USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY13 Final Performance Report
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Cover Page

PI:	Pierce Paul
Institution:	Ohio State University
Address:	Department of Plant Pathology 1680 Madison Ave. Wooster, OH 44691
E-mail:	paul.661@osu.edu
Phone:	330-263-3842
Fax:	330-263-3841
Fiscal Year:	FY13
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.
FY13 USDA-ARS Award Amount:	$ 64,185

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
MGMT	Managing FHB and DON with Fungicide, Resistance, and Grain Harvesting Strategies.	$ 29,338
MGMT	Influence of Variable Pre-anthesis Rainfall Patterns on FHB and DON in Wheat.	$ 21,271
MGMT	Development of Prediction Models for Fusarium Head Blight.	$ 13,576
	FY13 Total ARS Award Amount	**$ 64,185**

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 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?**

Issues addressed:

1. Under wet field conditions when fungicides are most needed for FHB and DON management, practical and physical limitations of spraying in the rain and driving equipment through soggy fields may make it impossible for fungicides to be applied at the recommended anthesis growth stage. These limitations have led to questions being asked about the benefit of pre- and post-anthesis fungicide applications for FHB and DON management.
2. When conditions are wet and humid during anthesis and early grain-fill, the best in-field FHB management approaches such as fungicide and cultivar resistance are often not sufficient to prevent grain yield and quality losses due to FHB and DON. Other mitigation strategies are needed in combination with resistance and fungicide treatment to better manage this disease and minimize losses.

Approaches for resolving these issues:

Two field experiments were conducted in 2013; one to evaluate the effect of post-anthesis application of Prosaro and Caramba on FHB and DON and the other to determine the value of modifying combine harvester configuration as part of an integrated management strategy to improve the quality of grain harvested from FHB-affected fields. For the first experiment, Prosaro and Caramba were applied at label-recommended rates (6.5 fl oz/A and 14 fl oz/A + NIS) at anthesis and at 2, 4 and 6 days after anthesis, and all plots were spray-inoculated with a spore suspension of *Fusarium graminearum*. For the second experiment, plots of four wheat cultivars with different levels of FHB resistance were treated with Prosaro at anthesis and then spray-inoculated with a spore suspension of *F. graminearum*. Two different combine harvester configurations (C1, the default, and C2, modified to increase air flow through the combine) were used to harvest plots of each cultivar x fungicide treatment combination.

2. **List the most important accomplishments and their impact (i.e. how are they 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>

Post-anthesis fungicide applications: Data from the 2013 experiment were combined with data from six additional experiments conducted in Ohio and Illinois and analyzed to quantify the efficacy post-anthesis fungicide application against FHB and DON. For both Caramba and Prosaro, post-anthesis fungicide applications provided comparable levels of FHB index and DON suppression to applications made at anthesis. Caramba tended to result in numerically lower FHB index and DON than Prosaro, particularly for some of the post-anthesis application timings, but the differences between the two fungicides were generally not statistically significant. Averaged across the seven experiments, applications made after 50% anthesis resulted in numerically higher percent control of FHB index than those made at anthesis. Relative to the untreated check, applications made two days after anthesis (A+2) resulted in 69% control of FHB index and 54% control of DON, whereas applications made four days after anthesis (A+4) reduced FHB index and DON by 62 and 52%, respectively; applications at six days after anthesis (A+6) reduced FHB index by 62% and DON by 48%; and applications made at anthesis reduced FHB index and DON by 56 and 50%, respectively. A+2 and A+6 applications significantly reduced FHB index by 30 and 14%, respectively, relative to the anthesis application. Post-anthesis applications did not reduce DON relative to anthesis applications.

Integrated effects of in-field and grain harvesting strategies: Increasing the air flow through the combine (modified configuration) contributed to improving grain quality mainly by increasing test weight. On average, management programs that included moderate resistance, fungicide treatment and grain harvested with the modified configuration resulted in higher overall percent FDK and DON reduction, and higher percent test weight increase relative to the reference management program (susceptible, untreated, and harvested with the default configuration). Integrating the three strategies resulted in 30 to 51% reduction in total estimated price discount, $51 to $126/acre increase in gross cash income, and economic benefit ranging from $12 to $110/acre, for FHB index ranging from 5 to 15%, grain prices from $3 to 7 per bushel, and fungicide application cost from $16 to 40 per acre.

Impact:

Post-anthesis fungicide applications: Results from these seven experiments (three years of data from two states) showed that both Caramba and Prosaro may still provide effective FHB and DON control when applied at label-recommended rates up to 6 days after anthesis. In fact, under some conditions (if it rains or conditions are cold during anthesis), post-anthesis applications may even be more effective than applications made at anthesis. Our results showed that under wheat-growing condition in Ohio and Illinois, if inclement weather prevents fungicide treatments for FHB management from being made at anthesis, producers have the option of making an application up to 6 days after anthesis without compromising efficacy against FHB and DON. These findings will likely result in changes in producers' approach to managing FHB with fungicides. Results were recently published in *Plant Disease* and will be made available to stakeholders by way of extension presentations and newsletters, and the USWBSI website.

Integrated effects of in-field and grain harvesting strategies: Our results showed that the integration of multiple approaches for managing FHB and DON is more effective and economically beneficial than a single approach. The greatest disease and DON reductions, test weight increases, reductions in price discounts and economic benefits were achieved when two or more management strategies were integrated. Management programs that included an application of Prosaro at anthesis and a moderately resistant cultivar resulted in the highest economic benefits. In the absence of moderate resistance, the use of the modified grain harvesting strategy in combination with a fungicide treatment proved to be very effective at reducing grain yield and quality losses. Our results provide producers with additional options for mitigating losses due to FHB. These findings were recently published in *Plant Disease* and will be made available to stakeholders by way of extension presentations and newsletters, and the USWBSI website.

Project 2: *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?**

***Issue being addressed*:**
Although it is well known that FHB development and DON accumulation are strongly influenced by rainfall and relative humidity, questions still remain regarding the role of these variables on DON accumulation in seemly healthy spikes or spikes with low levels of visual symptoms. It particular, the effect of discontinuous high moisture patterns on FHB and DON exceeding critical thresholds is still poorly understood.

Approaches for resolving these issues:
Expanding on work done in Ohio in 2011 and 2012, field experiments were conducted in 2013 to evaluate the effects of variable rainfall patterns on the probability of FHB index and DON exceeding critical thresholds. Beginning 8 days prior to anthesis, four rainfall treatments were applied to different plots of susceptible SRWW cultivar Hopewell: **RAIN1** = rain every day; **RAIN2** = rain on days 1, 2, 7, and 8, no rain on days 3, 4, 5 and 6; **RAIN3** = no rain on days 1, 2, 7, and 8, rain on days 3, 4, 5, and 6; and **RAIN4** = rain every other day (days 1, 3, 5, and 7). FHB incidence, severity, and DON were quantified, and the probably of infection and FHB index exceeding 10% were determined. In addition, the effect of rainfall treatment of DON accumulation after adjusting for FHB index was also determined. Plots not subjected to simulated rain were used as references against which the rainfall treatments were compared.

2. **List the most important accomplishments and their impact (i.e. how are they 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>

In 2011 and 2012, all intermittent rainfall treatments had significantly lower probabilities of infection (P_INFECT) and lower probabilities of index exceeding 10% (P_IN10) than the every-day-rainfall reference treatment (RAIN1). All but one intermittent rainfall treatment had significantly higher P_INFECT and P_IN10 values than the check. However, in spite of the difference in P_INFECT and P_IN10 values, several of the intermittent treatments had comparable levels of mean DON to the every-day-rainfall treatment (RAIN1). In fact, RAIN2 (rain only on the first and last two days of the treatment window) had significantly higher adjusted DON than RAIN1, suggesting that under some patterns of intermittent rainfall, DON may be higher than expected based on visual symptoms. In 2013, a year with cooler-than-usual temperatures before and during anthesis and very wet condition after anthesis, P_INFECT, P_IN10, and mean DON were not significantly different among rainfall treatments. However, all treatments had significantly higher P_INFECT, P_IN10, and mean DON than the check.

Impact:
Our results suggest that 4 days with between 26 and 36 mm of pre-anthesis rainfall, regardless of how it is distributed during the 8-day window, may be sufficient to result in comparable risk of infection and DON contamination to 7 or 8 consecutive days with rainfall during the week immediately before anthesis. Scenarios of relatively low FHB and high DON were evident when rainfall was discontinuous, improving our understanding of the effect of rainfall patterns on DON contamination in spike with relatively low levels of FHB index. These findings will be useful for refining FHB and DON prediction models.

Project 3: *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?**

Issue being addressed:
The FHB risk assessment tool is important for FHB management with fungicides. Although the prediction accuracy of this tool is about 80%, there is still room for improvement. Efforts to improve the system would benefit from the acquisition of data representing different patterns of associations between FHB/DON levels and weather/host variables, as well as the exploration of novel modeling approaches.

