USDA-ARS | U.S. Wheat and Barley Scab Initiative

FY22 Performance Progress Report

Due date: July 26, 2023

Cover Page

USDA-ARS Agreement ID:	59-0206-2-132
USDA-ARS Agreement Title:	Fusarium Head Blight Management and Risk Assessment
Principle Investigator (PI):	Pierce Paul
Institution:	The Ohio State University
Institution UEI:	DLWBSLWAJWR1
Fiscal Year:	2022
FY22 USDA-ARS Award Amount:	$71,595
PI Mailing Address:	Ohio State University, Department of Plant Pathology 1680 Madison Ave., Wooster, OH 44691
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Period of Performance:	May 1, 2022 – April 30, 2026
Reporting Period End Date:	April 30, 2023

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
MGMT IM-CP	Fungicide and Genetic Resistance for FHB and DON Management on Winter Wheat in Ohio	$56,457
MGMT	Improved Model Ensembles for Prediction of Fusarium Head Blight	$15,138
	FY22 Total ARS Award Amount	$71,595

I am submitting this report as an: ☒Annual Report

I certify to the best of my knowledge and belief that this report is correct and complete for performance of activities for the purposes set forth in the award documents.

07/26/2023

Principal Investigator Signature | Date Report Submitted

‡ BAR-CP – Barley Coordinated Project
DUR-CP – Durum Coordinated Project
EC-HQ – Executive Committee-Headquarters
FST-R – Food Safety & Toxicology (Research)
FST-S – Food Safety & Toxicology (Service)
GDER – Gene Discovery & Engineering Resistance
HWW-CP – Hard Winter Wheat Coordinated Project
MGMT – FHB Management
MGMT-IM – FHB Management – Integrated Management Coordinated Project
PBG – Pathogen Biology & Genetics
TSCI – Transformational Science
VDHR – Variety Development & Uniform Nurseries
NWW –Northern Soft Winter Wheat Region
SPR – Spring Wheat Region
SWW – Southern Soft Red Winter Wheat Region

Project 1: Fungicide and Genetic Resistance for FHB and DON Management on Winter Wheat in Ohio

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1. **What are the major goals and objectives of the research project?**
   The overall goal of this project (as part of the FHB Integrated Management Coordinated Project [**IM_CP**]) is to develop best-management practices for FHB and mycotoxins in wheat that are robust to conditions experienced in production fields. The specific objectives are to:
   1) Evaluate the integrated effects of fungicide treatment and genetic resistance on FHB and DON, with emphasis on the new combination fungicides Prosaro Pro and Sphaerex.
   2) Compare the efficacy of Prosaro Pro and Sphaerex to that of Prosaro, Caramba, and Miravis Ace.
   3) Determine the additivity of mixtures and sequential applications of fungicides and fungicide active ingredients for FHB and DON management.
   4) Determine the rainfastness of Prosaro Pro, Sphaerex, Prosaro, Caramba, and Miravis Ace.

2. **What was accomplished under these goals or objectives?** *(For each major goal/objective, address these three items below.)*

   a) What were the major activities?

   Obj 1 (**IM Coordinated Project; IM_CP - Ohio):** An inoculated field experiment was conducted in Ohio during the 2021-2022 growing season follow the IM-CP standard protocol. Six fungicide treatments (**1-** nontreated, inoculated check; **2-** nontreated, non-inoculated check, **3-** Prosaro at Feekes 10.5.1; **4-** Miravis Ace at Feekes 10.5.1; **5-** Prosaro Pro at Feekes 10.5.1, and **6-** Spharaex at Feekes 10.5.1) were assigned to plots of cultivars with different levels of resistance to FHB.

   Obj 2 and 3 (Uniform Fungicide Trial: UFT - Ohio): Separate plots of a susceptible cultivar were subjected to eleven fungicide treatments: **1)** an nontreated check; **2)** Prosaro at Feekes 10.5.1; **3)** Caramba at Feekes 10.5.1; **4)** Miravis Ace at Feekes 10.5.1; **5)** Prosaro Pro at Feekes 10.5.1; **6)** Spharaex at Feekes 10.5.1; **7)** Miravis Ace at Feekes 10.5.1 followed by (fb) Prosaro Pro at 4 days after early anthesis (DAA); **8)** Miravis Ace at Feekes 10.5.1 fb Spharaex at 4 DAA; and **9)** Miravis Ace at Feekes 10.5.1 fb Tebuconazole at 4 DAA; **10.** Proline at Feekes 10.5.1, **11.** Folicur (or generic tebuconazole) at Feekes 10.5.1, **12**. Miravis Ace at Feekes 10.5.1 fb Prosaro at 4-6 days DAA, and **13**. Miravis Ace at Feekes 10.5.1 fb Caramba at 4-6 DAA.

