USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY12 Final Performance Report
July 16, 2013

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:	FY12
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.
FY12 USDA-ARS Award Amount:	$ 143,450[*]

USWBSI Individual Project(s)

USWBSI Research Category[**]	Project Title	ARS Award Amount
VDHR-SPR	Breeding and Genetic Investigations of FHB Resistance in Spring Wheat.	$ 115,146
VDHR-SPR	Genetic Characterization of Fusarium Head Blight Resistance in Two Elite Spring Wheat Cultivars.	$ 3,377
VDHR-SPR	Fine Mapping and Validation of QTLs for FHB Resistance from PI 81791.	$ 24,927
	Total ARS Award Amount	**$ 143,450**

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Principal Investigator Date

[*] Award Amount does not include additional funding awarded in September of 2012 earmarked for other PIs at same institution

[**] 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 FHB 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?**

   Although a dramatic increase in genetic resistance to FHB has been observed in the spring wheat region of the U.S. in the past five years and these varieties are being widely adopted, there are still susceptible varieties in production. Furthermore, even the moderately resistant varieties 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 (1):

   'Linkert' hard red spring wheat was released in 2013. Linkert, tested as MN06028, is a mid-maturity hard red spring wheat with excellent straw strength, high grain protein content, and competitive grain yields. The pedigree of Linkert is MN97695-4/Ada. Linkert has moderate resistance to Fusarium head blight (5 on 1-9 scale) and prevalent races of leaf rust. Linkert is resistant to preharvest sprouting and has exhibited good end-use quality characteristics.

   Impact:

   Although Linkert'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 is projected to compete for acreage with other high straw strength varieties that have lower FHB ratings such as Brennan (7), Jenna (7),WB-Mayville (7), and Samson (8). Therefore, I expect Linkert to result in an overall improvement of spring wheat FHB resistance.

   Accomplishment (2):

   Five experimental lines were entered and evaluated in the 2012 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 four of the five were below the mean for DON. One line, MN09027, had the lowest DON and Disease Index, and 2nd lowest VSK of the 22 lines in the trial.

   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.

Accomplishment (3):

Scab nurseries were established at two field sites in 2012. A total of 3,417 genotypes were evaluated in 7,248 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 29 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 (4):

Marker-assisted selection was completed for 1,093 selected F_5 (pre-yield trial) lines, and 1,922 plants from 53 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 1,093 F_5 lines and selected in 23 and 21, respectively, of the 53 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 Sumai 3. 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 its 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 cultiva, 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's parentage does 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 wheat breeders. To address both topics indicated above and to clarify the genetics of FHB resistance of both Glenn and Parshall, several Recombinant Inbred Line (RIL) populations involving these two sources of 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:

Mr. Ahmed El Doliefy, our graduate student has been hired to work on this project since 2010. In 2012-13, he has continued his research activities related to this project by evaluations for FHB reaction of the RILs and their parents along with the checks under ND field and greenhouse conditions. Data entry and mapping work of the FHB resistance in Glenn and Parshall is being conducted. Drs J. Anderson and K. Glover were responsible for field evaluations in MN and SD, respectively. Data collected by both Drs Anderson and

Glover is being entered along with data collected from ND trials. Dr. S. Chao, in the USDA-ARS lab in Fargo, has provided Ahmed the SNPs data she will make available her facilities and expertise to help Ahmed in the mapping phase, particularly to saturate the genomic regions of interest that determined by the Diversity Array Technology (DArT, Australia) and SNPs data analysis. In 2012, greenhouse evaluations were continued and DNA samples preparation for SNPs analysis were achieved. Also, DON, and FDK work was continued in 2012-13. Following are the achievements in 2012.

Field evaluations:

In 2012, the final evaluation of RILs populations, their parents, and appropriate susceptible and most resistant FHB checks were conducted under filed and greenhouse conditions. The experiments were planted in the FHB field nurseries located in the three states, ND, MN, and SD in summer of 2012. Data on some agronomic traits including heading height and FHB diseases notes including incidence and severity visually estimated were recorded for each plot approximately 21 days after anthesis. Plots were harvested and seed were sampled for determination of TDK and DON levels.

Lab. Work and DNA extraction:
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In 2012, DNA was extracted (by Ahmed) from the RILS of all populations, their parents, and checks. This DNA was sent to Dr. Chao's lab for SNPs analysis. The SNP data has been received and is currently being analyzed to map FHB resistance QTLs/genes. In 2011, DNA was also sent for DAtT analysis. The data generated by both DArT and SNPs in 2011 and 2012, respectively will 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 as soon as all phenotypic data that was generated from 2010 to 2012 field FHB nurseries. At the moment Ahmed is in the process of generating the chromosomes maps based on SNPs and DArT data. He is also working on determining TDK on seed from greenhouse experiments conducted in 2012-13. Ahmed prepared samples from 2013 a greenhouse experiment for DON testing. Data entry and compiling has also been a major activity of Ahmed during the 2102-13 period.

Impact:

As previously stated, 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 needed 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: *Fine Mapping and Validation of QTLs for FHB Resistance from PI 81791.*

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

PI 81791 (Sapporo Haru Komugi Jugo) was identified, via USWBSI funding, as a line with very high FHB resistance, including low visually scabby kernels. PI 81791 does not contain *Fhb1* and it is, therefore, a good target for a new QTL mapping effort. 150 RILs of a PI 81791/Wheaton population were developed and phenotypic data on FHB traits was collected from three field and two greenhouse inoculated nurseries and a skeleton map was produced in an earlier funding period. Given the relative ease and lower expense of mapping with new markers in wheat today versus only a few years ago, we plan to use SNP markers to make a complete genetic map of this population and conduct a more thorough QTL mapping effort, including the initiation of QTL validation experiments.

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:

Genotyping with the Illumina 9K SNPs was completed. A total of 8,632 SNPs were analyzed on the 150 RILs and parents and 1,347 polymorphic markers were used to construct a genetic linkage map consisting of 25 linkage groups covering 902 cM. A preliminary QTL analysis has revealed three QTL that affect both field severity and incidence, and one additional QTL for incidence. Two these QTL also affect VSK and DON levels.

Impact:

It is likely that at least one novel QTL on chromosome 5A has been identified. Because both 5A QTLs we identified affect multiple traits, including Incidence, Severity, VSK, and DON, breeders are more likely to introgress them into their germplasm and result in greater FHB resistance.

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 'Linkert' released in 2013. Moderate resistance (5 on 1-9 scale) to FHB.

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, S. Reynolds, R. Caspers, S. Howey, C. Springer, J Kolmer, Y. Jin, R. Dill-Macky, and J.V. Wiersma. 2012. Hard Red Spring Wheat. In Minnesota Varietal Trials Results, University of Minnesota Agricultural Experiment Station.

Anderson, J.A. "Overview of Breeding for FHB Resistance in Wheat – Where We've Come From and Where We Are" Invited presentation at the National Fusarium Head Blight Forum, Orlando, FL (12/5/12)

Anderson, J.A. 2012. Breeding for *Fusarium* Head Blight Resistance in Wheat. In: R. Brettel and J. Nicole (Eds.), Proceedings of the 1st International Crown Rot of Wheat Workshop, Narrabri, Australia.