USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY11 Final Performance Report
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Cover Page

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Fiscal Year:	FY11
USDA-ARS Agreement ID:	59-0790-8-068
USDA-ARS Agreement Title:	Characterization of Resistance to Fusarium Head Blight in Wheat and its Relatives.
FY11 USDA-ARS Award Amount:	$ 73,699

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
DUR-CP	Introgression of Fusarium Head Blight Resistance from Hexaploid Wheat to Durum.	$ 38,823
VDHR-SPR	Enhancing Resistance of Spring Wheat to FHB Using Alien Species.	$ 34,876
	Total ARS Award Amount	**$ 73,699**

7/9/12

Principal Investigator Date

DUR-CP and VDHR-SPR

* MGMT – FHB Management
FSTU – Food Safety, Toxicology, & Utilization of Mycotoxin-contaminated Grain
GDER – Gene Discovery & Engineering Resistance
PBG – Pathogen Biology & Genetics
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: *Introgression of Fusarium Head Blight Resistance from Hexaploid Wheat to Durum.*

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

An effective source of resistance to Fusarium head blight (FHB) has not been found in durum wheat. Significant efforts have been made toward the identification and introgression of FHB resistance in the tetraploid relatives of durum, including *Triticum turgidum* ssp. *dicoccoides*, *T. turgidum* ssp. *dicoccum*, and *T. turgidum* ssp. *carthlicum*. However, a durum line with a resistance level comparable to the hexaploid wheat 'Sumai 3' has not been developed due to the lack of a 'Sumai 3'-like source of resistance in tetraploid wheat as well as the complex expression and inheritance of FHB resistance in the tetraploid wheat background. Here in this project, we have been transferring FHB resistance from hexaploid wheat into durum and characterizing the expression and inheritance of hexaploid wheat-derived resistance in the durum genetic background. This will potentially improve FHB resistance of durum and provide a better understanding of the expression and inheritance of FHB resistance in durum.

We have made over 50 crosses of seven durum genotypes with Sumai 3 and non-Sumai 3 derived hexaploid resistance sources and have been evaluating FHB resistance of F2, BC1F1, BC1F2, and BC2F1 progeny from these crosses to select resistant segregants in the greenhouse. Resistant segregants will be advanced to the next generation. Meanwhile, we have been analyzing chromosome constitutions of the most resistant and most susceptible segregants to determine the number and identity of D-genome chromosomes retained in those segregants. Also, we crossed seven tetraploid wheat genotypes with varied FHB resistance levels to an *Aegilops tauschii* accession and developed seven synthetic hexaploid wheat lines. These synthetic wheat lines will be evaluated for FHB resistance with their tetraploid wheat parents as controls in the greenhouse. In the meantime, these synthetic wheat lines will be crossed with their respective tetraploid wheat parents to develop wheat lines with various D-genome chromosomes from *Ae. tauschii*. In addition, we re-evaluated the entire set of Langdon durum D-genome substitution lines (14) for FHB resistance in two replicated greenhouse experiments. All these studies have provided significant information about the role of D-genome chromosomes in the expression of FHB resistance in wheat.

The advanced durum lines (F5 to F7) selected to have FHB resistance in the greenhouse have been evaluated for FHB resistance under the field condition in Fargo, ND and Jianyang, China. The durum lines that have consistently exhibited resistance in the greenhouse and field environments will be further verified for their resistance in the replicated evaluation experiments in the greenhouse and the FHB nurseries for several seasons.

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):

Accomplishment:

- Made over 50 new crosses/backcrosses of seven durum cultivars/lines with *fhb1* and non-*fhb1* derived hexaploid wheat genotypes and selected resistant segregants from these crosses.
- Developed about 300 lines with varied D-genome chromosomes in different durum backgrounds and have been evaluating these lines for FHB resistance in the greenhouse.
- Evaluated the 14 Langdon D-genome substitution lines in replicated experiments for three seasons in the greenhouse and one season in the field at Jianyang, China and identified a substitution line with higher levels of resistance than others and the Langdon parent.
- Evaluated over 500 durum lines at F5-F7 generations derived from the earlier crosses of durum and resistant hexaploid wheat for FHB resistance in two greenhouse seasons. About 200 of these lines that exhibited highest levels of resistance have been further evaluated in the FHB nurseries in Fargo, ND and Jianyang, China. Durum lines that have consistently showed improved resistance to FHB have been selected from these evaluation experiments.

Impact:

- The durum germplasm lines developed with improved FHB resistance will be further verified for resistance in the field at multiple locations. The germplasm lines verified with true resistance under multiple environments can be utilized directly to enhance FHB resistance of durum, making the resistance genes in hexaploid wheat accessible for durum breeding.
- This research has been providing new insights into the role of D-genome chromosomes and other genetic factors in the expression and inheritance of FHB resistance in wheat. A better understanding of the genetic basis for FHB resistance in both tetraploid and hexaploid wheat will facilitate the identification and utilization of FHB resistance genes in the development of superior durum varieties.

Project 2: *Enhancing Resistance of Spring Wheat to FHB Using Alien Species.*

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

The Chinese hexaploid wheat 'Sumai 3' and its derivatives remain the major source of resistance in breeding for FHB resistance in spring wheat. Additional sources of resistance have been identified and utilized in spring wheat breeding. However, neither of them is comparable to Sumai 3 in terms of the level and stability of resistance. Thus, there is an urgent need for novel sources of effective resistance to enhance and diversify the resistance of spring wheat to FHB. Here we have been searching for novel resistance from relatives of wheat and deploying the resistance into adapted spring wheat backgrounds for germplasm development in this research project. This will enrich the gene pool of wheat for FHB resistance and potentially strengthen the defense of spring wheat to FHB.

We evaluated 86 newly developed and collected wheat-alien species derivatives/varieties for reaction to FHB in the FHB nursery in Fargo, ND summer 2011. Nine of them exhibited resistance to FHB under that field condition. Genotyping with *umn10* marker indicated six of the nine resistant lines did not contain the Sumai 3 allele at this locus, suggesting non-*fhb1* type of resistance in these lines. These six non-*fhb1* resistant lines were crossed to three spring wheat varieties, including Alsen, Steele, and Russ. An established introgression procedure has been followed to deploy the non-*fhb1* resistance in the adapted spring wheat backgrounds.

We selected over 1,000 segregants with an FHB severity of 10-20% at the BC1F3, BC2F2, BC2F3, F3, and F4 generations of the crosses we made earlier from the greenhouse screening experiments summer 2011. Re-evaluation of the progeny from these segregants identified about 500 individuals with an FHB severity of 10-20% in the greenhouse fall 2011 and FHB nursery at Jianyang, China. The selected individuals are being further evaluated for FHB resistance in the greenhouse and FHB nursery in Fargo, ND. Genetically stabilized lines consistently showing resistance to FHB will be selected from these advanced generations and will be verified for FHB resistance in replicated experiments under multiple field conditions.

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):

Accomplishment:

- Identified six non-*fhb1* resistant wheat-alien species derivatives/varieties and made a number of crosses to incorporate the resistance from these sources into adapted spring wheat backgrounds.
- Evaluated 500-1,000 segregants at early generations for FHB resistance in two greenhouse seasons and at two field locations. Advanced spring wheat lines consistently showing FHB resistance have been selected from these greenhouse and field experiments for further verification of resistance in replicated experiments at multiple field locations.

Impact:

- We anticipate developing spring wheat germplasm lines with non-*fhb1* resistance from the sources identified in this project. Those germplasm will potentially enhance and diversify the resistance of spring wheat to FHB.
- Germplasm lines developed in this project will be immediately made available to the spring wheat and other wheat breeding programs for the development of superior wheat varieties with durable resistance to FHB and reduced DON accumulation in kernels.

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

Cai, X., Elias, E., Xu, S.S., Kianian, S., Zhong, S., Chao, S. 2011. Fusarium head blight resistance in durum wheat – progress and challenge. *In* Proc. 2011 National Fusarium Head Blight Forum, St. Louis, MO, December 4-6, 2011. p. 12.

McArthur, R.I., Zhu, X., Oliver, R.E., Klindworth, D.L., Xu, S.S., Stack, R.W., Wang, R. R.-C., **Cai, X.** 2012. Homoeology of *Thinopyrum junceum* and *Elymus rectisetus* chromosomes to wheat and disease resistance conferred by the *Thinopyrum* and *Elymus* chromosomes in wheat. Chromosome Research (under revision).