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:	59-0206-4-028
USDA-ARS Agreement Title:	Improvement of Soft Winter Wheat that is Resistant to FHB and Adapted to Eastern USA.
FY14 USDA-ARS Award Amount:	$ 66,864

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
VDHR-NWW	Improvement of Soft Winter Wheat that is Resistant to FHB and Adapted to Indiana.	$ 64,512
VDHR-NWW	Male Sterile Facilitated Recurrent Selection for FHB Resistance (MPI-5).	$ 681
VDHR-NWW	Coordinated Phenotyping of Uniform Nurseries and Official Variety Trials.	$ 1,671
	FY14 Total ARS Award Amount	**$ 66,864**

Mohsen Mohammadi, PhD — July 14, 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

Note: I took over Professor Herbert Ohm's wheat research program in April 2016 and reviewed the breeding program history. In this report, I will describe the research activities that were conducted by two recent graduate students under the advisory of Dr. Christie Williams and the field-based phenotyping work conducted by Mr. Andrew Linvill over the course of this ARS grant agreement # 59-0206-4-028 for the FY14.

Project 1: *Improvement of Soft Winter Wheat that is Resistant to FHB and Adapted to Indiana.*

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

Major problems: Fusarium head blight (scab) disease decreases the quantity and quality of wheat crop. The goals of our research program are to build host resistance in soft red winter wheat and education of next generation plant breeders and scientists. To build adequate host resistance, we 1) introduce and pyramid native and exotic sources of resistance to deliver high yielding and FHB resistance breeding lines and varieties; and 2) increase our knowledge of genetic maps and markers that are linked to resistance loci to increase the efficiency of marker assisted introgression of FHB resistance into high yielding germplasm.

How are you resolving: Two highly qualified PhD students were trained and obtained their PhD degree i.e., Drs. Xiangye Xiao (XX) and Jin Sun (JS). XX and JS each accomplished one breeding project and one genetic study. I have organized their accomplishments into two sections of breeding projects and genetic studies.

Breeding projects:

Pyramiding exotic and native sources of resistance in breeding lines (XX): An early generation heterozygous population 07469 (pedigree=992059A1-11/INW0315//981358C1-4-2-13/97462A1-21-1-5-1-15/5/0128A1-36/3/Chinese Spr.ph1b/KS24-2(275-4)//Chinese Spr./4/0128A1-36 and) was crossed with the wheat line "Wheater" and then top crossed into five adapted lines i.e., 1026A, 1065RA, P25R62, 1070RA, and 106A. Another early generation heterozygous population 07117 (pedigree=INW0411/3/Chinese Spr ph1b/KS24-2-2(275-4)//Chinese Spr/4/0128A1-36/INW0411/5/99840C4-8-4-11) was crossed with the wheat line Wheater and then top crossed into Roane. The top-crosses were all with adapted germplasm. The resulting F_1 was once again backcrossed into the adapted parents. The resulting backcross (BC) populations were selfed to at least BC_1F_4 generations. Both 07469 and 07117 segregated for a tall wheatgrass (*Thinopyrum ponticum*) translocation which harbors type II FHB resistance QTL (*Qfhs.pur-7EL*). 07469 may carry a second 7EL-7DL translocation from intermediate wheatgrass (*Th. intermedium*) which harbors the barley yellow dwarf virus resistance gene, *Bdv3* (Xiangye Xiao's PhD Thesis) and the wheat line "Wheatear " carries a 7EL-7DL translocation from tall wheatgrass which harbors a gene block for leaf rust and stem rust resistance (*Lr19/Sr25*). All adapted lines carry the type II QTL *Fhb1*. This project demonstrates an applied example of introgression of exotic sources and pyramiding them into adapted breeding germplasm that already have a resistance QTL

(i.e., *Fhb1*). The 2012 transplant nursery appeared to have an excellent disease developing conditions. Therefore, I based my judgment on this dataset and germplasm resources to move these breeding populations forward in our pipeline.

