USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY15 Final Performance Report
Due date: July 15, 2016

Cover Page

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Fiscal Year:	2015
USDA-ARS Agreement ID:	59-0206-4-029
USDA-ARS Agreement Title:	Development of Scab Resistant Soft Red Winter Wheat Varieties.
FY15 USDA-ARS Award Amount:	$ 107,256
Recipient Organization:	The Board of Trustees of the University of Illinois Grants & Contracts Office 1901 S. First Street, Suite A Champaign, IL 61820
DUNS Number:	41544081
EIN:	37-6000511
Recipient Identifying Number or Account Number:	AA051
Project/Grant Reporting Period:	06/08/15-06/07/16
Reporting Period End Date:	06/07/16

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
VDHR-NWW	Development of Scab Resistant Soft Red Winter Wheat Varieties.	$ 98,573
VDHR-NWW	Male Sterile Facilitated Recurrent Selection for FHB Resistance (MPI-5).	$ 680
VDHR-NWW	Coordinated Phenotyping of Uniform Nurseries and Official Variety Trials.	$ 8,003
	FY15 Total ARS Award Amount	**$ 107,256**

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 Soft Red Winter Wheat Varieties.*

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

Our major objective is to develop high-yielding, well-adapted soft red winter wheat lines with high levels of scab resistance. This is essential in order to minimize the damage from FHB. Development and deployment of FHB resistant lines has a major impact on wheat production and increases the stability of wheat yields and economic return from wheat.

As more lines with good to excellent scab resistance are identified we are using these parents in crosses, so that in many crosses both parents, or two parents out of three in a three-way cross, are scab resistant. We also believe that it is important to combine several types of resistance rather than rely solely on Type II resistance. We are addressing this by using the ISK index (0.3 x % incidence + 0.3 x % severity + 0.4 x % shriveled kernels) to select breeding lines with high levels of scab resistance. Development of varieties with low deoxynivalenol (DON) levels is also crucial; therefore, all breeding lines are evaluated each year for DON level.

2. What was accomplished under these goals?

1) major activities

In 2015, about 475 breeding lines from the University of Illinois wheat breeding program were evaluated. Scab resistant lines were evaluated for many traits including grain yield, milling and baking quality, standability, and resistance to diseases.

In 2014-15 we produced about 300 single crosses, and about 150 three-way and four-way crosses were made involving FHB resistance sources. About 30 F_3 and F_4 bulks were grown in the inoculated and mist irrigated FHB nursery, and heads were selected.

Soft red winter wheat breeding lines with a high level of FHB resistance and high yield potential were increased for potential release for licensing and potential commercial production. Ten lines were approved for release in early 2015, but no lines were advanced for release in the period covered by this report.

An association mapping panel of 273 lines (188 from the University of Illinois program) was used in Genome-Wide Association Study (GWAS) and genomic selection for FHB resistance. Phenotypic data for this graduate student study were collected in the inoculated, mist irrigated FHB field nursery. Molecular marker data were produced by genotyping by sequencing.

2) specific objectives

1) Continue selection of wheat lines with high levels of FHB resistance.
2) Evaluate all breeding lines for grain yield and test weight, milling and baking quality, standability, and resistance to other diseases.
3) Make crosses involving elite FHB resistant parents.
4) Publish results of genomic selection research to make knowledge available to other scientists.

5) Begin implementation of genomic selection in the breeding program.

3) significant results

1) All breeding lines in the program were evaluated for FHB resistance in the inoculated, mist irrigated field evaluation nursery.

2) Breeding lines were evaluated for many traits in addition to FHB resistance in order to combine FHB resistance with high grain yield and test weight, milling and baking quality, standability, and resistance to other diseases.

3) Based on the results of the genomic selection research, genomic selection for FHB resistance has been implemented at the Preliminary Yield Trial level of the wheat breeding program. This should significantly enhance our selection for FHB resistance at an early stage of the evaluation of breeding lines.

4) Genomic selection for FHB resistance and yield was implemented for the first time in the Preliminary Yield Trials (involving 378 breeding lines).

4) key outcomes or other achievements

1) Three manuscripts resulting from the research on genomic selection for FHB resistance were published.

2) Over 500,000 units of seed of scab resistant lines from the University of Illinois program were purchased by producers for the 2015-16 planting season.

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

Two graduate students completed their PhD degrees.

Two graduate students and a research specialist attended the 2015 National Fusarium Head Blight Forum, December 6-8, 2015, St. Louis, MO.

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

Three manuscripts were published. Data from cooperative nurseries were distributed to other wheat breeders.

