

**USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY16 Final Performance Report
Due date: July 28, 2017**

Cover Page

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Fiscal Year:	2016
USDA-ARS Agreement ID:	59-0206-6-003
USDA-ARS Agreement Title:	Development of Scab Resistant Wheat Varieties for Michigan.
FY16 USDA-ARS Award Amount:	\$ 74,765
Recipient Organization:	Michigan State University Contract & Grant Administration Hannah Administration Building, Room 2 East Lansing, MI 48824-1046
DUNS Number:	193247145
EIN:	38-6005984
Recipient Identifying Number or Account Number:	RC106028
Project/Grant Reporting Period:	4/24/16 - 4/23/17
Reporting Period End Date:	04/23/17

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
VDHR-NWW	Development of Scab Resistant Wheat Varieties for Michigan.	\$ 66,318
VDHR-NWW	Male Sterile Facilitated Recurrent Selection for FHB Resistance.	\$ 680
VDHR-NWW	Coordinated Phenotyping of Uniform Nurseries and Official Variety Trials.	\$ 1,942
VDHR-NWW	Implementing Genomic Selection for FHB Resistance in Soft Winter Wheat (SWW).	\$ 5,825
	FY16 Total ARS Award Amount	\$ 74,765



7/28/2017

Principal Investigator

Date

* MGMT – FHB Management
 FST – Food Safety & Toxicology
 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

Project 1: *Development of Scab Resistant Wheat Varieties for Michigan.*

1. What are the major goals and objectives of the project?

The mission of the Michigan State University Wheat Breeding and Genetics program is to develop high-yielding, high-quality soft red and soft white winter wheat varieties with exceptional resistance to FHB. Breeding populations are developed with parents having high levels of Fhb resistance and stringent phenotypic selection is applied for resistance is applied in segregating populations and derived inbred lines. Identifying novel sources of Fhb resistance in adapted and exotic wheat genotypes supports long term resistant variety development.

Major project objectives:

- A. Develop and apply selection to 600 breeding populations segregating for FHB resistance using a combination of phenotypic and marker-assisted selection strategies.
- B. Evaluate resistance levels of breeding yield trial entries in a misted FHB nursery.
- C. Perform marker-assisted selection for major resistance QTL.
- D. Disseminate resistant germplasm.
- E. Communicate levels of resistance in Michigan wheat varieties.

2. What was accomplished under these goals?

1) major activities

A. Development of breeding populations and early generation selection. Phenotypic selection was applied in 585 segregating F₂ populations. Populations were inoculated with 30 lb. per acre of infected grain spawn. Spikes of 10 to 20 plants per population were selected, harvested and threshed in bulk. Selections focused on plant height, early flowering and general plant type. In 2016, extremely dry weather precluded the development of FHB in F₂ bulk populations. No Fusarium damaged kernels (FDKs) were present in threshed seed and color sorting was not implemented. For each population, ~300 seed was vernalized in a germination box and plants were grown together in the greenhouse and harvested in bulk to advance F₃-F₄ and F₄-F₅ generations. In fall, 2017, the F₅ seed will be planted in bulk in Richville, MI.

A total of 810 crosses were made in fall 2016 and spring 2017 to develop new breeding populations segregating for Fhb resistance. F₂ seed will be planted in the field during fall 2017.

B. Phenotypic evaluation of Fhb resistance in breeding germplasm. A total of 826 breeding lines were evaluated for Fhb resistance under inoculated conditions. From preliminary yield trial of 703 lines was evaluated in one or two replications on a 0-4 rating scale (MR, MS, S, VS). The advanced yield trial of 100 lines was evaluated in three replications. The 23 state performance trial entries were evaluated in three replications.

C. Marker assisted selection for major Fhb resistance QTL. Crosses were made with lines carrying *Fhb1*, Ernie 5A and Massey 3BL QTL in fall 2016. Topcrosses were made in spring 2017 to pyramid QTL. These QTL will be evaluated in F₅-derived lines in fall, 2018.