Pyramiding type I and type II sources of resistance in breeding lines (JS): A collection of germplasm with either type I (Goldfield, Truman, Bess, and INW0412) or type II FHB resistance (INW0412, Sumai3, and a breeding line which contained *Qfhs.pur-7EL* introgressed from *Lophopyrum elongatum*) was considered as the founding parents. Crosses were made by Dr. Ohm among type I germplasm, among type II germplasm, and also between type I and type II germplasm to create a founding segregating population that could give rise to lines with transgressive segregation due to pyramiding resistance loci. This population was advanced and evaluated for FHB severity in 2012 and 2013 and for FHB incidence in 2013.

Genetics studies:

*Mapping type II FHB and leaf rust resistance in a wheatgrass introgression population (XX)***:** This project was focused on identification of molecular markers linked to a type II resistance QTL for FHB and a leaf rust resistance gene (*Lr19*) block which is tightly linked to the stem rust resistance gene (*Sr25*). As the three fungal pathogens threaten the wheat crop, identifying genetic solutions that harbors multiple resistance genes and QTL is always of importance to wheat breeders. This project used a population of 274 recombinant inbred (RIL) lines from the K2620 × K11463 cross for type II resistance phenotyping and genotyping using genotyping by sequencing (GBS) technique.

*Mapping type I resistance QTL in winter wheat Purdue line INW0412 (JS)***:** Preliminary field data indicated that wheat line 'INW0412' contained both type I and type II FHB resistance (unpublished data, Herbert Ohm). I received a personal communication from Dr. Jerry Johnson in UGA that the progeny of crosses he made using this Purdue line showed improved FHB resistance as well. The type II resistance in INW0412 has been inherited from the line Huapei 57-2, which was previously mapped by Bourdoncle and Ohm, (2003). A new recombinant inbred population of 198 lines was created by crossing INW0412 and 992060G1. F_8 RILs were evaluated for type I resistance to FHB in the fall 2012 and Spring 2013 greenhouse and also genotyped using GBS marker platforms.

2. List the most important accomplishment and its impact (i.e. how is it 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 (breeding projects):</u>

A total of **466** BC_1F_4 families were selected from Xiangye's PhD work that showed minimal FHB severity in transplant nursery 2012, which will be parts of materials we will be evaluating over FY16-17. This germplasm will be the basis of our population advancement and phenotypic evaluation for Fy16-17. Since Xiangye's data revealed that *Qfhs.pur-7EL* is

at least as effective for type II FHB resistance as *Fhb1*, it is anticipated that when the two QTL pyramided in a breeding lines they provide more durable resistance and perhaps less accumulation of DON. A total of 53 best families from the entire 237 families was selected on the basis of FHB severity and incidence from JS breeding project. Data from these selections will help strategize the next cycle of generation advancements, the next cycle of crosses, and subsequent germplasm releases.

Impact 1 (breeding projects):

The lines selected from these two founder populations are anticipated to have a significant advantage to the breeding industry as they combine both Type I and Type II resistance. Further field test and phenotypic evaluation will validate their agronomic performance and FHB resistance. The breeding lines can be released to other breeding programs and those with superior agronomic traits will be released to growers.

Accomplishment 2 (genetic projects):

XX's genetic study identified molecular markers that are tightly linked to the FHB-resistance QTL *Qfhs.pur-7EL* and the *Lr19/Sr25* gene block. Five lines were also identified with the resistance-associated SNP alleles in coupling with *Qfhs.pur-7EL* and *Lr19/Sr25*. In JS mapping project, at least four type I resistance QTL were identified i.e., *Qfhs.pur-1AS*, *Qfhs.pur-1BL*, *Qfhs.pur-2BL*, *Qfhs.pur-3AS*. These QTL can be used for marker assisted selection breeding. Furthermore, JS identified transgressive segregants, apparently due to combinations of multiple QTL in one or more recombinant inbred line(s).

