USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY14 Final Performance Report
July 15, 2015

Cover Page

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Fiscal Year:	FY14
USDA-ARS Agreement ID:	59-0206-1-114
USDA-ARS Agreement Title:	FHB Resistant Soft Wheat for Michigan and the Eastern Soft Wheat Region.
FY14 USDA-ARS Award Amount:	$ 66,464

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
VDHR-NWW	FHB-Resistant Wheat Varieties for Michigan and the Great Lakes Region.	$ 60,311
VDHR-NWW	Male Sterile Facilitated Recurrent Selection for FHB Resistance (MPI-5).	$ 681
VDHR-NWW	Coordinated Phenotyping of Uniform Nurseries and Official Variety Trials.	$ 1,946
VDHR-NWW	Implementing Genomic Selection for FHB Resistance in Soft Winter Wheat (SWW) Adapted to the Corn Belt.	$ 3,526
	FY14 Total ARS Award Amount	**$ 66,464**

7/15/2015

Principal Investigator Date

* MGMT – FHB Management
FSTU – Food Safety, Toxicology, & Utilization of Mycotoxin-contaminated Grain
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
WES-CP – Western 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: *FHB-Resistant Wheat Varieties for Michigan and the Great Lakes Region.*

1. **What major problem or issue is being resolved relevant to Fusarium head blight (scab) and how are you resolving it?**

   Preventing the mycotoxin, deoxynivalenol (DON), from entering the wheat value chain in Michigan is critical. The soft winter wheat produced in Michigan is used directly by the milling industry to produce flour and cereal products products consumed directly by humans. Soft white wheat is highly sought after by Michigan milling companies and cereal industries but requires intensive management combined with genetic resistance to control infection and maintain low mycotoxin levels in harvested grain. Controlling DON at the production level by developing resistant varieties will mitigate the impact of DON on the milling industry and consumers.

   The mission of the Michigan State University Wheat Breeding and Genetics program is to provide Michigan wheat producers with high-yielding, high-quality wheat varieties with exceptional resistance to Fhb and DON. Hundreds of crosses are made annually with Fhb-resistant line to incorporate resistance alleles into breeding populations. A combination of classical phenotypic selection and marker assisted selection methods are employed in developing resistant varieties. With the current scale and scope of MSU-WBG, new Fhb resistant varieties will have yield potential far exceeding that of current susceptible varieties.

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 1:</u>
Soft White Winter Wheat, E6012. In 2014, MSU-WBG has released a new soft white winter wheat variety. E6012 (Caledonia/P25W33) is a soft white winter wheat adapted to Michigan growing environments. E6012 is fully awned and short statured with white chaff. The early maturity of E6012 will enable growers to spread their maturities from early to late. Yield potential is stable and comparable to contemporary soft white winter wheat varieties grown in Michigan.

The most distinguishing trait E6012 carries is resistance to DON under heavy Fhb pressure. Across four years of evaluation in a misted-inoculated Fhb nursery, E6012 accumulates 6.5 ppm in contrast to DON levels of over 11 ppm in the widely planted varieties AC Mountain, Ambassador and Hopewell ($LSD_{0.05}$ = 2.3 ppm). The resistance to DON in E6012 is likely conferred in part by a known Fhb resistance QTL carried on chromosome 5A. E6012 Fhb incidence and severity are similar to trial means.

E6012 demonstrated a four-year average yield of 84.8 bu/Ac which is not significantly different ($LSD_{0.05}$ = 3.9 bu/Ac) from contemporary Michigan soft winter wheat varieties AC Mountain, Aubrey, Hopewell, Jupiter, Shirley and Red Ruby. Although yield potential is not the highest of all varieties tested, yields are not different from contemporary varieties. Yield stability of E6012

is improved over varieties that perform well in Michigan but were not developed and selected as varieties in Michigan. An example of contrasting yield stability is the soft red winter wheat variety, Shirley, which has a four-year average of 87.1 bu/Ac and yielded 79.4 bu/Ac in 2014, a 7.7 bu/Ac difference. E6012 has consistently yielded between 84 and 86 bu/Ac each year of testing.

Impact 1:
The release of E6012 will provide Michigan wheat growers, particularly white wheat growers, with a wheat variety having stable yield and strong resistance to DON accumulation. With the adoption of E6012, a greater proportion of Michigan wheat acres will be protected from Fhb and mycotoxin accumulation. Growers will experience less risk in planting E6012. The milling industry in Michigan will see greater stability in grain quality and supply. Consumers will experience a safer food supply.

