USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY14 Final Performance Report
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Cover Page

PI:	Frederic L. Kolb
Institution:	University of Illinois
Address:	Department of Crop Sciences 1102 S. Goodwin Ave. Urbana, IL 60801
E-mail:	f-kolb@illinois.edu
Phone:	217-333-9485
Fax:	217-333-9817
Fiscal Year:	FY14
USDA-ARS Agreement ID:	59-0206-4-029
USDA-ARS Agreement Title:	Development of Scab Resistant Soft Red Winter Wheat Varieties.
FY14 USDA-ARS Award Amount:	$ 98,490

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
VDHR-NWW	Development of Scab Resistant Soft Red Winter Wheat Varieties.	$ 89,798
VDHR-NWW	Male Sterile Facilitated Recurrent Selection for FHB Resistance (MPI-5).	$ 681
VDHR-NWW	Coordinated Phenotyping of Uniform Nurseries and Official Variety Trials.	$ 8,011
	FY14 Total ARS Award Amount	**$ 98,490**

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: *Development of Scab Resistant Soft Red Winter Wheat Varieties.*

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

   The major issue is that producers need varieties with high levels of scab resistance. We are working on the development of high-yielding, well-adapted, scab resistant lines. As more lines with good 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. **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: Data on FHB resistance of varieties in the Illinois State Variety Trial in a FHB evaluation nursery were made available to producers. In 2010 we developed a new index that incorporates the severity, incidence and FDK % into a single number. Using this index we can adjust ratings to the same disease level for each season (50% ISK index). We are continuing to use this index which allows producers and others to compare the FHB resistance of varieties evaluated in different seasons. FHB resistance information for entries in the Illinois Variety trial is made each year to producers via field day handouts and talks and the Variety trial website at http://vt.cropsci.illinois.edu/wheat.html.

   Impact: In order to use FHB resistance as a criterion in variety selection producers must have as much information as possible on FHB resistance. The FHB resistance data provide very useful information to Illinois seedsmen and producers and allows them to use FHB resistance as a criterion in variety selection. Producers and seedsmen have a three year summary of data of FHB resistance and DON level that can be used in decisions about what varieties to produce.

   Accomplishment: In 2014, about 490 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.

   Impact: Sustained annual selection for FHB resistance in the inoculated, misted field nursery has significant long-term impact by assuring that new varieties will be FHB resistant. Constant selection for FHB resistance in the breeding program is essential in order to identify breeding lines with FHB resistance and also to discard FHB susceptible lines early so that resources are not wasted evaluating FHB susceptible lines. The constant selection pressure applied using evaluation in misted, inoculated nurseries is essential in reducing DON. Using

the field based selection for FHB each year is having a major impact in developing FHB resistant lines. In our Advanced, Preliminary and single plot experiments we are seeing more and more lines with FHB resistance combined with excellent adaption and high yield.

Accomplishment: In 2014-15 we produced about 300 single crosses and about 155 three-way and four-way crosses were made involving FHB resistance sources. Marker assisted selection (MAS) was used for F_2 enrichment for the 3BS resistance locus was done in ten single cross pop three 3-way and three 4-way cross populations (MAS done in cooperation with Gina Brown-Guedira, USDA-ARS). About 27 F_3 and F_4 bulks were grown in the inoculated and mist-irrigated FHB nursery and heads were selected.

Impact: The crosses of scab resistant parents by adapted high yielding parents will provide populations that can be used for development of scab resistant varieties. These crosses are the source of variability that will be used for future development of scab resistant soft red winter wheat varieties.

Accomplishment: Soft red winter wheat breeding lines with a high level of FHB resistance (better than Bess) with high yield potential were increased for potential release for licensing and potential commercial production. Ten lines were approved for release in early 2015.

Impact: Lines that enter commercial production provide seedsmen and producers with additional FHB resistant varieties. The availability of improved varieties with FHB resistance provides additional choices for seedsmen and producers and contributes to an overall reduction in DON and decreased susceptibility to FHB. For the seed industry in this part of the Midwest, release of breeding lines for licensing results in breeding lines being grown on larger acreages than release as a named variety. Thus, licensing results in greater impact than release as a public variety because there is no marketing for a public variety.

Accomplishment: An association mapping panel of 273 lines (188 from the University of Illinois program) was used in 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. A manuscript resulting from this research has been accepted by The Plant Genome.

