USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY06 Final Performance Report (approx. May 06 – April 07)
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Cover Page

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Fiscal Year:	2006
USDA-ARS Agreement ID:	59-0790-4-091
USDA-ARS Agreement Title:	Breeding and Development of DNA Markers for Fusarium Head Blight Resistance in Wheat.
FY06 ARS Award Amount:	$ 169,247

USWBSI Individual Project(s)

USWBSI Research Area*	Project Title	ARS Award Amount
HGR	Development of Spring Wheat Varieties with FHB Resistance using DNA Markers and Retrospective Breeding.	$ 23,905
HGR	Discovery and Pre-Breeding of Novel Fusarium Head Blight Resistant Sources into Spring Wheat.	$ 62,152
VDUN	Breeding Fusarium Head Blight Resistant Spring Wheat.	$ 83,189
	Total Award Amount	**$ 169,247**

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Principal Investigator Date

* CBCC – Chemical, Biological & Cultural Control
EEDF – Etiology, Epidemiology & Disease Forecasting
FSTU – Food Safety, Toxicology, & Utilization of Mycotoxin-contaminated Grain
GET – Genetic Engineering & Transformation
HGR – Host Genetics Resources
HGG – Host Genetics & Genomics
PGG – Pathogen Genetics & Genomics
VDUN – Variety Development & Uniform Nurseries

Project 1: *Development of Spring Wheat Varieties with FHB Resistance using DNA Markers and Retrospective Breeding.*

1. What major problem or issue is being resolved and how are you resolving it?

Given i) the ongoing need for FHB resistant wheat varieties; ii) the current knowledge regarding the inheritance of FHB resistance and the number of quantitative trait loci (QTLs) that have been tagged with markers; and iii) the establishment of the USDA-ARS Small Grains Genotyping Centers, this project aims to employ our expertise, technology, and resources to develop Fusarium head blight resistant wheat varieties adapted for commercial production in Minnesota and the surrounding region using DNA markers to enrich selected populations for their frequency of major FHB QTLs. Another future outcome of this project will be to characterize the relative FHB resistance of different combinations of FHB QTLs.

2. List the most important accomplishment and its impact (how is it being used?). Complete all three sections (repeat sections for each major accomplishment):

Accomplishment:

As part of this grant, we submitted 6,759 leaf tissue samples (F_2 and BC_1F_1 generation) for processing by the USDA-ARS Fargo Genotyping Center, resulting in 22,719 marker data points. In addition, we genotyped 325 BC_1F_1 individuals in-house, resulting in 502 marker dataoints. Markers were used for *Fhb1*, *Qfhs.ifa-5A*, *Gpc-B1*（grain protein QTL), *Rht-1B* and *Rht-1D*, and *Tsn1* (tan spot). All of these materials are currently being grown for selection in our 2007 headrow nursery on the St. Paul campus.

Impact:

High priority populations were chosen for this marker-assisted selection effort. As a result, we will have populations with a greatly enhanced proportion of individuals containing important FHB QTLs as well as other important genes.

As a result of that accomplishment, what does your particular clientele, the scientific community, and agriculture as a whole have now that they didn't have before?

This was the second year of this project that was funded in part as an example for how other breeding projects can benefit from interaction with the Genotyping Centers. This project utilized retrospective breeding and judiciously applied marker-assisted selection on populations with a proven high probability of producing variety candidates. By applying marker-assisted selection in the most promising populations, we hope to demonstrate that this technology can increase the rate and frequency of variety candidates with high levels of FHB resistance and serve as an example for how other breeders may address complexly inherited traits, including FHB resistance, with marker technology.

Project 2: *Discovery and Pre-Breeding of Novel Fusarium Head Blight Resistant Sources into Spring Wheat.*

1. What major problem or issue is being resolved and how are you resolving it?

Fusarium head blight resistant spring wheat germplasm has been identified by vigorous screening of the worldwide collections in the National Small Grains Collection. The utilization of the selections is not satisfactory due to the lack of adequate information on their novelty, and the low direct breeding value of the unadapted germplasm. This project confronts the issue of characterizing the resistance, introgression of the resistance into elite germplam, and finding additional new sources of resistance in spring wheat. We used both breeding and FHB nurseries to select for FHB resistance and adaptability in germplasm introduction and pre-breeding populations. Spring wheat germplasm of special interest to US wheat breeding was planted in FHB field nurseries. Resistant selections made based on three year replicated FHB screening nurseries were evaluated for point-inoculation in the greenhouse, and genotyped with DNA markers linked to FHB resistant QTLs. Best resistant selections were distributed to breeders.

