

**USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY10 Final Performance Report
July 15, 2011**

Cover Page

PI:	Mohamed Mergoum
Institution:	North Dakota State University
Address:	Department of Plant Sciences NDSU Dept. # 7670 PO Box 6050 Fargo, ND 58108-6050
E-mail:	Mohamed.Mergoum@ndsu.edu
Phone:	701-231-8478
Fax:	701-231-8474
Fiscal Year:	FY10
USDA-ARS Agreement ID:	59-0206-9-066
USDA-ARS Agreement Title:	Breeding Adapted Spring Wheat for Scab Resistance.
FY10 USDA-ARS Award Amount:	\$ 160,470

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
VDHR-SPR	Development of Hard Spring Wheat Cultivars Resistant Scab Disease.	\$ 115,285
VDHR-SPR	Genetic Characterization of Fusarium Head Blight Resistance in Two Elite Spring Wheat Cultivars.	\$ 45,185
	Total ARS Award Amount	\$ 160,470

07/05/2011

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 Hard Spring Wheat Cultivars Resistant Scab Disease.*

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

Fusarium head bight (FHB) remains the major disease that threatens wheat production and industry in the Northern Central Plains of the US, particularly in North Dakota (ND) where the hard red spring wheat (HRSW) is leading crop is the State and US. The disease is complex and causes significant reduction in grain yield and impacts negatively the wheat quality. In ND, FHB disease had tremendous implications, particularly on HRSW producers; end-users; and export market. At NDSU, the HRSW wheat breeding program is addressing this problem by the development of 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 pyramiding several types of genetic resistance to FHB from diverse sources into adapted cultivars 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. During the 2010-2011 growing cycle, our efforts have continued to develop elite HRSW germplasm and cultivars that are adapted to ND in particular, and spring wheat region, in general. Significant accomplishments have been achieved and are listed in this report.

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:

During 2010-2011 cycle, significant progress has been accomplished by the HRSW breeding program at NDSU. These are illustrated in the release and pre-release of many HRSW cultivars and elite germplasm that are hallmark of wheat production in the spring wheat region in particular and in the US as a whole. These varieties are grown on large scale in ND and the entire 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:

New released cultivars:

- ❖ **‘Prosper’**: released for 2011: **Prosper** was selected from a cross involving ND2710 which is a derivative from Sumai3. Hence it has medium resistance to FHB is based on *fhb1* from Sumai3 similar to Faller released in 2007. Prosper has very high grain yield better or at least equal to Faller. It performs relatively well in The Eastern of ND and Western MN environments. It has medium straw strength. Prosper is a conventional to semi-dwarf height variety, with an early to medium early maturity. Prosper average protein content and test weight, similar to Faller,

and high flour extraction. Overall, it has good milling and baking qualities similar to Faller. Prosper possesses an excellent diseases resistances package. It is resistant to Leaf and stem rusts. Given that Prosper was targeted to high rainfall areas of ND and Western MN, it was also jointly released by North Dakota State University and the Minnesota Agricultural Experiment Station.

- ❖ **‘Velva’**: Released for 2012: **Velva** is medium susceptible to scab compared to susceptible checks. Velva was not selected from introduced FHB germplasm sources of resistances such as Chinese Sumai3. It was selected from a cross involving cultivars which may carry some indigenous FHB resistance. It has general adaptation but better fit to Central and Western ND environments. It has excellent performance, particularly where Reeder is grown. Overall, Velva has high grain yield, higher than most cultivars adapted to Central and Western region. It is a Semi-dwarf line with medium late maturity, similar to Reeder and Faller; and medium to strong straw strength similar to Reeder. Protein of Velva is good, similar to Reeder with average milling properties. Similarly, Velva has Good baking properties similar or slightly better than Reeder. Test weight is also average similar to Reeder. Velva has an excellent leaf diseases package better than Reeder. It is resistant or medium resistant to leaf and stem rusts; resistant to septorias; and resistant to races 2 and 3 of tan spot, but Velva is susceptible to bacterial leaf streak.

