USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY09 Final Performance Report
July 15, 2010

Cover Page

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Fiscal Year:	2009
USDA-ARS Agreement ID:	59-0206-9-066
USDA-ARS Agreement Title:	Breeding Adapted Spring Wheat for Scab Resistance.
FY09- USDA-ARS Award Amount:	$ 133,208

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Adjusted Award Amount
VDHR-SPR	Development of Adapted Hard Red Spring Wheat Cultivars and Germplasm Resistant Scab Disease.	$ 115,285
VDHR-SPR	Screening Newly Introduced Spring Wheat Germplasm for Novel Sources of Resistance to Scab.	$ 17,923
	Total Award Amount	**$ 133,208**

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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 Winter Wheat Region
SWW – Southern Sinter Wheat Region

Project 1: *Development of Adapted Hard Red Spring Wheat Cultivars and Germplasm Resistant Scab Disease.*

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

Scab of Fusarium head bight (FHB) remains the major disease that threatens wheat production and industry in the Northern Central Plains of the US. The disease is complex and causes significant reduction in grain yield and impacts negatively the wheat quality. In North Dakota, FHB disease had tremendous implications, particularly on HRSW producers; end-users; and export market. At NDSU, the hard red spring wheat (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, we strongly believe that genetic resistance is/will provides a strategic long-term, economically, and environmentally sound solution to the problem. During the 2009-2010 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 bellow.

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 2009-2010, 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:

Released cultivars:

- The 2009 release cultivar is **'Barlow'**. Prior to its release, Barlow was tested under **ND 809** experimental line for many years in different nurseries in our breeding program and in the regional nurseries, including URN. 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.
- The **2007** release **'Faller' (ND805)** was the second leading cultivar in wheat acreages after Glenn in ND and the leading cultivar in MN in 2009 with about 1.15 and 0.085 million acres, 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 is becoming very popular in ND and MN.

- Prior to the release of Faller, **'Howard'** (**ND 800**) 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 2009, Howard was grown on more than % of ND wheat acreages.
- **Glenn** (ND747) 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 24% (about 1.7 million acres) of ND wheat acreages. In MN, Glenn was among the 3 top wheat cultivars.
- The **2004** HRSW release, **Steele-ND (ND 741)** 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 more than 6-9% 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.
- 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:

- ND 808 has an agronomic performance slightly better than Faller, the second leading cultivar in ND and the leading cultivar in MN. ND808 has moderate resistance to FHB, similar to Faller.

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, about 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. In 2009, Faller was the leading wheat cultivar in MN with 21.3% of wheat acreages. 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.

Project 2: *Screening Newly Introduced Spring Wheat Germplasm for Novel Sources of Resistance to Scab.*

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

The Fusarium head blight (FHB) or scab disease is a major wheat disease in the spring wheat region. Combating this disease while protecting our environment by growing genetically resistant and adapted cultivars is the soundest, efficient, economical, and safe strategy. Recently developed HRSW cultivars by NDSU breeding program (Faller, Howard, Glenn, Steele-ND, and Alsen) with moderate FHB resistance are being grown extensively in ND. These cultivars were grown on 57% (3.85 million acres) of North Dakota Alone in 2009. Similar acreages were grown to NDSU FHB resistant cultivars in the past 5 years. However, new adapted cultivars with different and/or higher resistance levels, combining different sources of resistance to FHB and other diseases are needed. NDSU and other wheat breeding programs in the region main objective is to develop better wheat cultivars for the growers and end users in the US and international export markets. Previous studies have summarized the Fusarium head blight (FHB) sources of resistance in very few genotypes including Sumai 3, Ning 7840, Frontana, Nobeokabouza, 2375, Ernie, and Freedom. So far, Sumai3 is probably, one the most used germplasm for FHB resistance worldwide. In the spring wheat region, most released cultivars with FHB resistance are from the Chinese source. Genetic diversity is a major component of a successful breeding program. Hence, novel sources of resistance to FHB are needed today more than ever. The search for sources of resistance is essential to insure the development of FHB resistant spring cultivars.

