USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY20 Annual Performance Progress Report
Due date: July 29, 2021

Cover Page

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Fiscal Year:	2020
USDA-ARS Agreement ID:	59-0206-0-131
USDA-ARS Agreement Title:	Fusarium Head Blight Risk Assessment, Management, and Education
FY20 USDA-ARS Award Amount:	$ 83,140
Recipient Organization:	The Ohio State University Research Foundation Accounting Dept. 1960 Kenny Road, 4th Floor Columbus, OH 43210
DUNS Number:	07-165-0709
EIN:	31-6401599
Recipient Identifying Number or Account Number:	GRT00060644
Project/Grant Reporting Period:	5/13/20 - 5/12/21
Reporting Period End Date:	5/12/2021

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
MGMT	Efficacy of Miravis Ace in Combination with Resistance for FHB and DON Management	$ 71,174
MGMT	Application of Model Ensembles and Machine Learning to the Prediction of Fusarium Head Blight	$ 11,966
	FY20 Total ARS Award Amount	**$ 83,140**

07/29/2021

Principal Investigator Date

* MGMT – FHB Management
FST – Food Safety & Toxicology
R- Research
S – Service (DON Testing Labs)
GDER – Gene Discovery & Engineering Resistance
PBG – Pathogen Biology & Genetics
EC-HQ – Executive Committee-Headquarters
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

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Project 1: *Efficacy of Miravis Ace in Combination with Resistance for FHB and DON Management*

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 [MGMT_CP]) was to develop more robust "best-management practices" to provide producers with additional and more effective options for managing FHB and DON. The Ohio-specific objectives were to:

1) Evaluate the integrated effects of fungicide treatment and genetic resistance on FHB and DON in soft red winter wheat (SRWW), with emphasis on a new fungicide, Miravis Ace,
2) Compare the efficacy of Miravis Ace® when applied at early heading or at anthesis to that of standard anthesis application of Prosaro® or Caramba®.
3) Compare the efficacy of single and sequential applications of Miravis Ace, Prosaro, Caramba, and tebuconazole against FHB and DON.
4) Determine the effects of rainfall timing, amount, and duration on the efficacy and residual life of Miravis Ace, Prosaro, and Caramba on wheat spikes.

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?

Three field experiments were conducted during the 2019-2020 growing seasons in Ohio - an integrated management (IM), a uniform fungicide trial (UFT), and a rainfast fungicide trial (RF). **IM** (**Obj 1**): The treatments were: 1) an untreated, inoculated check; 2) Prosaro at anthesis; 3) Miravis Ace at anthesis; 4) Miravis Ace at Feekes 10.3; 5) Prosaro at anthesis, non-inoculated; and 6) an untreated, non-inoculated check. Treatments were applied to replicate plots of four cultivars with different levels of resistance to FHB. **UFT** (**Obj 2** and **3**): Plots of susceptible cultivars were subjected to ten fungicide treatments: 1) an untreated check; 2) Prosaro at anthesis; 3) Caramba at anthesis; 4) Miravis Ace at Feekes 10.3; 5) Miravis Ace at anthesis; 6) Miravis Ace at anthesis followed by Prosaro at 4 days after anthesis (DAA); 7) Miravis Ace at anthesis followed by Caramba at 4 DAA; 8) Miravis Ace at anthesis followed by Folicur at 4 DAA; 9) Miravis Ace at 4 DAA and 10) Prosaro at 4 DAA. **RF** (**Obj 4**): Separate plots of a susceptible wheat cultivar were treated with Miravis Ace, Prosaro, or Caramba at Feekes 10.5.1, or left untreated, 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, and Folicur were applied at 6.5, 13.5, 13.7, and 4

fl. oz./A, respectively, along with a non-ionic surfactant and, FHB, DON, FDK, yield, and test weight data were collected and analyzed.

b) What were the significant results?

Obj 1: All fungicide program x cultivar resistance combinations resulted in significantly lower mean FHB index (IND) and DON than the non-treated susceptible check (S_CK). The early application of Miravis Ace (FK 10.3) had comparable mean IND to the anthesis application of Miravis Ace or Prosaro on the MR cultivars. However, on the S or MS cultivars, the early application of Miravis Ace had significantly higher mean IND. Mean DON was significantly higher for Miravis Ace at FK 10.3 then Miravis Ace or Prosaro at anthesis, regardless of cultivar. The highest mean percent control of both IND and DON relative to S_CK was achieved when an anthesis application of Miravis Ace or Prosaro was combined with an MR cultivar.

Obj 2 and 3: All fungicide programs resulted in significantly lower mean IND and DON than the non-treated check (CK). Two-treatment programs with Miravis Ace applied at anthesis followed by Prosaro, Caramba, or Folicur at 4 days after anthesis (DAA) resulted in the highest percent reduction in IND and DON relative to CK. Among single-treatment programs, Miravis Ace at anthesis was the most effective against IND and DON, performing significantly better that Miravis Ace at early heading (FK 10.3) or after anthesis, Prosaro at or after anthesis, or Caramba at anthesis. The least effective single-treatment program against IND and DON was Miravis ace at FK 10.3.

Obj 4: On average, fungicide treatments with Induce reduced FHB index (IND) by 63 to 86% and DON by 53 to 64%. When applied with the surfactant, the performance of the three fungicides was fairly consistent across rainfall treatments. For DON, percent control (C) ranging from 48 to 68% across rainfall durations and 47 to 66% across rainfall start times. However, efficacy was substantially lower (C < 40% for both IND and DON) when the fungicides were applied without the surfactant and plots were subjected to 120 min of simulated rainfall, beginning immediately after the treatment was applied.

c) List key outcomes or other achievements.

Another season of data was successfully generated showing that for:

Obj: management programs consisting of Miravis Ace or Prosaro applied at anthesis to MR cultivars were the most effective against both IND and DON, whereas programs that included an early-heading (FK10.3) application of Miravis Ace were the least effective.

Obj 2 and **3:** Miravis Ace applied at anthesis outperformed Prosaro and Caramba in terms of percent control of both IND and DON, but this same fungicide was the least

effective of the tested treatments when applied at FK 10.3; and all tested two-treatment fungicide programs outperformed most single-treatment program in terms of percent control of IND and DON relative to the check. The exception was Miravis Ace alone at anthesis, which was just as effective as Miravis Ace at anthesis followed by a DMI four days after anthesis.

Obj 3: Prosaro, Caramba, and Miravis Ace were very rainfast once applied with Induce.

3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns and/or restrictions, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.

Greenhouse/growth chamber experiments designed to evaluate the effects of infection and fungicide application timing (relative to Feekes 10.5) on FHB development, DON contamination of grain, and fungicide efficacy against both response in winter malting barley were compromised by university shutdowns and hiring freeze. These trials were planned for winter 2019 to early spring 2020 and winter 2020 to early spring 2021. COVID-related restrictions compromised research during both of these periods.

4. What opportunities for training and professional development has the project provided?

A Post-doc, Research Assistant, and a graduate student contributed to this project. In addition to learning how to establish experiments and collect data to evaluate integrated management programs for FHB, they all learned basic data analysis and contributed to the preparation of abstracts and posters presented at the Scab Forum and the APS meeting.

5. How have the results been disseminated to communities of interest?

Results were disseminated by way of posters and abstracts at scientific meetings, electronic newsletter articles, and extension talks and field days.

Project 2: *Application of Model Ensembles and Machine Learning to the Prediction of Fusarium Head Blight*

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 were to:

1) Enhance the FHB data matrix with observations collected in collaboration with the MGMT IM-CP during recent growing seasons;
2) Improve predictive models for FHB through "ensemble modeling" approaches that combine estimates from multiple models resulting in a more robust estimate of disease risk;
3) Further apply machine learning algorithms that better address non-linear relationships between weather and FHB risk; and
4) 4) Uses the FHB observational matrix and the predictive models to develop a suite of case studies that will help stakeholders visualize and understand weather patterns that stimulate or suppress FHB epidemics.

