USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY17 Final Performance Report
Due date: July 31, 2018

Cover Page

Principle Investigator (PI):	Eric Olson
Institution:	Michigan State University
E-mail:	eolson@msu.edu
Phone:	517-353-0142
Fiscal Year:	2017
USDA-ARS Agreement ID:	59-0206-6-003
USDA-ARS Agreement Title:	Development of Scab Resistant Wheat Varieties for Michigan.
FY17 USDA-ARS Award Amount:	$ 98,848
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:	4/24/17 - 4/23/18
Reporting Period End Date:	4/23/2018

USWBSI Individual Project(s)

USWBSI Research Category[*]	Project Title	ARS Award Amount
VDHR-NWW	Development of Scab Resistant Wheat Varieties for Michigan.	$ 66,190
VDHR-NWW	Male Sterile Facilitated Recurrent Selection for FHB Resistance.	$ 678
VDHR-NWW	Coordinated Phenotyping of Uniform Nurseries and Official Variety Trials.	$ 1,938
VDHR-NWW	Implementing Genomic Selection for FHB Resistance in Soft Winter Wheat (SWW).	$ 5,814
VDHR-NWW	Improving Selection Efficiency for FHB and Yield in Early Stages of Breeding.	$ 24,228
	FY17 Total ARS Award Amount	$ 98,848

(signature)   7/30/2018

Principal Investigator   Date

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[*] 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

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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 among inbred lines derived from segregating populations. Novel sources of Fhb resistance are being identified in exotic germplasm to support the development of resistant varieties.
   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. Pyramid major resistance QTL using linked markers.
   D. Disseminate resistant germplasm.
   E. Communicate levels of resistance in Michigan wheat varieties.

2. **What was accomplished under these goals?** *Address items 1-4) below for each goal or objective.*

   1) Major Activities
   A. Development of breeding populations and early generation selection. Phenotypic selection was applied in 474 segregating F_2 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 2017, extremely dry weather limited FHB development in F_2 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 F_3-F_4 and F_4-F_5 generations. In fall, 2018, the F_5 seed will be planted in bulk at Mason, MI.

   A total of 691 crosses were made in fall 2016 and spring 2017 to develop segregating breeding populations. Approximately 500 crosses contain at least one FHB-resistant parent. Crosses are being advanced in bulk in the greenhouse and the F_4 seed will be planted in bulk in fall, 2018.

   B. Phenotypic evaluation of Fhb resistance in breeding germplasm. A total of 902 breeding lines were evaluated for FHB resistance in a misted and inoculated nursery. From the preliminary yield, 802 lines were 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. A total of 25 breeding program entries in the Michigan State University state performance trial 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 2017. In MSU breeding lines, these QTL appear to confer resistance singly and additively. Topcrosses were made in spring 2017 to pyramid multiple QTL.

D. Dissemination of resistant germplasm. For regional FHB resistance evaluation seven entries were submitted to the Uniform FHB nurseries. The predicted QTL for FHB resistance derived from *Ae. tauschii* was found to be ineffective and a statistical anomaly. MI14R0267 was found to have high levels of resistance due in part to the Massey 3BL QTL and is being used extensively in the development of new breeding populations.

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. A total of five talks were given to agribusiness and growers that included messages regarding the benefits of planting resistant varieties.

2) Specific Objectives

A. Crosses incorporating Fhb resistance. Selections were made in 474 segregating F_2 populations in spring, 2017. The F_3 seed was vernalized in germination boxes, grown and harvested in bulk in the greenhouse. The F_4 seed was again vernalized in germination boxes, grown and harvested in bulk in the greenhouse. The F_5 seed was planted in the bulk plots in fall, 2017 and single plant selections were made in spring, 2018.

Both molecular marker and phenotypic information were used to make 691 crosses incorporating FHB resistance in to breeding populations. The F_4 seed from all populations has been produced in the greenhouse and will be planted in bulk in the field in fall, 2018.
B. Identification advanced breeding lines with Fhb resistance. Phenotypic selection for FHB resistance was done on 902 breeding lines 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 consistently demonstrates 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 soft white winter wheat, MI14W0064 has been released as 'Whitetail'. This line has significantly improved resistance to FHB over the widely planted soft white winter wheat varieties Ambassador and Jupiter. The high and stable yield of this line

will contribute to replacement of highly susceptible varieties on soft white winter wheat acres in Michigan.

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.

The "minibulk" method of rapid generation advancement is now being applied at the F_2 and F_3 in all early generations to remove one year from the breeding cycle. Selection is now made in the field on F_4 individuals. The savings of one year has synchronized the 2017 and 2016 crosses and 1,165 populations will be planted in the field in fall, 2018.