   Obj 4 (Rainfastness): Separate plots of a susceptible wheat cultivar were treated with Miravis Ace, Prosaro, or Caramba at Feekes 10.5.1 or left nontreated, after which separate groups of plots were subjected to simulated rainfall treatments of different durations (15, 30, 60, and 120 min), beginning at different times (0, 15, 30, and 60 min) after fungicide application.

   In all trials, Prosaro, Caramba, Miravis Ace, Spharaex, Folicur, Proline, and Prosaro Pro were applied at label recommend rates (6.5, 13.5, 13.7, 7.3, 4, 5.7, and 10.3 fl. oz./A, respectively), along with a non-ionic surfactant (except for a few treatments in the rainfast experiment), plots were spray-inoculated with a spore suspension *Fusarium graminearum* at Feekes 10.5.1 (unless otherwise stated), and FHB index (IND), DON, FDK, foliar diseases severity, yield, and test weight data were collected and analyzed.

b) What were the significant results?

Obj 1: For all tested resistance classes, all fungicide treatments resulted in significantly lower mean FHB IND and DON than the nontreated check, with mean responses being comparable among Prosaro, Miravis Ace, Spharaex, and Prosaro Pro. Relative to the nontreated, susceptible check (UT_S_CK), management programs consisting of a fungicide application to an MR, MS, or S cultivar reduced mean IND by 90-97%, 89-91% and 77-86%, respectively, and mean DON by 87-91%, 72-82%, and 61-74%, respectively.

Obj 2: All tested fungicide treatments resulted in significantly lower mean FHB IND and DON than the nontreated check, with two-treatment programs having the lowest mean responses. Among treatments consisting of an anthesis-only application, Miravis Ace, Prosaro Pro and Spharaex resulted in slightly lower mean levels of IND and DON than Prosaro and Caramba.

Obj 3: Preliminary analyses of the data suggested that there were additive effectives of sequential fungicide applications on IND and DON when Miravis Ace was applied at early anthesis followed by an application of Prosaro, Caramba, Prosaro Pro, or Spharaex 4-6 days after early anthesis.

Obj 4: All fungicide-treated plots had significantly lower mean IND and DON than the nontreated check, with the means for both responses being comparable among Prosaro, Caramba and Miravis Ace, averaged across rainfall treatments. Mean percent control of IND and DON were considerably higher when the fungicides were applied with a nonionic surfactant and plots were subjected to 120 min of rainfall, beginning immediately after the treatments were applied, compared to when the fungicides were applied without a surfactant and subjected to the same rainfall treatment.

c) List key outcomes or other achievements.

We successfully conducted IM and UFT experiments which allowed us to evaluate and compared the efficacy of new fungicide mixtures against FHB and DON when applied alone, sequentially, or as part of integrated management programs.

Obj 1: As was previously shown for Prosaro and Miravis Ace, relative to the nontreated, suspectable check, the new fungicide mixtures Spharaex and Prosaro Pro were more effective against IND and DON when applied to a moderately resistant cultivar then to a susceptible cultivar. Integrated management (IM) programs with Spharaex and Prosaro Pro yielded fairly comparable results in terms of mean percent control of IND and DON to IM programs with Prosaro or Miravis Ace.

Obj 2: Based on percent control, Miravis Ace, Prosaro Pro, and Spharaex were slightly more effective again IND and DON than Prosaro and Caramba, reducing IND by 79, 81, and 75%, respectively, compared to 67% for Prosaro and 70% for Caramba. For DON, the corresponding values were 64, 70, and 65% for Miravis Ace, Prosaro Pro, and Spharaex, respectively, compared to 57% for Prosaro and 54% for Caramba.

Obj 3: We generated results showing that the tested sequential fungicide application programs had additive effects on IND and DON, demonstrating the value of following an anthesis application of Miravis Ace with a post-anthesis application of one of the other tested fungicides.

Obj 4: We successfully evaluated the rainfastness of Prosaro, Caramba, and Miravis Ace for a third successive growing season, with the results again showing the three fungicides were quite rainfast when applied with a nonionic surfactant.

