

**USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY13 Final Performance Report
July 15, 2014**

Cover Page

PI:	Mohamed Mergoum
Institution:	North Dakota State University
Address:	Department of Plant Sciences Rm 166 Loftsgard Hall Fargo, ND 58105-5051
E-mail:	Mohamed.Mergoum@ndsu.edu
Phone:	701-231-8478
Fax:	701-231-8474
Fiscal Year:	FY13
USDA-ARS Agreement ID:	59-0206-9-066
USDA-ARS Agreement Title:	Breeding Adapted Spring Wheat for Scab Resistance.
FY13 USDA-ARS Award Amount:	\$ 128,317

USWBSI Individual Project(s)

USWBSI Research Category *	Project Title	ARS Award Amount
VDHR-SPR	Development of Adapted Hard Red Spring Wheat Cultivars and Germplasm Resistant to Scab Disease.	\$ 105,681
VDHR-SPR	Genetic Characterization of Fusarium Head Blight Resistance in Two Elite Spring Wheat Cultivars.	\$ 22,636
	FY13 Total ARS Award Amount	\$ 128,317

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: *Development of Adapted Hard Red Spring Wheat Cultivars and Germplasm Resistant to Scab Disease.*

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

In ND in particular, and the Northern Central Plains of the US in general, Fusarium head blight (FHB) or scab disease remains the major threat for wheat production and its uses. North Dakota (ND) in particular where the hard red spring wheat (HRSW) is leading crop in the State and US, this disease can cause significant economic losses. The disease is complex and causes significant reduction in grain yield and impacts negatively the wheat quality. In the past two decades, FHB disease had tremendous implications on wheat on ND HRSW producers; end-users; and export market. The NDSU HRSW wheat breeding program is addressing this problem by developing elite and adapted genotypes/ lines/cultivars and breeding populations that incorporate diverse genetic resistance with desired agronomic and quality traits. The strategy used is based on incorporating genes of resistance into elite germplasm and pyramiding several types of genetic resistance to the disease from diverse sources using classical breeding methods and appropriate novel technologies such as selected molecular markers. Based on our accomplishments and impact (Listed in this and previous reports), we strongly believe that genetic resistance provides a strategic long-term, economically, and environmentally sound solution to this problem. In 2013-2014 growing cycle, our efforts have continued to develop elite HRSW germplasm and cultivars that are adapted to ND in particular, and the spring wheat region, in general. Many significant accomplishments have been achieved and are listed in this report.

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:

Significant progress in combating the FHB disease have accomplished by the NDSU HRSW breeding program during the 2013-2014 growing cycles. These are illustrated in the release and potential release of many HRSW cultivars and elite germplasm that are hallmark of wheat production in the spring wheat region in particular, USA and the wheat breeding program worldwide. The cultivars we released are grown on large scale in ND and the Northern plains (ND, MN, SD, and MT) generating hundreds of millions of dollars of benefits for the growers, the industry and export market. These cultivars are the following:

Recent released cultivars:

- ❖ **2014 Potential Release: ND817** is a line that was presented for release and accepted and recommended by the release committee to the NDSU Director of NDS-AES for final decision. If accepted, it will be released under the name of “Ayr”. ND817 presents many excellent characters that may contribute to the improvement of wheat

production in the US spring wheat region. In addition to its excellent agronomic and quality performances, ND817 has very good resistance to scab. Its FHB resistance level equals or surpasses in many cases, the best FHB resistant cultivars so far released, including Glenn.

- ❖ **2013 release: ‘Elgin-ND’ (ND818):** Elgin-ND is a HRSW cultivar with wide adaptation allowing it to compete very well with most dominant cultivars in ND and neighboring state including MN, SD and MT. In addition, Elgin-ND quality attributes are much improved compared to Faller, the dominant cultivars in Eastern ND and Western MN, the FHB prone zone. Elgin-ND has very high protein content, very close to Glenn, the current quality check cultivar. Overall, Elgin-ND has good milling (flour extraction similar to Glenn) and baking qualities similar to Barlow and Howard. Elgin-ND possesses an excellent diseases resistances package. It is moderate resistant/moderate susceptible to FHB. It is resistant to leaf and stem rusts prevalent races and medium susceptible/resistant to the new emerging leaf rust race Lr21.