Accomplishment 2:
A total of 865 crosses were made in between January 2014 and May 2015. Approximately half of all crosses were with at least one parent carrying Fhb resistance. The F2 populations have been generated or are currently being developed in the greenhouse. In September, populations will be planted in to 50' bulk plots of 700 to 1000 individuals.

In 2015, 734 F_2 bulk populations were inoculated with 30lb. per acre of barley grain spawn. From 10 to 20 individual spikes were selected per population. The F_3 seed will be screened through a color seed sorter to cull out FDKs. Presumably, seed from susceptible plants will be discarded and phenotypic selection is being applied for Fhb resistance at the F_2 generation.

A strategy of QTL enrichment in F_1 topcrosses has been implemented. An F_1 is generated between two individuals, each with at least one, usually two, Fhb resistance QTL that are unlinked. Four to five QTL are then present in a heterozygous state. The enriched F_1 is then crossed to an elite parent.

Impact 2:
With support from the USWBSI, soft winter wheat breeding populations are being developed that will have high levels of Fhb resistance in addition to high yield potential. MSU-WBG is provided with the manpower to make hundreds of crosses that enrich the breeding program for resistance alleles. Phenotypic selection can be applied as early as possible in the breeding cycle to cull susceptible genotypes and increase the frequency of resistance alleles ensuring that all genotypes advanced in the breeding program carry high levels of Fhb resistance.

Project 2: *Male Sterile Facilitated Recurrent Selection for FHB Resistance (MPI-5).*

1. What major problem or issue is being resolved relevant to Fusarium head blight (scab) and how are you resolving it?

The length of the wheat breeding cycle precludes methods like recurrent selection to quickly enrich populations for valuable alleles. Conventionally, wheat is inbred for several years to fix additive genetic variance. Lines are then evaluated in replication to select on the Fhb resistance present among lines. The entire process of inbreeding, selection and using resistant lines as parents can take up to five years.

Using the male-sterile system in wheat allows selection cycles, selection can be applied within a single season. Resistant plants can be selected and crossed within a single growing season. Methods used in this project drastically reduce the selection cycle for Fhb resistance in soft winter wheat.

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:

Fifteen lines have been derived from segregating male-sterile populations. Headrows of these lines were evaluated in the field in spring 2015 under heavy natural Fhb inoculum as well as pressure from Septoria, Cephalosporium, Bacterial Leaf Streak and Leaf Rust. Five lines have been advanced to preliminary yield trials and will be planted in fall 2015.

Impact:

The capacity to quickly select on Fhb resistance and accumulate resistance alleles within genotypes has enabled the rapid advancement of highly resistant lines in to yield trials. This project furthers to goal of providing wheat growers with Fhb-resistant varieties that outcompete the yield potential of susceptible varieties.

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

1. **What major problem or issue is being resolved relevant to Fusarium head blight (scab) and how are you resolving it?**

Planting Fhb resistant varieties is critical component of controlling scab. The combination of high yield potential and strong resistance to Fusarium head blight (Fhb) is not present in most varieties planted by wheat growers in Michigan. The most widely planted and recommended varieties have stable and high yield potential but are the most susceptible to Fhb.

In order for growers to make informed planting decisions and manage the risk of Fhb, they must have data on the levels of resistance and susceptibility of the varieties available to them. The MSU wheat breeding and genetics program evaluates the Michigan Wheat Variety trials in the inoculated Fhb nursery and provides data on incidence, severity and DON levels. Results are published and made available to agronomists and growers, enabling informed decisions to plant Fhb resistant varieties.

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:

An Fhb screening nursery comprised of over ~4000 headrows was used to generate valuable phenotypic data on Fhb incidence, severity, Fusarium damaged kernels and DON levels. A total of 94 entries in the Michigan Wheat Performance Trials were evaluated in four replicates. Fhb data are reported in trials results at varietytrials.msu.edu. The Preliminary and Northern Uniform Winter Wheat Nurseries were both evaluated. Other nurseries include the Uniform Eastern Red and White Wheat nurseries. Additionally, all 750 MSU preliminary breeding lines were evaluated in two replications. Data is currently being analyzed and will be provided to the project coordinator and collaborators.

Impact:

Efforts made in generating Fhb resistance data from variety trials and cooperative nurseries support the selection of resistant varieties by growers and development of resistant varieties by breeding programs. In Michigan, the sole source of information on variety resistance is the Fhb nursery operated by MSU-WBG. This information is used by MSU Extension personnel in developing fact sheets as well as by industry in order to better market resistant genotypes. Ultimately, growers are provided the information needed to make informed decisions to plant resistant varieties. By screening cooperative nurseries, breeding programs are provided valuable data on resistance. The nursery supports regional efforts to develop Fhb resistant varieties and germplasm.