Impact: The studies on genomic selection and the use of various models will be very useful in the application of genomic selection in wheat breeding programs. The studies have resulted in the identification of QTL important for selection for FHB resistance in our breeding material and should improve the efficiency of our selection for FHB resistance. These studies may also have broad implications for the application of genomic selection in wheat for FHB resistance as well as other complex traits. The phenotyping was conducted in our USWBSI funded FHB nursery, but much of the support for this project came from other sources. Thus, this is an example of leveraging USWBSI funds.

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 cooperative male sterile facilitated recurrent selection 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. **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: In 2014 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 2014. A mixture of FHB resistant lines from the University of Illinois breeding program was planted as pollinators in adjacent rows. Additional cycles of mating and selection for FHB resistance will be carried out.

   Impact: Male-sterile facilitated recurrent selections populations developed in the eastern soft wheat region 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.

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?**

   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) report on purification and seed increase of the best lines.

   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. **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: 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. Four University of Illinois breeding lines (out of four entries) were among the most FHB resistant lines in the 2014 NUWWN and five University of Illinois breeding lines (out of five entries) were among the most FHB resistant lines in the 2014 PNUWWN. Nine out of the nine Illinois entries in these two nurseries had low average DON levels.

   Impact: Exchange of FHB resistant breeding lines among programs is essential and will contribute to the development of FHB resistant varieties. Obtaining FHB resistance data for entries in the cooperative nurseries from many environments allow wheat breeders to make better selection decisions about what lines to advance for further evaluation. Breeding lines from the University of Illinois breeding program were made available to other breeding programs for use as parents if the breeders wish to use them.

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?**

   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 FY14 award period?**

   Yes

   If yes, how many? One

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?**

   No

   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?**

   No.

   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.*

The ten lines in **bold** in the tables below were approved for release in 2015 for licensing for commercial production.

Performance of University of Illinois lines and checks averaged over years 2012 - 2014 in the Advanced trials

	Urbana, IL					Brownstown, IL			
Name	Yield	Yield - % of mean	Test Weight	Height	Heading Date	Yield	Yield - % of mean	Test Weight	Height
	(bu/A)		(lbs/bu)	(in)	(Julian)	(bu/A)		(lbs/bu)	(in)
07-18533-3	**88.9**	**104**	**60.2**	**37.7**	**132.6**	**75.1**	**105**	**60.4**	**37.6**
07-30502-2	**92.2**	**107**	**59.3**	**36.2**	**131.6**	**73.9**	**103**	**59.0**	**34.7**
09-3264	**97.6**	**114**	**60.0**	**34.8**	**131.1**	**75.6**	**106**	**59.8**	**33.2**
10-19464*	**114.1**	**133**	**60.7**	**37.8**	**141.9**	**79.6**	**111**	**58.9**	**37.1**
10-19516*	**102.9**	**120**	**60.0**	**37.1**	**141.1**	**75.2**	**105**	**59.8**	**36.9**
10-21934*	**104.9**	**122**	**60.2**	**36.5**	**139.4**	**82.3**	**115**	**59.8**	**37.1**
10-21937*	**101.3**	**118**	**59.7**	**37.4**	**139.3**	**80.6**	**113**	**59.4**	**37.4**
02-19463-5**	**91.7**	**107**	**59.0**	**33.7**	**139.7**	**80.5**	**113**	**58.3**	**37.0**
02-19463-7**	**95.2**	**111**	**59.7**	**36.3**	**138.3**	**85.4**	**120**	**59.2**	**38.7**
02-19463-8**	**103.8**	**121**	**60.2**	**35.0**	**138.7**	**84.6**	**118**	**59.1**	**35.7**
Bess	84.1	98	59.3	36.3	133.9	68.9	97	59.0	36.6
Kaskaskia	75.3	88	59.6	40.1	136.4	61.8	87	59.7	37.8
Pio 25R47	87.7	102	56.8	34.9	133.8	77.3	108	56.5	34.7
Pio 25R62	92.6	108	56.6	35.2	133.1	73.8	103	55.6	33.8
Trial average	**85.8**		**59.8**	**36.7**	**132.5**	**71.4**		**59.7**	**36.5**
$LSD_{0.05}$	**5.4**		**1.8**	**1.9**	**1.8**	**10.2**		**1.3**	**2.5**
CV (%)	**9.8**		**1.6**	**3.4**	**1.0**	**9.6**		**1.4**	**4.6**
No. of trials	**9**		**7**	**9**	**9**	**9**		**6**	**9**