D. Dissemination of resistant germplasm. A total of 10 entries were submitted to the Uniform FHB nurseries, several of which carry a novel QTL for FHB resistance derived from *Ae. tauschii*. In the Uniform Eastern Soft White Winter Wheat nursery, 11 lines were shared with seven collaborators across the eastern US and Ontario, CA. The soft white wheat genotype MI14W0190, which carries *Fhb1* and demonstrates both low DON as well as low FHB index under misted nursery conditions, has been made available to nursery cooperators.

E. Communication of FHB resistance in Michigan wheat varieties. Wheat growers and agribusiness were educated on FHB-resistant varieties in presentations at field days and winter meetings. Additionally, a grower survey was conducted in collaboration with MSU-Extension to quantify the Michigan wheat acreage planted to resistant varieties. The results of this survey were communicated through publication of a fact sheet.

2) specific objectives

A. Crosses incorporating Fhb resistance. Selections were made in 585 segregating F₂ populations in spring, 2016. The F₃ seed was vernalized in germination boxes, grown and harvested in bulk in the greenhouse. The F₄ seed was again vernalized in germination boxes, grown and harvested in bulk in the greenhouse. The F₅ seed will be planted in the bulk plots in fall, 2017 and single plant selections will follow in spring, 2018.

Both molecular marker data and phenotypic data were used to make 810 crosses incorporating FHB resistance in to breeding populations. The F₂ seed from all populations has been produced in the greenhouse and will be planted in bulk in the field in fall, 2017.

B. Identification advanced breeding lines with Fhb resistance. Phenotypic selection for FHB resistance was done using an inoculated FHB nursery.

C. Marker assisted selection for Fhb resistance QTL. Pyramiding of FHB resistance QTL was done using a topcrossing strategy. QTL detection will be done on inbred lines derived from phenotypic selection on segregating populations.

D. Disseminate resistant germplasm. Lines with high levels of resistance to Fhb were entered in the Uniform Fhb nurseries in order to be made available to other regional breeding programs.

3) significant results

- The soft white winter wheat MI14W0190 has been identified to have low FHB index, low DON and very high yield potential. Incidence and severity are similar and DON levels are lower than the most FHB-resistant soft white winter wheat, Dyna-Gro 9242W. MI14W190 is not significantly different from the highest yielding soft white winter wheat tested in Michigan in 2017.
- The MSU wheat breeding program has increased in productivity testing 23 new entries in the Michigan OVT as well as the Uniform Easter White and Red Wheat nurseries. Of

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these lines tested, three soft white winter wheat variety releases are expected including MI14W0064, MI14W0190 and VA09W-192WS-29.

4) key outcomes or other achievements

Informed crosses based on molecular marker data have enabled the development of breeding populations segregating for resistance. Valuable phenotypic data from the inoculated Fhb nursery has enabled selection and advancement of wheat genotypes with high levels of resistance to FHB. Three soft white winter wheat varieties are being increased for release as varieties.

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

Four graduate students gained experience in evaluating FHB in an inoculated and misted nursery. Students included Andrew Wiersma, Linda Brown, Jeff Kovach, and Kyle McCarthy. One postdoctoral research associate, Amber Hoffstetter has also gained experience in evaluating FHB in an inoculated and misted nursery. Their efforts supported data collection on breeding lines and cooperative nursery entries.

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

Results from the 2016 project have been communicated to all industry stakeholders. Results were communicated in three talks given to the Michigan Agri-Business Association, Michigan Millers Association and Michigan Crop Improvement Association.

Project 2: *Male Sterile Facilitated Recurrent Selection for FHB Resistance.*

1. What are the major goals and objectives of the project?

Recurrent selection is a breeding procedure with the objective of increasing the frequency of desirable alleles for one or more traits while maintaining a high level of variability in the population. The goal for this project is to develop several adapted breeding populations with genes for FHB resistance derived from multiples sources. From segregating populations, inbred lines will be derived that will be evaluated for grain yield. Methods employed will rapidly incorporate FHB resistance into wheat genotypes with adaptation to soft winter wheat growing environments.