3. **What opportunities for training and professional development has the project provided?**
   Postdoctoral researchers, research technicians, and a graduate student contributed to the project, learning how to design field experiments and collect data to evaluate FHB and DON management programs. They also learned and contributed to data analysis and the preparation of abstracts, posters, and talks for scientific meetings; graphs and tables for extension talks; and manuscripts for publication.

4. **How have the results been disseminated to communities of interest?**
   Results were disseminated by way of posters, abstracts, and talks at scientific meetings, electronic newsletter articles, extension talks, and field demonstrations.

Project 2: Improved Model Ensembles for Prediction of Fusarium Head Blight

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1. **What are the major goals and objectives of the research project?**
   The overall goal of this project is to create better models for predicting Fusarium head blight (FHB). The objectives are to:
   1) Expand the data matrix used for modeling FHB with cases representing new environments and years (**Paul Lab**).
   2) Improve predictive performance of disease forecasts by combining models representing specific epidemiological processes within model ensembles (**The DeWolf Lab**).

2. **What was accomplished under these goals or objectives?** *(For each major goal/objective, address these three items below.)*

   a) What were the major activities?

   Obj 1) In 2022, integrated management trials were conducted in several US wheat growing states that are commonly affected by FHB. FHB and DON data were collected and sent to the Paul lab for processing and analysis.

   Obj 2) Work is in progress to develop model ensembles using specific FHB epidemiological (disease cycle-related) processes (reproduction, spore release events, infection) as the basis for combining logistic regression (LR) models rather than a random selection from the larger set of all potential base models as was done previously (see Dr. DeWolf's report for details).

   b) What were the significant results?

   Obj 1) As has become customary for the FHB model development research, IND data were again mined from the IM_CP dataset to extract trial-resistance-class cases that were not treated with fungicides or inoculated with a spore suspension of *Fusarium graminearum*.

   Obj 2) IND and weather data collected in 2022 is being edited and cleaned and will be added to the master dataset for model development. Based on the variable(s) used as predictors in the existing set of LR models, these models will be ensembles based on the relative importance of the predictor for different components of an FHB epidemic.

   c) List key outcomes or other achievements.

   Obj 1) New IND data and associated weather data were collecting from a range of wheat-growing locations that likely represent some unique FHB-weather patterns that are new to our master dataset.

   Obj 2) We anticipate that the proposed epidemiology-based approach to grouping LR base models will result in ensembles with very good FHB predictive performance.

3. **What opportunities for training and professional development has the project provided?**
   We are in the process of hiring a replacement postdoctoral researcher to work on this and other FHB projects.

4. **How have the results been disseminated to communities of interest?**
   Once results become available from this aspect of the FHB model development effort, posters and talks will be presented at scientific meetings and peer-reviewed journal articles will be prepared.

Publications, Conference Papers, and Presentations

Please include a listing of all your publications/presentations about your FHB work that were a result of funding from your FY22 grant award. Only citations for publications published (submitted or accepted) or presentations presented during the **award period** should be included.

Did you publish/submit or present anything during this award period May 1, 2022 – April 30, 2023?

☒ Yes, I've included the citation reference in listing(s) below.

☐ No, I have nothing to report.

Journal publications as a result of FY22 award

List peer-reviewed articles or papers appearing in scientific, technical, or professional journals. Include any peer-reviewed publication in the periodically published proceedings of a scientific society, a conference, or the like.

Identify for each publication: Author(s); title; journal; volume: year; page numbers; status of publication (published [include DOI#]; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).

PEER-REVIEWED ARTICLES:

1. Moraes, W. B., Madden, L. V., and Paul, P. A. 2022. Efficacy of genetic resistance and fungicide application against Fusarium head blight and mycotoxins in wheat under persistent pre- and post-anthesis moisture. Plant Dis. 106:2839-2855. https://apsjournals.apsnet.org/doi/10.1094/PDIS-02-22-0263-RE.
   Published
   Acknowledgement of federal support (yes)

2. Moraes, W. B., Madden, L. V., Baik, Byung-Kee, Gillespie, J., and **Paul, P. A.** 2023. Environmental conditions after Fusarium head blight visual symprom development affect contamination of wheat grain with deoxynivalenol and deoxynivalenol-3-glucocide. Phytopathology 113:206-224. https://apsjournals.apsnet.org/doi/10.1094/PHYTO-06-22-0199-R
   Published
   Acknowledgement of federal support (yes)