Impact:

The wheat cultivars released by our HRSW breeding program at NDSU generate **Hundreds of millions of dollars** every year for the spring wheat growers, US wheat industry, and by the wheat export market sector. Following are some facts that detail this situation:

- * In average, about 50-60% (3.3-4 million acres) of ND spring wheat acreages are grown to NDSU wheat cultivars. This demonstrates the good performance and adaptation of our cultivars to meet wheat growers and end-users. Among these common grown NDSU cultivars with FHB resistance are **Barlow, Glenn, Faller, Prosper, Steele-ND, Howard, and Alsen**. All of these cultivar have excellent agronomic/quality traits in addition to FHB resistance. In 2013, these and other NDSU cultivars have occupied more than 58% of 5.7 million acres (>3.2 million acres) of wheat grown in ND in 2013. Barlow, Glenn Faller, and Prosper, all NDSU cultivars were the top and leading cultivars in ND in 2013 with 18, 10.1, 9, and 8.8%, respectively of total ND wheat acres. These figures show that **the impact** on wheat business (growers, industry and export market) of the FHB resistant HRSW cultivars developed by our program using partly, the USWBSI initiative funds **is tremendous**.
- * In addition, the NDSU HRSW cultivars are also grown and leading in some neighboring states (MN, SD, and MT) where spring wheat is a major crop and FHB is a threat. From 2009 to 2012, Faller was the leading wheat cultivar in MN with about 30% of wheat acreages. In 2013, Prosper, our release took the lead in MN by 17.3% of wheat acreages, followed by Faller by 17.27%. Other cultivars such as Barlow, Glenn, Alsen, Steele-ND, and Howard are also grown in MN, SD, and MT as well. This is an important impact that should be factored in as well.
- * Our cultivars which have superior agronomic performance and very high quality with improved **FHB resistance** has allowed the spring wheat crop to survive in Western MN

and Eastern ND. It has also allowed the wheat growers to be competitive in the wheat market at the national and international levels.

- * Also, the HRSW germplasm and cultivars with FHB resistance that we have released are well known and extensively useful in the breeding program nationally and worldwide. Our HRSW breeding program continues to be the ‘**Center of excellence**’ for wheat germplasm with high quality and **good sources 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?

After more than two decades of breeding 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 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 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 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:

Mr. Ahmed El Doliefy is the graduate student that was hired to work on this project since 2010. In 2013-14, he has continued his research activities related to this project by conducting final evaluations for FHB reaction of the RILs and their parents along with the checks under 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 was also processed and analyzed along with data collected from ND trials. Dr. S. Chao, in the USDA-ARS lab in Fargo, has provide Ahmed the SNPs. In 2014, Ahmed focused on analyzing data and generating the maps using DArT and SNPs data. Ahmed is currently writing his dissertation and expected to defend it in this 2014 fall. Primary results re. FHB resistance in Glenn, shows that in fact Glenn does not possess *Fhb1* from Sumai 3 as we suspected. This a great finding and would impact tremendously whet breeding for FHB resistance in the future.

Impact:

As previously stated, this research has a substantial potential impact on the breeding for FHB resistance, particularly, now we know that Glenn resistance to FHB is not based on the *Fhb1* gene. This is a new development 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, another cultivar that we are studying, 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.

Include below a list of all germplasm or cultivars released with full or partial support of the USWBSI during the FY13 award period. List the release notice or publication. Briefly describe the level of FHB resistance.