Impacts 2 (genetic projects):

The QTL and lines identified in these genetic studies will be used in breeding programs to improve resistance to FHB.

For question 2, describe project achievements in a manner that facilitates ready communication by the Scab Initiative of its value. Explicit statements of impact are essential

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?

Major problems: Moving useful genes from one wheat variety to another using traditional breeding methods requires laborious manual emasculation and pollination. Male-sterility in a self-pollinated species greatly facilitates hybridizations without these laborious manual emasculation and pollination. The male-sterile facilitated selection method relies on natural hybridization of female gamete from male-sterile plant with the male gamete of the surrounding male fertile plants, eliminating the tedious need for emasculation of female plants. The goal of this project is to advance male-sterile facilitated recurrent selection populations that have been developed to combine genes for FHB resistance from multiple sources in soft winter wheat backgrounds adapted to the eastern U.S.

How are you resolving: This project was conducted over two consecutive cropping seasons i.e., 2013-2014 and 2014-2015 at the Agronomy Center for Research and Extension (ACRE). In 2013-2014 one strip of the male sterile population were planted, surrounded by strips of male fertile populations. At anthesis, male sterile looking heads were tagged and collectively harvested to constitute the male-sterile population of the next breeding cycle. No progeny selection was imposed. Male-sterile looking heads were collectively planted in one single strip in 2014-2015, surrounded again by strips of male fertile populations. In total, 34 male-sterile looking heads were tagged and harvested in the summer of 2015, which will be half-parents of the next breeding cycle.

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:

We have conducted two cycles of pollination of male-sterile plants with a bulk of male fertile plants. We have also learned that we could use our own high yielding and FHB resistance advanced breeding lines instead of male-fertile strips. This would 1) improve specific adaptation of progeny produced and 2) allow us to move FHB resistance QTL we have in our breeding programs to the recurrent population development scheme. For the new cycle, I intend to request a new male sterile population from Dr. Fred Kolb at UIUC.

Impact:

Male fertile looking heads from the central strip which have gone through two cycles of population development will be selected for line extraction, leaving the male sterile looking heads to become half parents of the next breeding cycle. For line extraction we will follow a head-to-row procedure and generation advancement. Advanced breeding lines will be tested for adaptation, agronomic traits, and evaluation of FHB resistance.

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?**

   Major problems: the overarching goal of breeding programs is to breed varieties that outperform not only nearby breeding sites but also do near optimal in a wide range of environments globally. Whether it is a trait like yield, or it is resistance to Fusarium head blight disease, stable expression of traits of interest (TOI) is among the most important criteria breeders and growers care about. The problem being addressed in this coordinated research project is to achieve the best yielding and widely adapted germplasm that stably express TOI over a wide range of environments.

   How are you resolving: Breeding programs that serve the soft red winter wheat region share a number of advanced breeding lines every year to make a pool of germplasm often called 5state and uniform nurseries. These nurseries will be planted in multiple locations in yield trials as well as disease inoculation nurseries. The results will help breeders to score germplasm based on yield, agronomic traits, overall adaptation to a wide range of environment, disease resistance, and last but not the least, end-use quality characteristics. We participate historically in all levels of these trials every year.

2. **List the most important accomplishment and its impact (i.e. how is it 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:</u>

   This research initiative has significantly enhanced the regional collaboration of wheat improvement and of phenotyping and genotyping for resistance to FHB and other important diseases. Identification of FHB resistance and lower DON is being done more effectively and with fewer years of testing due to the multiple locations of testing.

   <u>Impact:</u>

   FHB resistance that is consistently effective across the region is being identified. Collaborative and regional nurseries are significant decision making components of developing new cultivars that are more widely adapted and have more reliable and effective resistance to FHB and other diseases.

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? Two. Dr. Jin Sun PhD awarded in December 2014 and Dr. Xiangye Xiao PhD awarded in May 15, 2015.

3. **Have many 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?** None

   If yes, how many?

4. **Have many 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?** None

   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.*

None

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.

None