3. Moraes, W. B., Madden, L. V., Gillespie, J., and **Paul, P. A.** 2023. Environment, grain development, and harvesting strategy effects on zearalenone contamination of grain from Fusarium head blight-affected wheat spikes. Phytopathology 113:225-238. https://apsjournals.apsnet.org/doi/10.1094/PHYTO-05-22-0190-R
   Published
   Acknowledgement of federal support (yes)

4. Shah, D. A., De Wolf, E. D., Paul, P. A., and Madden, L. V. 2023. Into the trees: random forests for predicting Fusarium head blight epidemics of wheat in the United States. Phytopathology 113: https://doi.org/10.1094/PHYTO-10-22-0380-R.
   Published (first look March 2023)
   Acknowledgement of federal support (yes)

Books or other non-periodical, one-time publications as a result of FY22 award

Report any book, monograph, dissertation, abstract, or the like published as or in a separate publication, rather than a periodical or series. Include any significant publication in the proceedings of a one-time conference or in the report of a one-time study, commission, or the like.

Identify for each one-time publication: Author(s); title; editor; title of collection, if applicable; bibliographic information; year; type of publication (book, thesis, or dissertation, other); status of publication (published; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).

NA

Other publications, conference papers and presentations as a result of FY22 award

Identify any other publications, conference papers and/or presentations not reported above. Specify the status of the publication.

ABSTRACTS

1. Moraes, W. B., Madden, L. V., and **Paul, P. A.** 2022. Sample size matters: Interpretation of Fusarium head blight results in field experiments. (Abstr.) Phytopathology 112:S3.18. doi.org/10.1094/PHYTO-112-11-S3.1.
2. Moraes, W. B., Schwarz, P. B., Baik, B. K., Madden, L. V., and **Paul, P. A.** 2022. Environmental conditions after Fusarium head blight visual symptom expression affect the fate of deoxynivalenol in wheat grain. (Abstr.) Phytopathology 112:S3.201. doi.org/10.1094/PHYTO-112-11-S3.200.

PROCEEDINGS

1. Moraes, W. B., Madden, L. V., and Paul, P. A. 2022. Post-anthesis Rainfall Effects on the Efficacy of Genetic Resistance and Fungicide Application against Fusarium Head Blight and Mycotoxins in Wheat. Proceedings of the 2022 National Fusarium Head Blight Forum; Tampa, FL. December 4-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf
2. Moraes, W. B., Ng, S. J., Luis, M., Duffeck, M. R., Valle, J., Madden, L. V., and Paul, P. A. 2022. Rainfastness of Fungicides for Fusarium Head Blight and Deoxynivalenol Reduction in Soft Red Winter Wheat. Proceedings of the 2022 National Fusarium Head Blight Forum; Tampa, FL. December 4-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf
3. Moraes, W. B., Bergstrom, G., Bissonnette, K., Bowen, K., Bradley, C., Byamukama, E., Chilvers, M., Collins, A., Cowger, C., Darby, H., De Wolf, E., Dill-Macky, R., Esker, P., Friskop, A., Kleczewski, N., Koehler, A., Langston Jr., D., Madden, L. V., Marshall, J., Mehl, H., NegelKirk, M., Rawat, N., Smith, D., Telenko, D., Wegulo, S., Young-Kelly, H., and Paul, P. A. 2022. Fusarium Head Blight Management Coordinated Project: Integrated Management Trials 2022. Proceedings of the 2022 National Fusarium Head Blight Forum; Tampa, FL. December 4-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf
4. Moraes, W. B., Bergstrom, G., Bissonnette, K., Bowen, K., Bradley, C., Byamukama, E., Chilvers, M., Collins, A., Cowger, C., Darby, H., De Wolf, E., Dill-Macky, R., Esker, P., Friskop, A., Kleczewski, N., Koehler, A., Langston Jr., D., Madden, L. V., Marshall, J., Mehl, H., NegelKirk, M., Rawat, N., Smith, D., Telenko, D., Wegulo, S., Young-Kelly, H., and Paul, P. A. 2022. Fusarium Head Blight Management Coordinated Project: Uniform Fungicide Trials 2022. Proceedings of the 2022 National Fusarium Head Blight Forum; Tampa, FL. December 4-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf
5. Onofre, K. A., De Wolf, E., Moraes, W. B., and Paul, P. A. 2022. MGMT Coordinated Project Overview and Kansas Perspective. Proceedings of the 2022 National Fusarium Head Blight Forum; Tampa, FL. December 4-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf