terms of fungicide timing, producers should continue to target anthesis as the ideal time for fungicide application for FHB/DON control; however, our results showed that foliar fungicides may still provide effective FHB and DON control when applications are made up 6 days after anthesis. In fact, if it rains or conditions are cold during anthesis, post-anthesis applications may even be more effective than applications made at anthesis. Our results also showed that changing combine harvester configuration in order to remove diseased, lightweight kernels is an excellent approach for improving grain quality, even after integrated management strategies are implemented in the field. These are invaluable research-based data that will help to minimize losses due to FHB and DON.

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

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

   Both the application of a fungicide to manage FHB and DON when conditions are unfavorable for infection and the failure to do so under favorable conditions may lead to economic losses for producers. These decisions have to be made at anthesis, well before symptoms of FHB develops. An FHB forecasting system was developed as a tool to help guide fungicide applications and is now available for use in 30 US States. However, further research is needed to increase the accuracy of this tool, which was initially developed without accounting for the effects of post-anthesis weather, crop residue, or winter wheat variety resistance as predictors of FHB. Accounting for these factors may contribute to increasing the overall accuracy of current models and potentially to the development of new, more accurate models. Data were collected from USWBSI-funded FHB integrated management trials in an effort to evaluate the influence of weather factors, cultivar resistance, and host-crop residue on the risk of FHB epidemics and to identify predictor variables for the development and refinement of forecasting models. Novel modeling approaches such as Boosted Regression Tree were used for model development.

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>
   Several new observations were collected from the 2011 and 2012 FHB integrated management coordinated projects and are now being edited for incorporated into the FHB forecasting dataset. These new observations will be used to validate several new models that were developed over the last two years.

   The FHB forecasting system was again successfully deployed in 2012 and available for use in 30 US States. Also in 2012, a more user-friendly interface was developed for the desktop/laptop version of the tool, as well as new versions for smart phones and other mobile devices.

   <u>Impact:</u>
   The FHB forecasting system is now an integral part of FHB management programs, and based on the number of hits and visits received in 2012, the utilization of this tool continues to increase. This will likely continue as the accuracy of the models increase and the tool becomes available on mobile devices. Coupled with the FHB Alert System, this tool has helped growers and crop consultants make more informed FHB management decisions, minimizing FHB-related losses and reducing unnecessary production costs (based on a user survey conducted in 2012).

Project 3: *Influence of Variable Pre-anthesis Rainfall Patterns on FHB and DON in Wheat.*

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

While it is very clear and well-known that frequent rainfall or consecutive days of high relative humidity during anthesis are associated with high levels of FHB and DON in wheat, circumstantial evidence suggests that infections may still occur and DON contamination may still exceed critical thresholds under conditions of infrequent pre-anthesis rainfall. Both the duration and amount of rainfall around anthesis are important predictors of FHB and DON. However, it is unclear how the distribution of moisture during this period affects these responses. A study of the effects of discontinuous rainfall during the days leading up to anthesis on spore dissemination within the wheat canopy, infection, FHB development, and DON accumulation could help to answer questions pertaining to commonly-observed disparities between visual symptoms of FHB and DON, a major knowledge gap in our understanding of the epidemiology of this disease. Moreover, information generated in this type of research could be used to improve the accuracy of FHB forecasting models.

In 2012 a field experiment was conducted in Wooster Ohio to evaluate the effects of variable pre-anthesis rainfall patterns of FHB, FDK, DON and relationships among these variables. The experimental design was randomized complete block, with a split-split-plot arrangement of irrigation regimen (simulated rainfall pattern), planting date, and in-field inoculum source. Beginning 7 days prior to anthesis, four rainfall regimens consisted were: **A**) rain every day; **B**) rain on days 1, 2, 6 and 7, no rain on days 3, 4 and 5; **C**) no rain on days 1, 2, 6, and 7, rain on days 3, 4 and 5; and **D**) rain every other day (days 1, 3, 5, and 7). A susceptible cultivar (Hopewell) was planted on three different dates (7-10 days apart) to increase the flowering window, and consequently, the possibility of some plots receiving each of the rainfall treatments at the designated time relative to anthesis. Grain spawn and naturally-infected corn stalks were used as in-field sources of inoculum. Twenty spikes were collected per plot at daily intervals between heading and anthesis and assayed to quantify inoculum density on the spikes under each rainfall regimen. FHB intensity was rated at soft dough, and Fusarium damaged kernels (FDK) and DON were quantified after harvest. In addition, grain samples from each plot were analyzed for fungal biomass (FBM) using quantitative real-time PCR.

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>
For all inoculum source x planting date combinations, mean FHB index, DON, and fungal biomass (FBM) were highest in the continuous rainfall treatment, and varied among the intermittent treatments. Comparable or lower IND:DON ratios were observed for several intermittent rainfall treatments compared to the continuous rainfall treatment. FBM and DON increased as FHB increased under continuous rainfall, but these relationships tended to breakdown with intermittent rainfall. The rates of increase in DON per unit increase in FHB

index and DON per unit increase in FBM varied among rainfall treatments. Scenarios of relatively low FHB and high DON, and low FBM and high DON were evident when rainfall was discontinuous.

