USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY11 Final Performance Report
July 13, 2012

Cover Page

PI:	James Anderson
Institution:	University of Minnesota
Address:	Department of Agronomy and Plant Genetics 411Borlaug Hall 1991 Upper Buford Circle St. Paul, MN 55108
E-mail:	ander319@umn.edu
Phone:	612-625-9763
Fax:	612-625-1268
Fiscal Year:	FY11
USDA-ARS Agreement ID:	59-0206-9-070
USDA-ARS Agreement Title:	Breeding and Development of DNA Markers for Fusarium Head Blight Resistance in Wheat.
FY11 USDA-ARS Award Amount:	$ 161,464

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
VDHR-SPR	Breeding and Genetic Investigations of Fusarium Head Blight Resistance in Spring Wheat.	$ 115,285
VDHR-SPR	Genetic Characterization of Fusarium Head Blight Resistance in Two Elite Spring Wheat Cultivars.	$ 7,273
VDHR-SPR	Mapping of an Inhibitor of Fhb1, the Major QTL for FHB Resistance in Wheat.	$ 38,906
	Total ARS Award Amount	**$ 161,464**

_____

Principal Investigator Date

* 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: *Breeding and Genetic Investigations of Fusarium Head Blight Resistance in Spring Wheat.*

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

Despite the dramatic increase in genetic resistance to FHB of released varieties in the spring wheat region in the past few years and the fact that these varieties are being widely adopted, there are still susceptible and moderately susceptible varieties in production. In addition, even the varieties with enhanced FHB resistance available today can suffer significant damage due to FHB and elevated DON in environments favorable for disease development. Therefore, the overall level of FHB resistance of regional varieties must be improved.

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:
'Norden' hard red spring wheat was released in 2012. Norden combines high grain yield and test weight, and good straw strength. Norden has average grain protein content and moderate Fusarium head blight resistance, both similar to Faller, the current variety with the most acreage in the state of Minnesota. Norden has good leaf rust resistance and excellent resistance to preharvest sprouting.

Impact:
Although Norden's FHB rating of 5 (1-9 scale where 1 is immune, 9 is very susceptible) places it in the middle of the pack for FHB reaction of current varieties, it has comparatively good resistance compared to the current highest yielding varieties.

Accomplishment:
Five experimental lines were entered and evaluated in the 2011 Uniform Regional Scab Nursery. These lines were identified in previous testing as having improved levels of FHB resistance. All five lines were below the mean of the trial for VSK and three were below the mean for DON.

Impact:
These lines combine FHB resistance from different sources and are candidates for future germplasm release. These lines are available and have been requested by other wheat breeders in the region for use as crossing parents. One of the lines, from the cross Wheaton/Excelcier, originated from a Host Genetics Resistance (HGR) grant that ended in FY07.

Accomplishment:
Scab nurseries were established at two field sites in 2011. A total of 3,382 genotypes were evaluated in 7,774 total rows among the locations. The Crookston and St. Paul FHB screening nurseries were excellent, and provided highly discriminatory data. As a result of these nurseries and results from previous years, the FHB resistance of 30 spring wheat cultivars was assessed and reported to growers via print media and field day presentations.

Impact:
Good field screening nurseries are needed to maintain progress in breeding for FHB resistance. Our screening of more 2,000 F_5 lines for FHB reaction at two locations eliminates virtually all susceptible lines. Our FHB resistance ratings are an important part of growers' decision regarding which variety they will grow.

Accomplishment:
Marker-assisted selection was completed for 1,135 selected F_5 (pre-yield trial) lines, and 992 plants from 68 BC_1 and top-cross families segregating for FHB resistance QTL and other important genes. The F_5 lines were processed by the USDA-ARS Genotyping Center in Fargo and the BC_1 and top-cross samples were processed in-house. *Fhb1* and the 5AS FHB QTL were used to screen all 1,135 F_5 lines and selected in 40 and 29, respectively, of the 68 BC_1 and topcross populations subjected to MAS.

Impact:
The screening of BC_1 and top-cross lines enriches populations for FHB resistance QTL. Likewise, selecting F_5 lines containing the *Fhb1* and 5AS QTLs enhances the chances of advancing lines with high levels of FHB resistance.