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:

Two hundred twenty introduced wheat genotypes along with the mostly resistant cultivars or genotypes have been screened for FHB in 2008 and 2009. The germplasm includes 186 genotypes developed by CIMMYT using the funds from the USWBSI to introgress novel FHB sources of resistance into the US wheat germplasm and 36 genotypes received from East Europe. The screening started in 2008 and continued in 2009. The field screening is being conducted at Prosper, ND using the Scab nursery. The nursery is equipped with a misting system to keep humidity at the optimum level for disease development. The greenhouse screening was supposed to be conducted in the fall of 2009 and include only genotypes that showed good levels of FHB resistance in the field tests. However, based on 2008 and 2009 results, most genotypes showed no or very little resistance. In the field test, ants were misted periodically to maintain the proper relative humidity for disease development. The 2009 screening nurseries were very successful. The results showed excellent FHB infection levels which allowed us good discrimination among genotypes. The screening nurseries were repeated in 2009 to validate the 2008 data. Final selection and data analysis over the two years project period was done in Fall 2009. The two years average

disease severity of genotypes and checks varied from 4.5 and 66% for ND2710, the most resistant genotype and Line 154, respectively. Glenn and Alsen, our most popular cultivars and FHB checks scored respectively 5.9 and 8.2%, better than any new genotypes. Among the 220 introduced genotypes tested in this study, the most resistant had about 10% severity. Our susceptible cultivar check Reeder had 18% severity. Among the 220 genotypes only 16 had severity between 8.2 and 18% registered for Alsen and Reeder respectively. Among these 16 genotypes, only four genotypes had severities non significantly different from Alsen. However, Glenn had significantly lower severity (5.9%) that ALL the tested genotypes.

The four genotypes that showed similar resistance than Alsen were agronomically not adapted (tall or late). This raises the question of their "true" reaction to FHB. We suspect that the resistance of these genotypes may be due to their lateness and may be escape. Further tests will be conducted to confirm that.

Impact:

Novel and divers sources of FHB resistance are paramount to the wheat breeding programs in the region where scab is a major limiting factor. Identifying additional sources of resistance different from what we have now will allow our breeding programs to develop cultivars with high and durable FHB resistance. The NDSU HRSW breeding program has released several wheat cultivars with FHB resistance. This has allowed the US wheat growers in the spring region to grow once again, on a large scale (3-4 million acres), wheat in scab prone regions. This obviously, has been generating for the growers, hundreds of millions of dollars annually. Similarly, the wheat industry is having better wheat quality for their products, particularly during the scabby years. In addition, as more than 50% of total HRSW is exported worldwide for its superior quality, the NDSU HRSW cultivars with high quality and scab resistance has allowed our export market to be more competitive at the international level. Hence, substantial financial impact on wheat industry and export market due to NDSU HRSW cultivars has been generated. Finally, NDSU germplasm with FHB resistance and high quality is being used nationally and internationally in the research improvement program as a hallmark sources for these traits. Therefore this project has a tremendous potential impact.

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. **2010**. Improving adaptation of hard red spring wheat to spring wheat region: Registration of 'Barlow' Spring Wheat. **Journal of plant Registration.** ***(Accepted)***

Mergoum, M., P. Singh, R. C. Frohberg, S. Kianian, S. Simsek. **2009**. Registration of the Steele-ND/ND 735 Wheat Recombinant Inbred Lines Mapping Population. **Journal of plant Registration 3 (3): 300-303.**

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. **2010**. Improving adaptation of hard red spring wheat to spring wheat region: Registration of 'Barlow' Spring Wheat. **Journal of plant Registration.** ***(Accepted)***

Mergoum, M., P. Singh, R. C. Frohberg, S. Kianian, S. Simsek. **2009**. Registration of the Steele-ND/ND 735 Wheat Recombinant Inbred Lines Mapping Population. **Journal of plant Registration 3 (3): 300-303.**

Guorong Zhang, **Mohamed Mergoum**, Shahryar Kianian, Dwain W. Meyer, Senay Simsek, and Pawan K. Singh. **2009**. Genetic relationship and QTL association between kernel shattering and agronomic traits. **Crop Science 49: 451-458**

Proceedings

Dalitso Yabawalo1, Mohamed Mergoum1*, and William Berzonsky. 2009. Chromosome Characterization for Fusarium Head Blight Resistance in 'Frontana' Spring Wheat. *In* Canty, S. M., A. Clark, J. Mundell, E. Walton, D. Ellis, and D.A. Van Sanford (Eds), Proceedings of the National Fusraium Head Blight Forum; 2009 Dec 7-9, Orlando, FL. Lexington, KY: University of Kentucky. Pp. 161-164.

Abstract/Presentations

Singh, P. K., **M. Mergoum**, and T.B. Adhikari. **2009**. Mapping Resistance to Multiple Leaf Spotting Diseases in Steele-ND/ND 735 Wheat Population. *In* ASA-CSSA-SSSA-CSSS Abstracts 2009 [CD-ROM], Pittsburg PA, USA.