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

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

The cooperative male sterile facilitated recurrent selection (MSFRS) populations were developed as a way to generate FHB resistant breeding lines and facilitate the combination of FHB resistant genes from different sources. Recurrent selection has the objective of increasing the frequency of desirable alleles for one or more traits while maintaining a high level of variability in the population. Intermating among selected parents each generation allows recombination to occur thus combining genes from different sources. Male sterility provides a mechanism to easily allow recombination among FHB resistance sources. The dominant male-sterile gene was utilized to create recurrent selection populations segregating for FHB resistance because the progenies of the male-sterile plants always segregate 1:1 for sterility and a generation of selfing is not required to obtain true-breeding fertile genotypes. Our objective was to create four populations with FHB resistance adapted to different regions of the eastern U.S. Seed from the sterile heads were planted, and their sterile offspring were tagged for harvest to repeat the process. These populations were developed over several seasons at the Ohio Agricultural Research and Development Center in Wooster, Ohio. Breeding programs in the eastern U.S. contributed FHB resistant lines to serve as pollinators. Sterile plants were selected; those highly susceptible to FHB were discarded.

2. What was accomplished under these goals?

1) major activities

In 2015 the male-sterile population was grown in the field at Urbana, IL. Sterile heads were identified and tagged. Sterile heads that were very susceptible to *Fusarium graminearium* were removed. After being harvested and threshed, *Fusarium* damaged kernels were removed by aspiration, removing approximately 50% of the kernels. Remaining seed was space planted in the fall of 2015. A mixture of FHB resistant lines from the University of Illinois breeding program was planted as pollinators in adjacent rows. Additional MS plants were identified in headrows selected from the main population. Additional cycles of mating and selection for FHB resistance will be carried out.

2) specific objectives

Continue to develop male-sterile facilitated recurrent selection populations in the eastern soft wheat region that can be used with local FHB resistant breeding lines as pollinators to further develop recurrent selection populations as a source of potential FHB resistant breeding lines with resistance from different sources.

3) significant results

We have maintained the MS gene in the population and through pollination with locally adapted FHB resistant lines we are continuing to change the population to shorter, earlier and higher level of FHB resistance. We have extracted lines from the population.

During the winter of 2015-16 we also grew male sterile plants from the population in the greenhouse and by bagging the MS plants with specific lines with high levels of FHB resistance we obtained seeds that will be used to establish a second MSFRS population.

4) key outcomes or other achievements

Selection and crossing to locally adapted FHB resistant lines is resulting in improvement in the adaptation of the population. We have grown remnant seed from successive generations and can see the changes occurring in the population.

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

One graduates student has learned to identify male sterile wheat heads and has gained experience in selection of male sterile heads.

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?

Objectives: 1) Phenotype advanced breeding lines that are candidates for release: 2) place FHB and other agronomic, disease resistance, and quality data in database: 3) provide FHB resistance data for lines and varieties in the OVT to producers and seedsmen.

Data on FHB resistance collected from the OVT entries provide information to seedsmen and producers that can be used in making decisions about which wheat varieties to produce. These data are important because they allow seedsmen and producers to use FHB resistance as one criterion in their variety selection decisions.

Coordinated evaluation of breeding lines among the programs in the NWW provides all breeding programs in the CP with FHB resistance data from multiple locations in a single season. This coordinated evaluation of breeding material plays an important role in the identification of breeding lines with high levels of FHB resistance. Our objective is to cooperatively obtain information on breeding lines from various programs within the CP and the SWW CP to allow the breeders involved to make better decisions about which breeding lines to advance and release.

2. What was accomplished under these goals?

1) major activities

An inoculated, mist irrigated field evaluations nursery at Urbana, IL was used to evaluate the Fusarium Head Blight resistance of entries from the following trials by collecting data on % incidence, % severity, % Fusarium damaged kernels (FDK) and deoxynivalenol (DON) level.

- 103 entries in the Illinois Variety Trial
- 31 entries in the Uniform Eastern Soft Red Winter Wheat Nursery
- 25 entries in the Advanced Five State Nursery
- 25 entries in the Preliminary Five State Nursery
- 60 entries in the Northern Winter Wheat Scab Nursery
- 41 entries in the Preliminary Northern Winter Wheat Nursery
- 49 entries in the Southern Winter Wheat Scab Nursery

2) specific objectives

1) Provide data on OVT entries to seedsmen and producers.

2) Collect data on FHB resistance of entries in uniform cooperative nurseries and distribute data to cooperators.

3) significant results

1) Data from the Illinois Variety Trial were summarized and distributed.