*2012 data from Preliminary trials

**2014 data only

Performance of University of Illinois lines and checks averaged over years 2012 - 2014 in the disease trials

				Scab Evaluation Nursery			
Name	Leaf Blight	Leaf Rust	Stripe Rust	FHB Index	Kernel Rating	ISK Index	DON
	(0-9)	(0-9)	(0-9)	(0-100)	(%)	(0-100)	(ppm)
07-18533-3	**5.7**	**1.0**	**5.0**	**35.1**	**33.0**	**51.0**	**7.9**
07-30502-2	**7.3**	**1.0**	**5.8**	**26.1**	**34.0**	**50.5**	**5.8**
09-3264	**3.8**	**1.0**	**4.3**	**28.1**	**44.0**	**53.6**	**5.0**
10-19464*	**4.4**	**3.0**		**23.4**	**31.0**	**46.7**	**7.4**
10-19516*	**4.1**	**4.0**		**21.6**	**28.0**	**45.4**	**6.2**
10-21934*	**5.5**	**5.5**		**23.8**	**21.0**	**42.7**	**7.0**
10-21937*	**5.9**	**6.5**		**17.9**	**18.0**	**38.2**	**5.1**
02-19463-5**	**7.0**			**40.0**	**20.0**	**50.5**	**4.1**
02-19463-7**	**7.0**			**36.7**	**17.5**	**45.6**	**2.7**
02-19463-8**	**4.7**			**30.5**	**37.0**	**52.3**	**2.9**
Bess	4.6	2.0	3.8	22.7	40.0	50.1	11.0
Kaskaskia	5.6	1.0	3.3	83.3	55.0	77.0	7.5
Pio 25R47	3.4	1.0	1.3	61.3	50.0	68.8	10.5
Pio 25R62	3.5	2.0	1.3	45.9	81.0	76.0	14.4
Trial average	**5.2**	**1.4**	**5.1**	**29.5**	**34.3**	**50.6**	**6.0**
$LSD_{0.05}$	**1.8**	**1.0**	**1.6**	**15.4**	**19.6**	**11.3**	**3.6**
CV (%)	**24.7**	**50.6**	**26.4**	**34.9**	**34.1**	**13.4**	**31.7**
No. of trials	**12**	**1**	**6**	**6**	**6**	**6**	**6**

*2012 data from Preliminary trials

**2014 data only

Leaf Blight data from Urbana 2014-2013, Brownstown 2013, St.

Leaf Rust data from Brownstown 2012

Stripe Rust data from Urbana 2012 and Brownstown 2012

FHB data from Urbana Scab nursery 2014-2012

Leaf blight, leaf rust, stripe rust:
0 = no symptoms, 9 = severe symptoms

Incidence = the percent of heads in a row with symptoms.
Severity = the percent of spikelets in a head with symptoms.
FHB Index = incidence x severity/100.
Kernal rating = percent of shriveled seed.
ISK Index combines incidence, severity, and % shriveled seed.

Varieties with greater resistance have lower numbers

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.

Arruda, Marcio P., Patrick J. Brown, Alexander E. Lipka, Allison M. Krill, Carrie Thurber, and Frederic L. Kolb, 2015. Genomic selection for predicting *Fusarium* head blight resistance in a wheat breeding program. The Plant Genome (in press).

Abstracts:

Bissonnette, K.M., K.A. Ames, Y. Dong, **F.L. Kolb** and C.A. Bradley, 2014. Accumulation of *Fusarium graminearum* Mycotoxins in Wheat Straw at Various Intervals after Anthesis. for Wheat Cultivars Ranging in Susceptibility to Fusarium Head Blight. In: S. Canty, A. Clark, N. Turcott, and D. Van Sanford (Eds.), *Proceedings of the 2014 National Fusarium Head Blight Forum (* p 4). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.

Arruda, M.P., A.M. Krill, P.J. Brown, C. Thurber and **F.L. Kolb**. 2014. Genomic Selection for Fusarium Head Blight Resistance in a Soft Red Winter Wheat (*Triticum aestivum* L.) Breeding Program. In: S. Canty, A. Clark, N. Turcott, and D. Van Sanford (Eds.), *Proceedings of the 2014 National Fusarium Head Blight Forum (* p. 72). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.

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 (* p. 75). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.

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 (* p. 75). East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative.