USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY08 Final Performance Report (approx. May 08 – April 09)
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Cover Page

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Fiscal Year:	2008
USDA-ARS Agreement ID:	59-0790-4-112
USDA-ARS Agreement Title:	Splash Dispersal, Innoculum Level and Fungicide Effects on Fusarium Head Blight.
FY08 USDA-ARS Award Amount:	$ 55,866

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Adjusted Award Amount
MGMT	Efficacy and Economics of Integrated Control Strategies for FHB and DON in Wheat.	$31,001
MGMT	Incorporating Infection Cycle Components into FHB and DON Prediction Models.	$ 24,865
	Total Award Amount	**$ 55,866**

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
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

(Form FPR08)

Project 1: *Efficacy and Economics of Integrated Control Strategies for 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?

The efficacy, consistency, and economics of combining fungicide application, cultivar resistance, and cultural practices to minimize losses due to FHB and DON warrant further investigation under a range of disease pressures and environmental conditions. Previous attempts to address these issues were hampered by low levels of disease in most wheat-growing regions. It is clear from previous studies that no single management strategy will be fully effective against FHB and DON. The effects of fungicide, genetic resistance, and residue management (crop rotation or tillage) are highly variable and strongly influenced by the environment. Yield and quality gains from fungicide use are not always enough to offset application cost. Research is needed to evaluate the efficacy of using multiple management approaches to suppress FHB and DON over multiple years and location under both conditions of natural infection and artificial inoculation. Research is also needed to evaluate i) the performance of moderately resistant advance breeding line in integrated FHB management programs and ii) the influence of row spacing and planting density of FHB development.

Five integrated management experiments were conducted at three locations in Ohio. In the first experiment, conducted at Wooster, pairs of plots of six commercial soft red winter wheat cultivars with different levels of resistance to FHB were planted in a split-plot treatment layout in a randomized complete block design, and one plot of each cultivar was treated with a fungicide (3 fl oz/A Proline + 3 fl oz/A Folicur) at Feekes 10.5.1. A similar experimental design was used in experiments 2 and 3; however, the latter experiments were artificially inculcated. In experiment 2, four advanced breeding lines were planted along with a susceptible and a moderately resistant cultivars, plots were inoculated with *F. graminearum*-colonized corn kernels, mist-irrigated, and a fungicide (3 fl oz/A Proline + 3 fl oz/A Folicur) was applied at anthesis. Experiment 3 was conducted near Custar, OH, using the same six cultivars used in experiment 1; however, plots were spray-inoculated (25,000 spores/ml) at anthesis after the application of Prosaro (6.5 fl.oz/A) and Folicur (4 fl. oz./A) to separate sub-plots of each cultivar. Experiments 4 and 5 were conducted to evaluate the effects of planting density (18, 23, and 28 seeds per foot of row) and row spacing (7- and 15-inch rows) on FHB and DON. In experiment 4, the experimental design was a split-split plot with 3 replicate blocks. Row spacing served as the whole-plot, seeding rate as the sub-plot, and fungicide application (with and without a single application of Prosaro at 6.5 fl. oz/a + 0.125% Induce) as the sub-sub plot. In experiment 5, conducted near Bucyrus, OH, a split-plot design was used with four replicate blocks. Row spacing served as the whole-plot and seeding rate as the sub-plot. No fungicide was applied in the latter experiment. Incidence and severity ("index") of FHB were assessed in all experiments at Feekes GS 11.2 and a sample of harvested grain was tested for DON.

Data from other FHB integrated management experiments conducted across the US were combined with those from Ohio for analysis and synthesis.