2) Data collected on cooperative nurseries were made available to cooperators in each nursery to facilitate selection of FHB resistant breeding lines.

3) Lines from the Univ. of Illinois program were submitted for all of the cooperative nurseries, thus, breeding lines with FHB resistance were made available to other breeding programs for use as germplasm. Five University of Illinois breeding lines (out of five entries) were among the most FHB resistant lines in the 2015 NUWWN and five University of Illinois breeding lines (out of five entries) were among the most FHB resistant lines in the 2015 PNUWWN.

4) key outcomes or other achievements

1) FHB resistance data collected from the Illinois Variety Trial were summarized and the data made available to producers and seedsmen.

2) Data collected on cooperative nurseries were made available to cooperators in each nursery to facilitate selection of FHB resistant breeding lines.

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?

FHB resistance data collected from the Illinois Variety Trial were summarized and the data made available in the annual Variety Trial Report and on the Illinois Variety Trial website (http://vt.cropsci.illinois.edu/wheat.html). Handouts summarizing the 2015 data and data over multiple years were prepared, discussed and distributed at several producer/seedsmen meetings including the Illinois Soybean Association Double Crop Conference (Feb.10, 2016, Mount Vernon, IL) and the Southern Illinois Wheat Tour (May 26, 2016, Belleville, IL).

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY15 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 FY15 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 FY15 award period?**

   Yes.

   If yes, how many? Two.

3. **Have any post docs who worked for you during the FY15 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 FY15 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 full or partial support through the USWBSI during the FY15 award period. 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**

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

Refer to the FY15-FPR_Instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY15 grant. If you did not have any publications or presentations, state 'Nothing to Report' directly above the Journal publications section.

Journal publications.

Arruda M.P., A.E.Lipka , P.J.Brown, A.M. Krill, C. Thurber, G. Brown-Guedira, Y. Dong, B.J. Foresman, F.L. Kolb. 2016. Comparing genomic selection and marker-assisted selection for Fusarium head blight resistance in wheat (*Triticum aestivum* L.). Molecular Breeding 36:84
DOI 10.1007/s11032-016-0508-5
Status: Published
Acknowledgement of Federal Support: YES

Arruda, M.P., P. J.Brown, G. Brown-Guedira, A.M. Krill, C. Thurber, K.R.Merrill, B. J. Foresman, and F. L. Kolb. 2016. Genome-wide association mapping of Fusarium head blight resistance in wheat using genotyping-by-sequencing. The Plant Genome 9
doi: 10.3835/plantgenome2015.04.0028
Status: Published
Acknowledgement of Federal Support: YES

Arruda, M.P., P. J. Brown, A.E. Lipka, A.M. Krill, C. Thurber, and F. L. Kolb. 2015. Genomic selection for predicting Fusarium head blight resistance in a wheat breeding program. The Plant Genome 8: doi:10.3835/plantgenome2015.01.0003
Status: Published
Acknowledgement of Federal Support: YES

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

Other publications, conference papers and presentations.

Bissonnette, K.M., F.L. Kolb, Y. Dong, K. A. Ames, and C. A. Bradley, 2015. Effectiveness of FHB indices in estimating straw DON accumulation in winter wheat cultivars. In: S. Canty, A. Clark, S. Vukasovich, and D. Van Sanford (Eds.). *Proceedings of the 2015 National Fusarium Head Blight Forum*. pp. 3-4. East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
Status: Abstract published and poster presented
Acknowledgement of Federal Support: YES

Cabrera, A., J. Isidro, E. Olson, B. Brisco, F. Kolb, E.A. Brucker, A. Krill, M.P. Arruda, M. Sorrels, D. Van Sanford, A. Clark, A. McKendry and C. Sneller. 2015. Utilizing genomic selection to accelerate the pace of developing resistant varieties. In: S. Canty, A. Clark, S. Vukasovich, and D. Van Sanford (Eds.). *Proceedings of the 2015 National Fusarium*

Head Blight Forum. p. 80. East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
Status: Abstract associated with oral presentation published
Acknowledgement of Federal Support: NO

Krill, A.M., M. P. Arruda, P.J. Brown, A.E. Lipka, G. Brown-Guedira, and F. L. Kolb**.** 2015. Incorporation of genomic selection into the University of Illinois soft red winter wheat breeding program. In: S. Canty, A. Clark, S. Vukasovich, and D. Van Sanford (Eds.). *Proceedings of the 2015 National Fusarium Head Blight Forum*. p. 93. East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.
Status: Abstract published and poster presented
Acknowledgement of Federal Support: Not in abstract but in the poster presentation.