- ❖ **2014 Potential Release: *ND817*** is a line that was presented for release and accepted and recommended by the release committee to the NDSU Director of NDS-AES for final decision. If accepted, it will be released under the name of “Ayr”. *ND817* presents many excellent characters that may contribute to the improvement of wheat production in the US spring wheat region. In addition to its excellent agronomic and quality performances, *ND817* has very good resistance to scab. Its FHB resistance level equals or surpasses in many cases, the best FHB resistant cultivars so far released, including Glenn.
- ❖ **2013 release: ‘*Elgin-ND*’ (ND818):** *Elgin-ND* is a HRSW cultivar with wide adaptation allowing it to compete very well with most dominant cultivars in ND and neighboring state including MN, SD and MT. In addition, *Elgin-ND* quality attributes are much improved compared to Faller, the dominant cultivars in Eastern ND and Western MN, the FHB prone zone. *Elgin-ND* has very high protein content, very close to Glenn, the current quality check cultivar. Overall, *Elgin-ND* has good milling (flour extraction similar to Glenn) and baking qualities similar to Barlow and Howard. *Elgin-ND* possesses an excellent diseases resistances package. It is moderate resistant/moderate susceptible to FHB. It is resistant to leaf and stem rusts prevalent races and medium susceptible/resistant to the new emerging leaf rust race Lr21.

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 FY13 grant. Please reference each item using an accepted journal format. If you need more space, continue the list on the next page.

Peer-reviewed articles:

Mohamed Mergoum, Senay Simsek, Shaobin Zhong, Maricelis Acevedo, Timothy L. Friesen, Pawan K. Singh, Tika B. Adhikari, Jack W. Rasmussen, Mohammed S. Alamri, and Richard C. Frohberg. 2014. ‘Velva’ Spring Wheat: An Adapted cultivar to North Central Plains of the USA with High Agronomic and Quality Performance. **Journal of plant Registration 8 (1):32-37**

Abstracts:

Mohamed Mergoum, Ahmed ElFatih ElDoliefy, Ajay Kumar, Jim Anderson, Karl Glover, Mohammed S. Alamri, Shahryar Kianian, Senay Simsek, Shaobin Zhong, and Shiaoman. 2013. Revealing the Genetic Basis of Fusarium Head Blight Resistance in a Major Adapted High Quality USA Spring Wheat Cultivar. In The 12th International Wheat Genetic Symposium, September 8-14, 201, Pacifico Yokohama, Japan.

Ahmed ElFatih ElDoliefy, James A. Anderson, Karl D. Glover, Ajay Kumar, Shiaoman Chao, Mohammed S. ALamri, and **Mohamed Mergoum**. 2013. Molecular Mapping of Fusarium Head Blight Resistance in Two Adapted Spring Wheat Cultivars. *In* ASA-CSSA-SSSA-CSSS Abstracts 2013 [CD-ROM], Tampa, FL, USA.

Proceedings:

Mohamed Mergoum, Senay Simsek, Shaobin Zhong, Maricelis Acevedo, Timothy L. Friesen, Mohammed S. Alamri, and Richard C. Frohberg. 2013. Combating Fusarium Head Blight in the Spring Wheat Region: ‘Eling-ND’, a New Hard Red Spring Wheat Cultivar with High Level of Resistance. In S. Canty, A. Clark, A. Anderson-Scully, D. Ellis, and D.A. Van Sanford (Eds), Proceedings of the 2013 National Fusarium Head Blight Forum, Dec. 3-5, Milwaukee, Wisconsin: U.S.

Ahmed ElFatih ElDoliefy, James A. Anderson, Karl D. Glover, Ajay Kumar¹, Elias Elias Shiaoman Chao, Mohammed S. Alamri and **Mohamed Mergoum**. 2013. Molecular Mapping of Fusarium Head Blight Resistance in Glenn, a High Quality and Adapted Hard Red Spring Wheat Cultivar. In S. Canty, A. Clark, A. Anderson-Scully, D. Ellis, and D.A. Van Sanford (Eds), Proceedings of the 2013 National Fusarium Head Blight Forum, Dec. 3-5, Milwaukee, Wisconsin: U.S.

J. Tyler Eckard, Jose L. Gonzalez-Hernandez, Karl Glover, James Anderson, **Mohamed Mergoum**. 2013. Multiple FHB Resistance QTL Pyramided Onto Elite Spring Wheat Fhb1 Backgrounds Using a Family-based Mapping Approach. In S. Canty, A. Clark, A. Anderson-Scully, D. Ellis, and D.A. Van Sanford (Eds), Proceedings of the 2013 National Fusarium Head Blight Forum, Dec. 3-5, Milwaukee, Wisconsin: U.S.