Project 4: *Implementing Genomic Selection for FHB Resistance in Soft Winter Wheat (SWW) Adapted to the Corn Belt.*

2. What major problem or issue is being resolved relevant to Fusarium head blight (scab) and how are you resolving it?

Phenotypic selection for Fhb resistance is time consuming in that multiple generations are required to observe variation and apply selection for resistance. Genomic Selection enables the selection and advancement of resistant lines based on genotype, in the absence of phenotypic selection. It's possible to identify highly resistant genotypes in the F_2 generation and inter-mate the most resistant lines. Generations of selection for resistance can take place in the greenhouse before phenotypic selection.

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:

Multiple crosses were made between highly resistant lines derived from the MPI-4 project. The F_1s were selfed to generate F_2 plants. DNA was isolated from the F_2 and subsequently genotyped by GBS. Analysis and development of GEBVs was done by collaborators at Ohio State. Selected F_2 plants were inter-mated to generate F1s which are currently being selfed to generate a new F_2 generation. A second round of selection will be applied and the $F_{2:3}$ families will be planted in the Fhb nursery in fall, 2015.

Impact:

Using GS, it's possible to make incredible genetic gains in scab resistance in the span of several years. Populations can be enriched for resistance alleles for several generations prior to phenotypic selection. When lines are finally derived and phenotypes are observed, there will be high levels of resistance present. Genomic selection provides a means to make rapid progress in the development of Fhb resistant germplasm.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY14 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 FY14 award period?**
   N/A
   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 FY14 award period?**
   N/A
   If yes, how many?

3. **Have any post docs who worked for you during the FY14 award period and were supported by funding from your USWBSI grant taken faculty positions with universities?**
   N/A
   If yes, how many?

4. **Have any post docs who worked for you during the FY14 award period and were supported by funding from your USWBSI grant gone on to take positions with private ag-related companies or federal agencies?**
   N/A
   If yes, how many?

Include below a list of all germplasm or cultivars released with full or partial support of the USWBSI during the FY14 award period. List the release notice or publication. Briefly describe the level of FHB resistance. *If not applicable because your grant did NOT include any VDHR-related projects, enter N/A below.*

E6012 is a soft white winter wheat that demonstrates resistance to DON under heavy Fhb pressure. Across four years of evaluation in a misted-inoculated Fhb nursery, E6012 accumulates 6.5 ppm in contrast to DON levels of over 11 ppm in the widely planted varieties AC Mountain, Ambassador and Hopewell ($LSD_{0.05}$ = 2.3 ppm). The resistance to DON in E6012 is likely conferred in part by a known Fhb resistance QTL carried on chromosome 5A. E6012 Fhb incidence and severity are similar to trial means.

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 FY14 grant. Please reference each item using an accepted journal format. If you need more space, continue the list on the next page.

Presentations:
Results from both USWBI projects were presented by Eric Olson at the 2015 Michigan Agri-Business Association meeting, The Michigan Wheat Program Annual winter meeting, and The 2015 Michigan Miller's Association meeting and the 2015 Michigan Crop Improvement Association Membership meeting.

Extension Publications:
Lee Siler, Andrew Wiersma, Linda Brown, Beth Brisco, Eric Olson (2014) Michigan State Wheat Variety Trial. varietytrials.msu.edu.

Non-Peer Reviewed:
Cabrera, A., E. Olson, B. Brisco, F. Kolb, E.A. Brucker, A. Krill, M.P. Arruda, M. Sorrells, D. Van Sanford, A. Clark, A. McKendry and C. Sneller. 2014. "Phenotypic Analysis of FHB Resistance in a Soft Wheat Population for Genomewide Analyses." In: S. Canty, A. Clark, N. Turcott and D. Van Sanford (Eds.), *Proceedings of the 2014 National Fusarium Head Blight Forum.* East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative. p. 75.

Cabrera, A., M. Huang, E. Olson, B. Brisco, F. Kolb, E.A. Brucker, A. Krill, M.P. Arruda, M. Sorrells, D. Van Sanford, A. Clark, A. McKendry and C. Sneller. 2014. "Preliminary Analysis of Genomic Selection for FHB Resistance." In: S. Canty, A. Clark, N. Turcott and D. Van Sanford (Eds.), *Proceedings of the 2014 National Fusarium Head Blight Forum.* East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative. p. 76.