2. What was accomplished under these goals?

1) major activities. Inbred lines were extracted from segregating populations in summer, 2015, and were planted in 2016 preliminary yield trials.

2) specific objectives. The primary objective in this goal was to identify Fhb-resistant lines extracted from segregating populations that have superior agronomic performance and high yield.

3) significant results. One inbred line derived from segregating populations, MI15R0416 was tested in five locations in two replicates across Michigan. Grain yield at 73.1 bu/ac was below the trial mean of 76.5 bu/ac and will not be moved forward in the breeding program. The line was also evaluated in three replications in the misted and inoculated FHB nursery. FHB severity, incidence and index were well above the nursery means at 58.9%, 38.8% and 22.8%, respectively.

4) key outcomes or other achievements

Nothing to report

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

Nothing to report

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

Nothing to report

Project 3: *Coordinated Phenotyping of Uniform Nurseries and Official Variety Trials.*

1. What are the major goals and objectives of the project?

Selections by breeders and planting decisions by growers affect the amount of wheat acreage planted to resistant varieties. Information on FHB resistance in breeding germplasm and varieties available to wheat growers is critical to making selections and planting decisions. The goal of this project is to provide wheat breeders, FHB researchers, extension, agri-business and farmers on the levels of resistance present in wheat breeding lines and varieties.

2. What was accomplished under these goals?

1) major activities. In coordination with the breeding program an Fhb nursery was planted to assess levels of resistance in elite breeding lines and varieties available to growers. Two disease ratings took place on June 19 through June 21, 2017. A total of 123 entries from the Michigan State Wheat Performance trial were evaluated for FHB incidence, severity and index. Other nurseries evaluated include the Preliminary and Northern Uniform FHB nurseries, the Uniform eastern soft red and soft white winter wheat nurseries. Samples were collected for DON analysis which will take place in the coming months after sample processing.

2) specific objectives. The objective of this work is to determine the level of Fhb resistance in wheat varieties available to wheat farmers and provide wheat breeders with information on levels of resistance in breeding germplasm.

3) significant results. Across all nurseries evaluated in the misted and inoculated FHB nursery, the average severity, incidence and FHB index were 40.9%, 42.2%, and 19.3%. Both soft red and soft white winter wheat varieties with resistance to FHB have been identified.

4) key outcomes or other achievements. Data on FHB resistance will assist in management decisions and variety selection by Michigan wheat growers.

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

Nothing to report

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

Results of this work have been communicated to cooperating breeding programs to help identify resistant lines as sources of resistance for introgression into the crossing program. FHB resistance in the Michigan State Wheat Performance Trial will be reported in Michigan Farm news and online at <https://varietytrials.msu.edu/wheat>.

Project 4: *Implementing Genomic Selection for FHB Resistance in Soft Winter Wheat (SWW).*

1. What are the major goals and objectives of the project?

The major goal of this project is to quickly incorporate Fhb resistance into elite soft winter wheat breeding lines. Genomic selection enables prediction of Fhb resistance based on marker genotype. Selection candidates can be genotyped and levels of Fhb resistance estimated based on a genome wide SNP marker profile. Selected lines predicted to have high levels of resistance can be inter-mated to develop new populations with progressively higher levels of resistance. The time frame of a selection cycle using genomic selection is on the order of months compared to years of selection using phenotypic selection alone.

2. What was accomplished under these goals?

1) major activities

Hundreds of DNA isolations took place to genotype individuals and develop predictions of FHB resistance based on SNP markers. A total of 84 F_{3:4} lines and F_{2:3} families were evaluated for FHB severity, incidence and index data were collected.

2) specific objectives

In the FY16 phase of the project, phenotyping was carried out on lines predicted to have FHB resistance based on GEBVs.