Impact:

Factors affecting DON contamination above critical thresholds, particularly in the absence of visual FHB symptoms or when FHB levels are low, are still poorly understood. Our results showed that rainfall patterns during the week before anthesis may affect FHB, DON, fungal colonization of the grain, and relationships among these variables, with some intermittent rainfall patterns resulting in deceptively higher DON levels for a given level of colonization or visual symptoms. These findings could be used to develop or improve the accuracy of FHB and DON prediction models, important tools for the management of this disease-toxin complex.

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.

PUBLICATONS

Peer-reviewed Articles:

Willyerd, K.T., Li, C., Madden, L.V., Bradley, C.A., Bergstrom, G.C., Sweets, L.E., McMullen, M., Ransom, J.K., Grybauskas, A., Osborne, L., Wegulo, S.N., Hershman, D.E., Wise, K., Bockus, W.W., Groth, D., Dill-Macky, R., Milus, E., Esker, P.D., Waxman, K.D., Adee, E.A., Ebelhar, S.E., Young, B.G., **Paul, P.A.** 2012. Efficacy and stability of integrating fungicide and cultivar resistance to manage fusarium head blight and deoxynivalenol in wheat. Plant Dis. 96:957-967.

Abstracts

Salgado, J. D., Paul, P. A., Willyerd, K.T., and Madden, L. V. 2012. Integrating grain harvesting and pre-harvest management strategies to minimize losses due to Fusarium head blight and deoxynivalenol in wheat. Phytopathology 102:S4.105.

Andersen, K. F., Willyerd, K. T., Madden, L. V., and Paul, P. A. 2012. Influence of variable moisture patterns on the association between Fusarium head blight and deoxynivalenol contamination in wheat. Phytopathology 102:S4.5.

D'Angelo, D., Willyerd, K., Salgado, J. D., Madden, L. and Paul. P.A. 2012. Associations between the timing of fungicide application and percent control of Fusarium head blight and deoxynivalenol contamination in wheat. Phytopathology 102:S4.28.

Salgado, J., Paul, P. A., Willyerd, K., Madden, L. V. 2012. A cost-benefit assessment of integrated management strategies for Fusarium head blight and deoxynivalenol control in wheat. Phytopathology 102: S5.8.

Proceedings:

Salgado, J. D., Madden, L. V. and Paul, P. A. 2012. Characterization of differential spike colonization and deoxynivalenol accumulation in susceptible and resistant wheat cultivars. In: S. Canty, A. Clark, A. Anderson-Scully and D. Van Sanford (Eds.), *Proceedings of the 2012 National Fusarium Head Blight Forum* (pp. 25). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.

Andersen, K. F., Morris, L. A., Derksen, R. C., Madden, L. V. and Paul, P.A. 2012. Determining 'Rain Fast' time and residual life of Prosaro on wheat spikes. In: S. Canty, A. Clark, A. Anderson-Scully and D. Van Sanford (Eds.), *Proceedings of the 2012 National Fusarium Head Blight Forum* (pp. 4). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.

D'Angelo, D., Willyerd, K., Cabrera, A., Madden, L. and Paul. P.A. 2012. Evaluating the effect of fungicide chemistry and application timing on FHB, DON, and Fusarium graminearum biomass in soft red winter wheat. In: S. Canty, A. Clark, A. Anderson-Scully and D. Van Sanford (Eds.), *Proceedings of the 2012 National Fusarium Head Blight Forum* (pp. 16). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.

De Wolf, E., Shah, D., Paul, P., Willyerd, K. and Madden, L. Boosted regression trees identify pre- and post-wnthesis weather variables for predicting Fusarium head blight epidemics. In: S. Canty, A. Clark, A. Anderson-Scully and D. Van Sanford (Eds.), *Proceedings of the 2012 National Fusarium Head Blight Forum* (pp. 17). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.

Willyerd, K., Ames, K., Bergstrom, G., Bradley, C., Cummings, J., Gross, P., Madden, L., Ransom, J., Ruden, K., Salgado, J.D., Sweets, L., Wise, K., and Paul, P. 2012. Uniform FHB integrated management trials: a summary from 2012. In: S. Canty, A. Clark, A. Anderson-Scully and D. Van Sanford (Eds.), *Proceedings of the 2012 National Fusarium Head Blight Forum* (pp. 29). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.

PRESENTATIONS:

Unpublished Scholarly Presentations:

Paul, P. A., and Willyerd, K. T. 2012. Use of Regionally based Integrated Management Trials and the Role of Variety Selection in Combination with Foliar Fungicide Applications. Proceedings of the National Integrated Pest Management Symposium, 2012. March 27-29; Memphis, TN.

Extension Presentations:
Event: 2012 Ohio Foundation Seed Annual Meeting
Title: “*Wheat Pathology Update: Major Diseases and their Management with Fungicides*”
Location: Croton, OH
Date: 09/05/2012

Event: 2012 Paulding County Agronomy Day
Title: “*Wheat Head Scab Update*”
Location: Paulding, OH
Date: 01/27/2012

Event: 2012 Putnam County Agronomy Night
Title: “*Wheat Scab Fungicides-Research Trail Results From 2011*”
Location: Kalida, OH
Date: 01/26/2012

Event: 2012 Top Farmers of Ohio - Annual
Title: "*Corn and Wheat Disease Management Update: Emphasis on Fungicide Timing*"
Location: Columbus, OH
Date: 01/14/2012