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: During the 2019-2020 growing season 33 integrated management trials were conducted as part of the MGMT_CP in 19 US wheat-growing states (AL, DE, ID, IL, IN, KY, MD, MI, MO, MN, ND, NE, NY, OH, PA, SD, TN, VA, and WI). At least two commercial wheat cultivars, classified as susceptible, moderately susceptible or moderately resistant, were planted in each trial. FHB index, incidence and DON data were collected from non-treated, non-inoculated plots of each cultivar and edited for inclusion in the master data file for FHB risk model development and validation.

Obj 2: Working in collaboration with Dr DeWolf, three ensemble modeling approaches (soft voting, weighted model averaging, and stacking) were used to combine 39 logistic regression models that were correlated in their predictions of FHB epidemics. Ensembling was performed on models that were grouped primarily based on weather variables and time periods considered during model development.

Obj 3 and **4:** will be the focus of FY21 and beyond.

b) What were the significant results?

Obj 1: A total of 88 new cases (unique combination of cultivar resistance class x trial) with a range of IND levels were collected across states and gain market classes, expanding the range of environmental conditions available in our dataset for model development.

Obj 2: The three ensembling approaches were successfully used to combine logistic regression models into ensembles that captured more information and improved prediction accuracy relative to the individual models in several but not all cases.

c) List key outcomes or other achievements.

Obj 1: The MGMT_CP again served as an excellent source of new observations for FHB model development.

Obj 2: Stacked regression outperformed soft voting and model averaging, resulting in a 24% increase in model accuracy (based on PR-AUC) than the original, individual models.

3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns and/or restrictions, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.

No

4. What opportunities for training and professional development has the project provided?

A graduate student who contributed to the MGMT_CP learned certain basic aspects of data mining for predictive model development.

5. How have the results been disseminated to communities of interest?

A manuscript was published.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY20 award period (5/13/20 - 5/12/21). The term "support" below includes any level of benefit to the student, ranging from full stipend plus tuition to the situation where the student's stipend was paid from other funds, but who learned how to rate scab in a misted nursery paid for by the USWBSI, and anything in between.

1. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their MS degree during the FY20 award period?**
   ☐Yes ☒No
   If yes, how many? Click to enter number here.

2. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY20 award period?**
   ☐Yes ☒No
   If yes, how many? Click to enter number here.

3. **Have any post docs who worked for you during the FY20 award period and were supported by funding from your USWBSI grant taken faculty positions with universities?**
   ☐Yes ☒No
   If yes, how many? Click to enter number here.

4. **Have any post docs who worked for you during the FY20 award period and were supported by funding from your USWBSI grant gone on to take positions with private ag-related companies or federal agencies?**
   ☐Yes ☒No
   If yes, how many? Click to enter number here.

Release of Germplasm/Cultivars

Instructions: In the table below, list all germplasm and/or cultivars released with full or partial support through the USWBSI during the FY20 award period (5/13/20 - 5/12/21). All columns must be completed for each listed germplasm/cultivar. Use the key below the table for Grain Class abbreviations.

NOTE: Leave blank if you have nothing to report or if your grant did NOT include any VDHR-related projects.

Name of Germplasm/Cultivar	Grain Class	FHB Resistance	FHB Rating (0-9)	Year Released
N/A	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year

NOTE: List the associated release notice or publication under the appropriate sub-section in the 'Publications' section of the FPR.

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Publications, Conference Papers, and Presentations

Instructions: Refer to the PR_Instructions for detailed more instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY20 grant award. Only citations for publications published (submitted or accepted) or presentations presented during the **award period (5/13/20 - 5/12/21**) should be included. If you did not publish/submit or present anything, state 'Nothing to Report' directly above the Journal publications section.