Approaches for resolving these issues:
FHB integrated management coordinated projects (MGMT_CP) were established in a manner that allowed appropriate data to be gathered for FHB prediction model development. Traits were conducted with at least one untreated, non-inoculated plot of each variety. Data were collected from these trials in 2013 and are being edited for incorporated into the FHB forecasting dataset. There were 22 experiments, 4 each from MD and ND, 3 from IL, 2 each from SD, NY and MO, one each from AR, OH, IN, NE and WI. Fifteen of the experiments were conducted with SRWW, 4 with HRWW and 3 with HRSW.

2. **List the most important accomplishments and their impact (i.e. how are they being used) to minimize the threat of Fusarium Head Blight or to reduce mycotoxins. Complete both sections; repeat sections for each major accomplishment:**

Accomplishment:

A total of 1,882 observations were collected in 2013, representing 174 unique variety-locations. For the purpose of model development, only data from untreated, non-inoculated plots will be used. These data are being compiled into a data matrix with indicator variables for location, year, variety, wheat market class, previous crop residue, and variety FHB resistance classification, and will be added to the master dataset for model development and validation. Working closely with Dr. DeWolf and his team at Kansas State, weather-based predictors will be combined with genetic resistance, wheat market class and presence of host crop residues to develop new FHB prediction models and to validate existing models.

Impact:

The FHB forecasting system was again successfully deployed in 2013 and available for use in 30 US States. The tool again incorporated advice from state specialists in plant pathology to helps growers with fungicide application decisions, minimizing unwarranted and ineffective applications. Based on the number of hits and visits received in 2013, the utilization of this tool continues to increase. In 2013, the site received over 20,000 unique visits, with 122,000 individual hits. A recent study found that the average annual monetary value of this risk tool is $17,000 per user. This gives an estimated minimum annual benefit for the country of over $170 million. Ongoing efforts to improve the accuracy of this tool through the addition of new data and refinement of models will likely improve its value to users and the wheat industry in general.

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 FY13 grant. Please reference each item using an accepted journal format. If you need more space, continue the list on the next page.

PEER-REVIEWED ARTICLES

1. Shah, D. A., De Wolf, E. D., Paul, P. A., and Madden, L. V. 2014. Predicting Fusarium head blight epidemics with boosted regression trees. Phytopathology 104:702-714.
2. Salgado, J. D., Madden, L. V., and Paul, P. A. 2014. Efficacy and economics of integrating in-field and harvesting strategies to manage Fusarium head blight of wheat. Plant Dis. 98: *First Look*.
3. Andersen, K. F., Morris, L., Derksen, R.C., Madden, L.V., and Paul, P. A. 2014. Rainfastness of prothioconazole+tebuconazole for Fusarium head blight and deoxynivalenol management in soft red winter wheat. Plant Dis. 98: *First Look*.
4. D'Angelo, D. L., Bradley, C. A., Ames, K. A., Willyerd, K. T., Madden, L. V., and Paul, P. A. 2014. Efficacy of fungicide applications during and after anthesis against Fusarium head blight and deoxynivalenol in soft red winter wheat. Plant Dis. 98: *First Look*.

PRESENTATIONS

1. Paul, P. A., Andersen, K. F., Bradley, C. A., D'Angelo, D. L., and Madden, L. V. "***Implications of rainfall at anthesis for scab management with fungicide.***" 2013 National Fusarium Head Blight Forum. Milwaukee, WI. Dec 2013.

2. Andersen, K. F., Cabrera, A., Sneller, C. H., Madden, L. V., and Paul. P.A. "***Effects of pre- and post-anthesismoisture patterns on IND/DON relationships and FHB and DON risk prediction.***" 2013 National Fusarium Head Blight Forum. Milwaukee, WI. Dec 2013.
3. D'Angelo, D., Willyerd, K.T., Cabrera, A., Sneller, C.H., Madden, L.V. and Paul, P.A. "***Evaluating the effects of quinone outside inhibitor fungicides on DON accumulation after adjusting for the effects of FHB and Fusarium graminearum biomass in soft red winter wheat.***" 2013 National Fusarium Head Blight Forum. Milwaukee, WI. Dec 2013.
4. Salgado, J., Madden, L. V., and Paul, P. A. "***Soft red winter wheat yield and quality as influenced by the Fusarium head blight-Stagonospora leaf blotch complex and disease management strategies.***" 2013 Meeting of The American Phytopathological Society. Austin, TX. Aug 2013.