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 in 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 2017 project have been communicated to all industry stakeholders. Results were communicated in three talks given to the Michigan Agri-Business Association, Michigan Millers Association, Michigan Crop Improvement Association.

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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?** *Address items 1-4) below for each goal or objective.*

   1) major activities. Inbred lines were extracted from segregating populations in summer, 2015, and were planted in 2016 preliminary yield trials. One line, MI15R0416 was tested in the replicated advanced yield trial in five locations across Michigan.

   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

(Form – FPR17)

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

1. **What are the major goals and objectives of the project?**
    A. Phenotype advanced breeding lines that are candidates for release
    B. Place FHB and other agronomic, disease resistance, and quality data in a database
    C. Report on purification and seed increase of the best lines.

2. **What was accomplished under these goals?** *Address items 1-4) below for each goal or objective.*

    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 and results are being reported in the 2018 wheat performance trial results.

    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.

    The Uniform FHB nurseries are a valuable source of resistant germplasm. At least ten new lines from this nursery are used in crosses each year.

    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 are reported in Michigan Farm news and online at https://varietytrials.msu.edu/wheat.

(Form – FPR17)

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? *Address items 1-4) below for each goal or objective.*

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 78 $F_{3:4}$ lines and $F_{2:3}$ families were evaluated for FHB severity, incidence and index data were collected.

2) specific objectives

In the FY17 phase of the project, phenotyping was carried out to identify inbred lines with high levels of FHB resistance based on GEBVs.

3) significant results

The families and inbred lines developed in this project had the lowest levels of FHB infection in the entire FHB nursery of breeding lines and commercial varieties. The germplasm developed in this project will be a valuable for the development of FHB-resistant wheat varieties.

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 5: *Improving Selection Efficiency for FHB and Yield in Early Stages of Breeding.*

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

    A. To implement GS for FHB resistance in soft winter wheat by completing two cycles of GS.
    B. Initiate evaluation of the effectiveness of GS.

2. **What was accomplished under these goals?** *Address items 1-4) below for each goal or objective.*

    1) major activities
       A. *To implement GS for FHB resistance.* DNA was isolated for 1,880 F_4-derived lines at OSU. The DNA was quantified and normalized at MSU. Sequencing libraries are currently under preparation
       B. *Evaluate the effectiveness of GS.* Nothing to report

    2) specific objectives
       Genotyping of lines is currently underway. The marker data generated will be used in combination with phenotypic data to develop prediction models. The highest yielding and FHB-resistant genotypes will be intercrossed to produce segregating populations. Predictions will be made among progeny of these crosses to select high yielding, FHB-resistant individuals.

    3) significant results   Nothing to report

    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

(Form – FPR17)

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY17 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 FY17 award period?** Yes

   If yes, how many? One

2. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY17 award period?** Yes

   If yes, how many? Two

3. **Have any post docs who worked for you during the FY17 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 FY17 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?

Release of Germplasm/Cultivars

Instructions: In the table below, list all germplasm and/or cultivars released with <u>full or partial</u> support through the USWBSI during the <u>FY17 award period</u>. All columns must be completed for each listed germplasm/cultivar. Use the key below the table for Grain Class abbreviations. *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 (S, MS, MR, R, where R represents your most resistant check)	FHB Rating (0-9)	Year Released
'Whitetail' (MI14W0064)	SWWW	MS	5	2017
Check MI14W0190 (Fhb1)	SWWW	R	1	

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

Publications, Conference Papers, and Presentations

Instructions: Refer to the FY17-FPR_Instructions for detailed instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY17 grant. Only include citations for publications submitted or presentations given during your award period (4/24/17 - 4/23/18). If you did not have any publications or presentations, state 'Nothing to Report' directly above the Journal publications section.

NOTE: Directly below each reference/citation, you must indicate the Status (i.e. published, submitted, etc.) and whether acknowledgement of Federal support was indicated in publication/ presentation.

Journal publications.
Nothing to report

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

Siler L., M. Grahm, A.T. Wiersma, L.K. Brown K. McCarthy, J. Kovach, D. Pennington and **E.L. Olson**. 2017. 201 Michigan State University Wheat Performance Trials.
Status: Published
Acknowledgement of Federal Support: YES (publication)

Other publications, conference papers and presentations.

Olson E.L. June, 2017. *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, 2017. *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, 2017. *Michigan Wheat Breeding and Genetics Program Update*. Michigan Agri-Business Association Meeting, Lansing, MI.
Status: Presented
Acknowledgement of Federal Support: YES (presentation)