3) significant results

The families and inbred lines developed in this project and evaluated in the misted and inoculated nursery had very low levels of FHB infection.

4) key outcomes or other achievements

Nothing to report.

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

Nothing to report.

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

Nothing to report.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY16 award period. 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 FY16 award period?**

No

If yes, how many?

- 2. Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY16 award period?**

No

If yes, how many?

- 3. Have any post docs who worked for you during the FY16 award period and were supported by funding from your USWBSI grant taken faculty positions with universities?**

No

If yes, how many?

- 4. Have any post docs who worked for you during the FY16 award period and were supported by funding from your USWBSI grant gone on to take positions with private ag-related companies or federal agencies?**

No

If yes, how many?

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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 FY16 award period. All columns must be completed for each listed germplasm/cultivar. Use the key below the table for Grain Class abbreviations.

Name of Germplasm/Cultivar	Grain Class	FHB Resistance (S, MS, MR, R, where R represents your most resistant check)	FHB Rating (0-9)	Year Released

Add rows if needed.

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

Abbreviations for Grain Classes

- Barley - BAR
- Durum - DUR
- Hard Red Winter - HRW
- Hard White Winter - HWW
- Hard Red Spring - HRS
- Soft Red Winter - SRW
- Soft White Winter - SWW

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Publications, Conference Papers, and Presentations

Instructions: Refer to the FY16-FPR_Instructions for detailed instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY16 grant. Only include citations for publications submitted or presentations given during your award period (4/24/16 - 4/23/17). If you did not have any publications or presentations, state 'Nothing to Report' directly above the Journal publications section.

Journal publications.

Brisco E.I., L.K. Brown and **E.L. Olson**. 2017. Fusarium head blight resistance in *Aegilops tauschii*. Genetic Resources and Crop Evolution. DOI: 10.1007/s10722-017-0495-3.

Status: Published

Acknowledgement of Federal Support: YES (publication)

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

Siler L., M. Graham, A.T. Wiersma, L.K. Brown K. McCarthy, J. Kovach, D. Pennington and **E.L. Olson**. 2016. 2016 Michigan State University Wheat Performance Trials.

Status: Published

Acknowledgement of Federal Support: YES (publication)

Nagelkirk M., **E. Olson**, D. Pennington. Results of a survey of Michigan growers to identify wheat varieties being grown and extent to which genetic resistance to Fusarium head blight is being utilized. 2016.

Status: Published

Acknowledgement of Federal Support: YES (publication)

Other publications, conference papers and presentations.

Olson E.L., Brown L.K and E.I. Brisco. 2016. Characterization of Fusarium Head Blight Resistance in *Aegilops tauschii* and QTL Discovery in Hexaploid Wheat. *US Wheat and Barley Scab Initiative Forum*. St. Louis, MO.

Status: Abstract Published and Presented

Acknowledgement of Federal Support: YES (publication)

Wiersma A.T., E.I. Brisco, L.K. Brown and **E.L. Olson**. 2016. Discovery of *Fusarium graminearum* resistance in *Aegilops tauschii* germplasm and introgression into wheat. *Crop Science Society of America Annual Meeting*. Phoenix, AZ. Poster.

Status: Abstract Published and Presented

Acknowledgement of Federal Support: YES (presentation)

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Olson E.L. June, 2016. *Wheat Breeding Program Update and Wheat Crop Conditions.*

Michigan Millers Association Annual Meeting, Michigan Millers Association, Traverse City, MI.

Status: Presented

Acknowledgement of Federal Support: YES (presentation)

Olson E.L. March, 2016. *Wheat Breeding and Genetics at Michigan State University.*

Michigan Crop Improvement Association Membership Meeting. Okemos, MI.

Status: Presented

Acknowledgement of Federal Support: YES (presentation)

Olson E.L. January, 2016. *Michigan Wheat Breeding and Genetics Program Update.*

Michigan Agri-Business Association Meeting, Lansing, MI.

Status: Presented

Acknowledgement of Federal Support: YES (presentation)