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 2008, FHB intensity and DON contamination were low in Ohio. Even though it rained during the flowering period, the rain events did not occur on consecutive days and temperatures were cooler than usual from mid-to-late May. Consequently, FHB and DON levels were too low to evaluate and compare treatment combinations in non-inoculated experiments. However, moderate levels of FHB developed in the inoculated experiment conducted at Custar, allowing us to evaluate fungicide and cultivar effects on FHB, DON accumulation in both disease and disease-free spikes, and fungal colonization of disease-free spikes. Mean FHB incidence and index in the inoculated, untreated check ranged from 2.5 to 29.3% and 0.15 to 12.7%, respectively. The main effects of cultivar and fungicide on index were statistically significant; however, their interaction was not. Prosaro was significantly more effective than Folicur, leading to a 54% reduction in index relative to the check (average across all cultivars). The moderately resistant cultivars, Truman and McCormick had significantly lower mean index than the moderately susceptible and susceptible cultivars. For DON, the main and interaction effects of cultivar and fungicide were statistically significant, with the combination of Truman and Prosaro resulting in the lowest mean level of toxin contamination. For yield, only the main effect of cultivar was statistically significant. Fungicide and cultivar did not have a significant effect on the DON contamination or fungal biomass (based on RT-PCR analysis) of grain harvested from asymptomatic spikes.

The main effects of row spacing (7 and 15 inches between rows) and planting density (seeds per foot of row) on test weight and spike counts (number of spikes per foot of row) were not statistically significant. However, the effects of both factors on FHB index and the effect of row spacing on yield were significant. Yield was significantly higher in 7-inch rows than in 15-inch rows. Index was significantly higher at the wider row spacing (15 inch) and at the lowest seeding rate (18 seeds per foot of row) than at other planting density x row spacing treatment combinations. These results suggest that row spacing and planting density may be manipulated to alter the architecture of the crop canopy under conditions in Ohio (in some years) to minimize the impact of FHB.

Impact:

Data form these and other integrated management experiments are being used to develop a series of ***best management practices*** **(BMPs)** for FHB and DON that will be made available to wheat grower through the *SCABSMART* website which is being developed. Experiments conducted at multiple locations will allow for the evaluation of similar integrated strategies under a range of environmental conditions, potentially reducing the time needed for the establishment of the **BMPs**. However, efforts to develop the **BMPs** and to evaluate the economics of FHB/DON management strategies have been hindered by low FHB development in most non-inoculated experiments. The results from this project showed that spray-inoculation, without irrigation can be used to achieve infection, allowing for the separation of treatments and identification of the most effective treatment combinations. It may be possible to use this approach in other integrated management experiments to hasten the development of the **BMPs**.

Project 2: *Incorporating Infection Cycle Components into FHB and DON Prediction Models.*

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

FHB risk assessment models have become an integral part of integrated management strategies for FHB. With more effective fungicides available to suppress FHB, growers and crop consultants now refer to these models to make fungicide application decisions. A thorough understanding of relationships among weather, pathogen abundance, disease, and mycotoxin is critical for accurate FHB and DON risk assessment. The accuracy of current disease prediction models ranges from 75 to 80%. However, missing from these models is direct prediction of the risk of DON accumulation. The dataset available during initial model development did not permit direct DON prediction. Using current models, high risk of FHB is often used as an implicit indicator of high risk of DON accumulation. On average, high levels of FHB (based on visual symptoms) leads to high levels of DON contamination; however, low levels (or absence) of visible symptoms does not necessarily translate into proportionally low levels of DON-contaminated grain. Additional information is needed to develop models that specifically address these variations in DON and to estimate the risk of DON accumulation. In addition, modifications of existing models are needed to better address the influence of host resistance and inoculum density on FHB and DON in winter wheat.

Two field experiments were conducted in Wooster, OH. In experiment 1, three soft red winter wheat (SRWW) cultivars with different levels of resistance to FHB (Cooper, susceptible; Hopewell, moderately susceptible; and Truman, moderately resistant) were inoculated at four different growth stages with different inoculum densities. Inoculations were done at anthesis, one week post-anthesis, two weeks post-anthesis, and three weeks post-anthesis using spore densities of 0, 10,000, 20,000, and 30,000 spore/mL. The experimental design was a split-split plot, with cultivar as the whole-plot and inoculation timing and density as the sub and sub-sub plots, respectively. In experiment 2, six SRWW cultivars with varying levels of resistance to FHB infection were planted in 10-ft x 30-ft plots and spray-inoculated at anthesis with a concentration of 50,000 spores/mL. There were three replicate plots of each cultivar. In all experiments, FHB index was rated at soft dough, and prior to physiological maturity, spikes were tagged in different index categories in each plot and later individually harvested. Samples of both symptomatic and asymptomatic grain were analyzed for DON. In experiment 2, 30 clusters with 20 spikes each were tagged in each plot, rated for visual disease symptoms, and assayed for DON. Quantitative RT-PCR was used to quantify *F. graminearum* biomass by amplifying *Tri5* DNA from grain samples form a subset of the plots from both experiments