Previous released cultivars:

- ✱ The 2009 release cultivar **‘Barlow’**. Barlow is also a derivative cultivar of Sumai3. Hence it has medium resistance to FHB is based on *fhb1* from Sumai3. The level of resistance of Barlow is close to Alsen and Faller, very popular HRSW cultivars in the spring region. However, Barlow has high yield than Alsen and Glenn, the number one cultivar in the spring region, very good leaf disease package compared to Glenn, and excellent quality attributes. Barlow has wide adaptation. It performs very well in all ND environments, including the Western dry land regions of ND. Barlow was grown on about 1% of 6.7 million wheat acres in ND. Barlow was also grown in neighboring states of MN, SD and MT.
- ✱ The **2007** release **‘Faller’** was the second leading cultivar in wheat acreages after Glenn in ND (17 and 15% of ND wheat acreages in 2009 and 2010, respectively) and the leading cultivar in MN since 2009 (21 and 30% of MN wheat acreages in 2009 and 2010, respectively). Faller is a derivative cultivar of Sumai3. Hence it has medium resistance to FHB, similar to Alsen. Faller is a very high yielding cultivar with very good leaf disease package compared to Glenn and medium protein content. Faller is recommended for high rainfall and FHB prone spring wheat regions. It is the first NDSU cultivar with such high yield potential. Faller was also grown in other neighboring states of SD and MT.
- ✱ **‘Howard’** HRSW wheat variety was released in **2006** with good FHB resistance level comparable to **‘Steele-ND’**. Both Howard and Steele-ND have FHB resistance different from Alsen (Sumai3). Howard has wide adaptation and recommended mainly, for the regions where Reeder and Alsen are grown because of its high yield level and good leaf diseases resistances package. Howard main attributes are FHB

- resistance, high yield and quality, and excellent leaf disease package compared to Alsen and Reeder. In 2010, Howard was grown on about 5% of ND wheat acreages. Howard was also grown in other neighboring states of SD and MT.
- * **'Glenn'** released in **2005** is has been the **LEADING** HRSW cultivar in the spring wheat region replacing since 2008. Glenn replaced Alsen that dominated the wheat production for 5 years since 2003. Glenn with parentages involving both Sumai-3 and Steele-ND has higher FHB resistance level (better than Alsen variety). In addition Glenn has excellent quality attributes allowing it to be the quality standard by the Wheat Quality Council and the industry in the USA. Based on the US-Wheat Associates survey (OVA), Glenn is now the most preferred cultivar by the wheat importers worldwide. Glenn is expected to dominate the wheat production for some years. In 2009, Glenn was grown on 25% (about 1.7 million acres) of ND wheat acreages. Glenn was also grown in neighboring states of MN, SD and MT.
 - * The **2004** HRSW release, **'Steele-ND'** has good FHB resistance level and wide adaptation is now a major grown cultivar in the spring wheat region. Steele-ND has been grown on about 5% of ND acreages in the past two years. It is recommended mainly, for the regions where Reeder and Alsen are grown because of many attributes including high yield level. It expected that Steele-ND will replace significant acreages of Alsen and Reeder across all the State and probably other cultivars in the region.

Previous released germplasm, RIL population:

- * In 2009, we have released the RILs population ND735/Steele-ND with resistance to leaf spotting diseases and scab.
- * In 2007, we have released **ND 756** as a germplasm with FHB resistance (see publications). Prior to that, we have released several key sources of FHB resistance wheat germplasm including, ND 2710, ND 744, and ND 751 (See Crop Sciences).

Pre-released Lines with FHB resistance:

- * **ND818** is a HRSW line with wide adaptation allowing it to compete very well with most dominant cultivars in the State, Glenn and Faller. In addition its quality attributes are much improved compared to Faller, the dominant cultivars in Eastern ND and Western MN, the FHB prone zone. ND818 is moderate resistant/susceptible to FHB, similar to Steele-ND which traces its FHB resistance to *T. dicoccoides*, a wide relative of wheat.