NOTE: Directly below each citation, you **must** indicate the Status (i.e. published, submitted, etc.) and whether acknowledgement of Federal support was indicated in the publication/ presentation. See example below for a poster presentation with an abstract:

Winn, Z.J., Acharya, R., Lyerly, J., Brown-Guedira, G., Cowger, C., Griffey, C., Fitzgerald, J., Mason R.E., and Murphy, J.P. (2020, Dec 7-11). Mapping of Fusarium Head Blight Resistance in NC13-20076 Soft Red Winter Wheat (p. 12). In: Canty, S., Hoffstetter, A. and Dill-Macky, R. (Eds.), *Proceedings of the 2020 National Fusarium Head Blight Forum*. https://scabusa.org/pdfs/NFHBF20_Proceedings.pdf.
Status: Abstract Published and Poster Presented
Acknowledgement of Federal Support: YES (Abstract and Poster)

Journal publications.

Shah, D. A., De Wolf, E. D., Paul, P. A. and Madden, L. V. 2021. 2021. Accuracy in the prediction of disease epidemics when ensembling simple but highly correlated models. PLOS Computational Biology | https://doi.org/10.1371/journal.pcbi.1008831
Statue: Published
Acknowledgements of Federal Support: Yes

Books or other non-periodical, one-time publications.

Nothing to report

Other publications, conference papers and presentations.

Bucker Moraes, W., Madden, L. V. and Paul, P. A. 2020. Effects of genetic resistance and fungicide application on Fusarium head blight as influenced by pre- and post-anthesis rainfall. In: Canty, S., A. Hoffstetter, and R. Dill-Macky (Eds.), Proceedings of the 2020 National Fusarium Head Blight Forum (p.29). East Lansing, MI: U.S. Wheat & Barley Scab Initiative.
Statue: Abstract published and Poster Presented
Acknowledgements of Federal Support: Yes (Abstract and Poster)

Bucker Moraes, W., Ng, S. J., Madden, L. V. and Paul, P. A. 2020. Rainfastness of fungicides for Fusarium head blight management in soft red winter wheat. In: Canty, S., A. Hoffstetter, and R. Dill-Macky (Eds.), Proceedings of the 2020 National Fusarium Head Blight Forum (p.30). East Lansing, MI: U.S. Wheat & Barley Scab Initiative.
Statue: Abstract published and Poster Presented
Acknowledgements of Federal Support: Yes (Abstract and Poster)

Luis, J.M., Ng, S.J., Bergstrom, G., Bissonnette, K., Bowen, K., Bradley, C., Byamukama, E., Chilvers, M., Collins, A., Cowger, C., Darby, H., DeWolf, E., Dill-Macky, R., Esker, P., Friskop, A., Kleczewski, N., Koehler, A., Madden, L., Marshall, J., Mehl, H., Moraes, W., Nagelkirk, M., Rawat, N., Smith, D., Telenko, D., Wegulo, S., Young-Kelly, H., and Paul, P.A. (2020). Fusarium head blight management coordinated project: Integrated management trials 2018-2020. In: *Proceedings of the 2020 National Fusarium Head Blight Forum*. Online: December 7-11, 2020, pp. 38-43.
Status: Published
Acknowledgement of Federal Support: Yes

Luis, J.M., Ng, S.J., Bergstrom, G., Bissonnette, K., Bowen, K., Bradley, C., Byamukama, E., Chilvers, M., Collins, A., Cowger, C., Darby, H., DeWolf, E., Dill-Macky, R., Esker, P., Friskop, A., Kleczewski, N., Koehler, A., Madden, L., Marshall, J., Mehl, H., Moraes, W., Nagelkirk, M., Rawat, N., Smith, D., Telenko, D., Wegulo, S., Young-Kelly, H., and Paul, P.A. (2020). Fusarium head blight management coordinated project: Uniform fungicide trials 2018-2020. In: *Proceedings of the 2020 National Fusarium Head Blight Forum*. Online: December 7-11, 2020, pp. 44-48.
Status: Published
Acknowledgement of Federal Support: Yes

Pierce A. Paul. 2020. "*Fungicides and Integrated Management of Head Scab and Vomitoxin in Wheat with Emphasis on Miravis Ace: A 2020 Update*". 2020 National Fusarium Head Blight Forum. Virtual, December 2020.
Statue: Talk presented
Acknowledgements of Federal Support: Yes