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 experiment 1, the effects of cultivar, infection timing, inoculum density, and their interactions on DON accumulation in diseased and disease-free spikes and FHB intensity were statistically significant. At all inoculum concentrations, DON and index were highest when inoculations were done at anthesis. Both disease intensity and toxin contamination increased with increasing spore concentrations. For both samples from the entire plot (including diseased and diseased-free spikes) and samples of asymptomatic spikes, the critical threshold for DON (2 ppm) was exceeded in Cooper and Hopewell inoculated at anthesis, but not in Truman. Among the cultivars, Hopewell consistently had the highest mean index and DON contamination. Hopewell was the only cultivar to accumulate DON in excess of 2 ppm in grain harvested from asymptomatic spike inoculated after anthesis. For post-anthesis infections, there was a significant positive correlation between fungal biomass and DON in grain from disease-free spikes ($r = 0.69$). The infection time with the strongest correlation was 1 wk post-anthesis, with $r = 0.86$. Among the cultivars, the strongest correlation between fungal biomass and DON was for Hopewell ($r = 0.62$), the cultivar that accumulated the higher levels of DON and contained the greatest amount of fungal biomass in late-infected, disease-free spikes.

In experiment 2, mean index and DON ranged from 0.91 to 31.58 % and 1.14 to 17.00 ppm, respectively, and index and DON variances among clusters within plots ranged from 1.43 to 140.40 and 0.51 to 39.05, respectively. There were significant linear relationships between log-transformed variances and log-transformed means for both IND and DON. This implies that, on a log-transformed scale, as mean IND and DON increased their respective variances also increased. There were significant linear relationships between FHB and DON, DON and fungal biomass, and FHB and fungal biomass for all cultivars, with significantly difference regression slopes among cultivars for the FHB/DON and FHB/biomass relationships. For a given level of FHB, Hopewell had significantly higher fungal biomass and accumulated significantly more DON than Cooper and Truman. The rates of DON and fungal biomass increase with increase in FHB were similar for Cooper and Truman, but significantly higher for Hopewell. However, the rate of DON increase with increase in fungal biomass was similar among the cultivars in all experiments.

Impact:

The results from these experiments are being used to refine existing FHB risk models and to develop new DON prediction models. Current web-based FHB models are available for used in 24 US states to help guide fungicide application decisions. Candidate DON prediction models, with accuracy ranging from 75 to 83%, were developed in 2008. The DON modeling effort will continue in 2009 and will benefit from our results on DON accumulation in disease-free grain and differential DON accumulation cultivars with different levels of resistance.

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

(1) Peer-reviewed

Paul, P. A., Lipps, P. E., Hershman, D. E., McMullen, M. P., Draper, M. A., and Madden, L. V. 2008. Efficacy of triazole-based fungicides for Fusarium head blight and deoxynivalenol control in wheat: A multivariate meta-analysis. Phytopathology 98:999-1011.

(2) Abstracts

Nita, M., De Wolf, E., Madden, L., Paul, P., Shaner, G., Adhikari, T., Ali, S., Stein, J., Osborn, L., and Wegulo, S. 2008. Use of mechanistic simulation models to predict disease intensity of Fusarium head blight and deoxynivalenol concentration. Phytopathology 98:S113.

(3) Proceedings and presentations

De Wolf, E., Nita, M., Paul, P., Madden, L., Stein, J., Ali, S., and Wegulo, S. 2008. Advances in the Epidemiology of Fusarium Head Blight and Applications in Prediction Models. In: Canty, S. M., E. Walton, A. Clark, D. Ellis, J. Mundell, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2008 Dec 2-4; Indianapolis, IN. Lexington, KY: University of Kentucky. pp. 18.

Guttieri, M., Jackwood, R., Paul, P., and Sneller, C. 2008. Resistance to Accumulation of Deoxynivalenol in Soft Red Winter Wheat. In: Canty, S. M., E. Walton, A. Clark, D. Ellis, J. Mundell, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2008 Dec 2-4; Indianapolis, IN. Lexington, KY: University of Kentucky. pp. 166.

Kriss, A, Madden, L. V., and Paul, P. A. More than 40 years of Observations from Ohio confirm the Importance of Relative Humidity and Precipitation for Fusarium Head Blight Epidemics. In: Canty, S. M., E. Walton, A. Clark, D. Ellis, J. Mundell, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2008 Dec 2-4; Indianapolis, IN. Lexington, KY: University of Kentucky. pp. 39.

Li., C., Madden, L. V. and Paul, P. A. 2008. Study of Fungicide Effect and its Combination with Wheat Cultivar Resistance on the Relationship between FHB and DON and the accumulation of DON in Asymptomatic Wheat Spikes. In: Canty, S. M., E. Walton, A. Clark, D. Ellis, J. Mundell, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2008 Dec 2-4; Indianapolis, IN. Lexington, KY: University of Kentucky. pp. 41.

Li., C., Madden, L. V., and Paul, P. A. 2008. Relationship between FHB and DON among SRWW Cultivars with Different Levels of Type II Resistance. In: Canty, S. M., E. Walton, A. Clark, D. Ellis, J. Mundell, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2008 Dec 2-4; Indianapolis, IN. Lexington, KY: University of Kentucky. pp. 40.

Nita, M., De Wolf, E., Paul, P., Madden, L., Stein, J., and Ali, S. 2008. Prediction Models for Deoxynivalenol Accumulation Risk using Empirical and Mechanistic Modeling Approaches. In: Canty, S. M., E. Walton, A. Clark, D. Ellis, J. Mundell, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2008 Dec 2-4; Indianapolis, IN. Lexington, KY: University of Kentucky. pp. 49.

Odenbach, K. J. Salgado, J. D., Madden, L. V. and Paul, P. A. 2008. Influence of Cultivar Resistance, Infection Timing, and Inoculum Density on FHB development and DON Accumulation in Asymptomatic Wheat Spikes. In: Canty, S. M., E. Walton, A. Clark, D. Ellis, J. Mundell, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2008 Dec 2-4; Indianapolis, IN. Lexington, KY: University of Kentucky. pp. 50.

Odenbach, K. J., Madden, L. V., and Paul, P. A. 2008. Influence of Within-plot FHB Variability on the Relationship between FHB and DON. In: Canty, S. M., E. Walton, A. Clark, D. Ellis, J. Mundell, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2008 Dec 2-4; Indianapolis, IN. Lexington, KY: University of Kentucky. pp. 51.

Paul, P. A., and Madden, L. V. 2008. Integrating Fungicide and Variety Resistance to Manage FHB/DON in Wheat in Different Cropping Systems. In: Canty, S. M., E. Walton, A. Clark, D. Ellis, J. Mundell, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2008 Dec 2-4; Indianapolis, IN. Lexington, KY: University of Kentucky. pp. 56.

Paul, P. A., Madden, L., McMullen, M., Hershman, D., Sweets, L., Wegulo, S., Halley, S., Osborne, L., Ruden, K., and Padgett, B. 2008. Integrated Management of FHB and DON in Small Grain: 2008 Uniform Trials. In: Canty, S. M., E. Walton, A. Clark, D. Ellis, J. Mundell, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2008 Dec 2-4; Indianapolis, IN. Lexington, KY: University of Kentucky. pp. 52-55.

Phillips, A., Sneller, C., Lewis, J., Paul, P., and Guttieri, M. 2008. The Effect of Key Chromosome Segments on FHB Resistance in a Cross of Soft-Winter by Hard-Spring Parents. In: Canty, S. M., E. Walton, A. Clark, D. Ellis, J. Mundell, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2008 Dec 2-4; Indianapolis, IN. Lexington, KY: University of Kentucky. pp. 193.

Salgado, J. D., Wallhead, M. W., Madden, L. V. and Paul, P. A. 2008. Comparing the Effects of Macroconidia and Ascospores of *Gibberella zeae* on Fusarium Head Blight Development in Wheat. In: Canty, S. M., E. Walton, A. Clark, D. Ellis, J. Mundell, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2008 Dec 2-4; Indianapolis, IN. Lexington, KY: University of Kentucky. pp. 59.

Schisler, D. A., Boehm, M. J., Paul, P., and Slininger, P. J. 2008. Evaluation of prototype commercial media for the production of Fusarium head blight antagonist *Cryptococcus flavescens* OH 182.9. In: Canty, S. M., E. Walton, A. Clark, D. Ellis, J. Mundell, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2008 Dec 2-4; Indianapolis, IN. Lexington, KY: University of Kentucky. pp. 60.

Sneller, C, Paul, P., and Guttieri, M. 2008. Ten years of uniform FHB testing of soft winter wheat from the northern US. In: Canty, S. M., E. Walton, A. Clark, D. Ellis, J. Mundell, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2008 Dec 2-4; Indianapolis, IN. Lexington, KY: University of Kentucky. pp. 208.

Sneller, C, Paul, P., L. Herald, Sugerman, B., and Johnton, A. 2008. Report on the 2007-08 Northern Uniform Winter Wheat Scab Nurseries (NUWWSN and PNUWWSN). In: Canty, S. M., E. Walton, A. Clark, D. Ellis, J. Mundell, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2008 Dec 2-4; Indianapolis, IN. Lexington, KY: University of Kentucky. pp. 203.

Souza, E., Sneller, C., Paul, P., Sweets, L., amd Guttieri, M. J. 2008. Wheat Quality Evaluation of Fusarium Head Blight Resistant Soft Red Wheats and the Effects of Fungicide management on Wheat Quality. In: Canty, S. M., E. Walton, A. Clark, D. Ellis, J. Mundell, and D. A. Van Sanford (Eds.), Proceedings of the National Fusarium Head Blight Forum; 2008 Dec 2-4; Indianapolis, IN. Lexington, KY: University of Kentucky. pp. 213.

(4) Editor-reviewed journal article

Paul, P. A., Mills, D., and Johnston, A. L. 2008. Effects of foliar fungicides on wheat powdery mildew, Stagonospora blotch and Fusarium head blight in Ohio, 2007. Plant Disease Management Report 2:CF027.

(5) Bulletin

Paul, P., Beuerlein, J., Loux, M., Lentz, E., Hammond, R., and Mullen, R. 2008. Improving Wheat Profits in Ohio. The Ohio State University/OSUE. Bulletin 938.

(6) Department series

Beuerlein, J., Minyo, R., Paul, P., and Sneller, C. 2008. Ohio Wheat Performance Trials, 2008. Horticulture and Crop Science Series 228.

(7) Extension newsletters (electronic)

Pierce Paul, and Dennis Mills - Another Low to Moderate Head Scab Year in Ohio. C.O.R.N 2008-20.

Pierce Paul and Dennis Mills – Low Wheat Head Scab Risk. C.O.R.N 2008-14.

Pierce Paul, and Dennis Mills - Wheat Scab Risk Prediction 2008. C.O.R.N 2008-12.

Pierce Paul, and Dennis Mills - More Fungicides Registered for The Suppression of Head Scab in Wheat. C.O.R.N 2008-12.

If your FY08 USDA-ARS Grant contained a VDHR-related project, include below a list all germplasm or cultivars released with full or partial support of the USWBSI. List the release notice or publication. Briefly describe the level of FHB resistance. If this is not applicable (i.e. no VDHR-related project) to your FY08 grant, please insert 'Not Applicable' below.

Not applicable.