Project 2: *Genetic Characterization of Fusarium Head Blight Resistance in Two Elite Spring Wheat Cultivars.*

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

Decades of breeding of HRSW for FHB resistance at NDSU, U of MN, and SDSU and other breeding programs in the spring region, many cultivars with FHB resistance have been released and are being grown on a large scale, particularly, NDSU cultivars, replacing the most susceptible cultivars. Most of these cultivars trace their resistances to the Chinese sources, particularly Sumai3. This is true for cultivars such as Alsen and supposedly **Glenn**, both NDSU releases that have dominated the spring wheat area since 2002. However, recently we have collected some data showing that Glenn does not show the presence of the closest markers to the main FHB resistance gene Fhb1 from Sumai 3. These results have been confirmed by many labs including U of MN (USDA-ARS, Fargo,…etc). All these results show that haplotyping Glenn is consistent with our data that Glenn may not have *Fhb1* markers as we previously believed based on Glenn pedigree. This has raised a major question among us, breeders involved in this project. *Does Glenn have a new combination of FHB resistant genes from its diverse pedigree tracing to Chinese, US, and wild type wheat origin?* or *have breeders at NDSU who developed this cultivar have broken the linkage between the Fhb1 and the new flanking markers?* To confirm either case, more research is needed to elucidate this assumption. Similarly, among the most popular grown cultivar developed by NDSU, **Parshall** was grown on significant acreages in the spring wheat region for many years because it has showed consistently good tolerance to FHB. Parshall parentage do not trace to any exotic origin such as Chinese germplasm. We believe Parshall has an indigenous source of resistance that may be of great interest to the wheat breeders. To address both topics indicated above and to clarify the genetics of FHB resistance of both Glenn and Parshall, several Recombinant Inbred Lines (RILs) populations involving these two sources or resistances and susceptible parents from MN (MN00261-4), SD (SD3870), and ND (Reeder) were developed. In this study we will use a couple RIL populations with Glenn and Parshall to map the FHB resistance and use other RIL populations for validating our results.

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:

A graduate student, Mr. Ahmed El Doliefy was hired to work on this project in 2010. He has been conducting research activities related to this project. Particularly, he has been doing field evaluations for FHB reaction of the RILs and their parents along with the checks in ND and lab. Work to map the FHB resistance in Glenn and Parshall will start in Fall 2012. Drs J. Anderson and K. Glover are responsible for field evaluations in MN and SD, respectively. Dr. S. Chao, in the USDA-ARS lab in Fargo, will provide Mr. Ahmed El Doliefy the

facilities and guidance in the mapping phase, particularly to saturate the genomic regions of interest that determined by the Diversity Array Technology (DArT, Australia) data analysis. In 2011, significant results related to FHB field evaluations and DNA samples preparation for DArT analysis were achieved. Following are the achievements in 2011.

Field evaluations:
In summer 2011, the RILs populations, their parents, and appropriate susceptible and most resistant FHB checks were included in four experiments in this project. The experiments were planted in three to four FHB field nurseries located in the three states, ND, MN, and SD in summers of 2011. Data on some agronomic traits including heading, height and FHB incidence and severity were recorded for each plot approximately 21 days after anthesis. Plots were be harvested to determine DON levels in the lab. However, at Prosper, ND severe floods affected the FHB nursery.

Lab. Work and DNA extraction:
DNA has been extracted (by Ahmed) from the RILS of all populations, their parents, and checks. This DNA was sent for DArT mapping the most known genes on wheat genomes. Therefore, the DNA extraction and its quality should meet the DArT standards. The data generated by DArT was performed in 2011 and is now available to be used by Mr. Ahmed El Doliefy with the help of Dr Chao to (1) generate a basic map and identify important QTL regions, (2) augment the identified QTL regions with microsatellite markers (SSR) that show polymorphism between parents; and (3) subsequently, generate linkage maps. This work will start in Fall 2012 to include phenotypic data that will be generated in this coming 2012 field FHB nurseries. However, we believe that mapping FHB genes in these populations would be more accurate and useful using SNPs panel that is now available at the USDA-ARS genotyping Center at Fargo. Hence, we are looking for funding (about $15,000) to conduct this additional operation.

Impact:

This research has a substantial potential impact on the breeding for FHB resistance, particularly, if Glenn resistance to FHB is not based on the Fhb1 gene. This would be breakthrough for all wheat breeding programs dealing with FHB as a major threat for wheat. Similarly, new genes for resistance to FHB in wheat are warranted as the arsenal of genes available to breeders is very limited. Parshall can be a good source of novel FHB resistance genes that could be mined by breeders. In both cases, the direct impact on wheat production at the state and regional (northern Great Plains), and national levels is tremendous. In the past years, NDSU HRSW cultivars with FHB resistance have been dominating the spring wheat growing region in the US. Recently released NDSU cultivars Barlow, Faller, Glenn, Steele-ND and Howard are major HRSW cultivars in the US spring wheat region. However, new and novel FHB resistant genes are needed to enhance the resistance of the most common and available cultivars.

Project 3: *Mapping of an Inhibitor of Fhb1, the Major QTL for FHB Resistance in Wheat.*

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

   The literature contains many reports of QTLs for FHB resistance being derived from the "susceptible" parent in biparental crosses. Although some of these are minor QTL and may be statistical artifacts, others have moderate effects and have been validated in other populations. We observed what are consistent with inhibitory effects in *Fhb1* near-isogenic lines we developed. More recently, while investigating *Fhb1* candidate genes as part of our ongoing efforts to clone this gene, we discovered that the recipient genotype, 'Bobwhite' inhibited the effect of *Fhb1*.

   The goal of this research is to map QTL associated with scab resistance and determine if they are inhibiting *Fhb1*, haplotype our germplasm to identify prevalence in our lines, and selectively remove inhibitors from our breeding lines so the resistant phenotype conferred by *Fhb1* is fully expressed. To do so, we developed a population of RILs from a cross between the resistant *Fhb1* – containing near-isogenic-line 260-2 (Sumai 3/Stoa) and the susceptible non – *Fhb1* – containing variety Bobwhite.

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:
   The mapping population consists of the 129 RILs that are homozygous for the presence of *Fhb1* as identified by the umn10 marker previously developed in our lab. This population has undergone two seasons of Type II screening in the greenhouse and one season in the field in which disease severity, 30 head weight, visually scabby kernels, DON accumulation, heading date, and height were measured. A second field season is currently underway in the scab nurseries at St. Paul and Crookston with the same data being collected. The mapping population has been genotyped with the 9k Infinium SNP array, and the phenotypic data presently available has been analyzed and QTL analysis performed. Nine significant QTL have been identified that are associated with at least one aspect of scab resistance and there is at least one QTL identified for each trait measured. As yet, it is unknown whether any of these QTL are inhibiting *Fhb1* or just indicative of additional unknown resistance genes in the resistant parent 260-2.

   Impact:
   The major finding of this project will be the identification of the location of genomic region(s) inhibiting the expression of *Fhb1*. If such an inhibitor is found, it could explain why *Fhb1* (and possibly other FHB QTLs) shows little or no affect in some genetic backgrounds. This knowledge and identification of molecular markers tightly linked to the inhibitor(s) will allow wheat breeders to advance only lines lacking the inhibitor and avoid using parents possessing it. Removal of these inhibitory regions will then make the

expression of resistance conferred by *Fhb1* much more consistent and pronounced, thus leading to reduced levels of Fusarium head blight and the subsequent mycotoxins.

Include below a list of all germplasm or cultivars released with full or partial support of the USWBSI. List the release notice or publication. Briefly describe the level of FHB resistance.

Spring wheat variety Norden released in 2012. Moderate resistance (5 on 1-9 scale).

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.

Anderson, J.A., J.J. Wiersma, G. Linkert, S. Reynolds, and C. Springer. 2011. Hard Red Spring Wheat. In Minnesota Varietal Trials Results, University of Minnesota Extension Service.

Anderson, J.A., J.J. Wiersma, G.L. Linkert, J.A. Kolmer, Y. Jin, R. Dill-Macky, J.V. Wiersma, G.A. Hareland, and R. H. Busch. 2012. Registration of 'Sabin' Wheat. J. Plant Registrations 6:174-179.

Anderson, J.A., J.J. Wiersma, G.L. Linkert, J.A. Kolmer, Y. Jin, R. Dill-Macky, J.V. Wiersma, G.A. Hareland, and R. H. Busch. 2012. Registration of 'Tom' Wheat. J. Plant Registrations 6:180-185.