Impact:

Hundreds of millions of dollars are yearly generated by the NDSU wheat cultivars to the spring wheat growers and industry in the USA and by the wheat export market sector. Following are some facts that detail this situation:

- * In average, more than 60% (3.5-4 million acres) of ND spring wheat are grown to NDSU wheat cultivars. This shows how the good performance and adaptation of our cultivars to meet wheat growers and end-users. Among these common grown NDSU cultivars,

Glenn, Faller, Steele-ND, Howard, and Alsen cultivars have resistance to FHB and excellent agronomic/quality traits contribute. These five cultivars have occupied more than 57% (3.85 million acres) of wheat grown in ND in 2009. These figures show that **the impact** on wheat business (growers, industry and export market) of the FHB resistant HRSW cultivars developed by this program using partly, the USWBSI initiative funds **is phenomenal**.

- * 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. Since 2009, Faller was the leading wheat cultivar in MN with 21.3 and 30% of wheat acreages in 2009 and 2010, respectively. Other cultivars such as Glenn, Steele-ND, and Howard are also popular in MN, SD, and MT as well. This is an important impact that should be factored in as well.
- * Releasing superior and very high quality HRSW cultivars with improved **FHB resistance** has allowed the spring wheat growers to be competitive in the wheat market at the national and international levels.
- * The HRSW germplasm and cultivars with FHB resistance that we have released are well known and extensively used in the breeding program nationally and worldwide. Our HRSW breeding program is now a **‘Center of excellence’** for wheat germplasm with high quality and **good sources of FHB** resistance.

Include below a list 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.

Mergoum, M., R. C. Frohberg, T. L. Friesen, J. B. Rasmussen, G. Harland, and S. Simsek. 2011. ‘Barlow’: A High Quality and Yielding Hard Red Spring Wheat Cultivar Adapted to the North-Central Plains of the USA. *Journal of plant Registration* 5: 62-67

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.

Mergoum, M., R. C. Frohberg, T. L. Friesen, J. B. Rasmussen, G. Harland, and S. Simsek. 2011. ‘Barlow’: A High Quality and Yielding Hard Red Spring Wheat Cultivar Adapted to the North-Central Plains of the USA. *Journal of plant Registration* 5: 62-67

Rishi Ram Burlakoti, Mohamed Mergoum, and Tika B. Adhikari. 2010. Combining different resistance components enhances resistance to Fusarium head blight in spring wheat. *Euphytica*: 197-205.

Yabwalo, D.N., M. Mergoum, and W.A. Berzonsky. 2011. Further characterization of the scab resistance of ‘Frontana’ spring wheat and the relationships between resistance mechanisms. *Plant Breeding (In press)*

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 many years of breeding hard red spring wheat (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 replacing the most susceptible cultivars. However, 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.

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:

In Fall 2010, a graduate student, Mr. Ahmed El Doliefy was hired to work on this project. He will be leading all activities related to this project. Particularly, he will be responsible for field evaluations in ND and lab. Work to map the FHB resistance in Glenn and Parshall; while Drs J. Anderson and K. Glover will be 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 2010, significant results related to FHB field evaluations and DNA samples

preparation for DArT analysis were achieved. Following are the achievements in 2010.

Field evaluations:

In summer 2010, except for the Parshall/Reeder RILs which will be F_{2:10}, the other RILs populations were at the F_{2:8} generation. 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 2010. 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 to determine DON levels in the lab.

Lab. Work and DNA extraction:

In the lab, DNA has been extracted (by Ahmed) from the RILs of all populations, their parents, and checks. This DNA is intended to be sent to the DArT for 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 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.

Impact:

The potential impact of this research on the breeding for FHB resistance is phenomenal. If we can prove that 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.

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