2. List the most important accomplishment and its impact (how is it being used?). Complete all three sections (repeat sections for each major accomplishment):

Accomplishment:
In the 2006 summer season, germplasm introduction and pre-breeding populations were planted in the FHB and breeding nurseries for disease evaluation and observation of general performance. New germplasm introduced included 66 spring wheat PI accessions selected by Dr. Yue Jin at CDL for resistance to an emerging dangerous stem rust race Ug-99. The 66 accessions were planted in the Preliminary Screening Nursery (PSN) in St. Paul. Selections from the previous years were planted in a replicated field Elite Germplasm Nursery (EGN). Twenty-six accessions from the 2005 PSN selection and 15 accessions from the 2004 PSN selection were planted in the St. Paul nursery with 2 replications. Sixty-one accessions of the 2003 PSN selection were planted in St. Paul, Morris, and Crookston FHB screening nursery with two replicates/location. The pre-breeding materials in the St. Paul FHB nursery included 140 $F_{5:6}$ RILs of Wheaton/Tokai 66, 50 RILs of Wheaton/PI 81790, and 50 RILs of Wheaton/PI 345731, and thirty-one RILs of the Abura/Wheaton cross selected for FHB resistance in 2004 and 2005 field nurseries. The RILs from Abura/Wheaton were also planted in the Morris and Crookston FHB nursery with 2 replicates/location. Disease severity and incidence in each plot were recorded. The Morris nursery was discarded due to inoculum failure following extremely hot and dry conditions in June and July. The EGN nursery and the pre-breeding RILs were hand harvested, and processed for VSK, and DON determination. A total of 13 accessions were selected from the PSN nursery and will be tested in replicated nurseries in 2007. The top five selections from the Wheaton/Abura cross were made available to other breeders in the region by entering them into the 2007 URSN regional nursery. Seed of ten accessions with high resistance to VSK and DON were provided to SDSU wheat breeding programs.

Fifty $F_{5:6}$ RILs of Wheaton/PI 285933 (Chudoskaja), and Wheaton/PI 185380 (Prodigio Italiano) were planted in a breeding nursery. Severe stem rust damage was observed in those two

populations. One hundred and fifty RILs of Wheaton/PI 81791, Wheaton/PI 345731 were advanced to $F_{6:7}$ in a greenhouse for potential mapping of novel resistance QTLs.

In fall 2006, three top FHB resistant accessions PI 19766, PI 62083, and PI 69261 none of which contain the *Fhb1* QTL, and CItr 9348 with *Fhb1* QTL were crossed with Wheaton and MN99436-6 (released as RB07). Those crosses are being advanced to F_3 in the greenhouse. About 120 accessions were tested for Type II resistance in two greenhouse seasons, and haplotyped with DNA marker STS256 for *Fhb1* gene, barc180 for the 5AS QTL from Sumai 3, dupw227 for the 3AL QTL from Frontana, and gwm566 from Nyu Bai.

During this funding period, an important manuscript 'New Fusarium Head Blight Resistant Spring Wheat Germplasm Identified in the USDA National Small Grains Collection' was accepted for publication by *Crop Science*. In this report, 73 accessions with different levels of resistance based on FHB index, VSK and DON were identified. Among those selections, the FHB resistance in 63 accessions was not previously reported. The seed of those selections were deposited in USDA Small Grains Collection with a new PI number.

Impact:

The discovery of new FHB resistant wheat germplasm as reflected in the *Crop Science* manuscript will be a great addition to the FHB resistance gene pool. The large screening effort by our program has proven that there is diversity of FHB resistance in the primary gene pool of wheat. Our proactive distribution of the newly identified FHB resistant germplasm and elite lines from the pre-breeding populations will directly benefit the US wheat breeding programs for enhancing FHB resistance.

As a result of that accomplishment, what does your particular clientele, the scientific community, and agriculture as a whole have now that they didn't have before?

The identified and characterized resistance germplam using conventional and molecular marker tools will provide the wheat community diversified source of resistance for germplasm enhancement and fundamental studies of FHB resistance. The introgression effort will facilitate the breeding efforts to improve FHB resistance levels in commercial cultivars.

Project 3: *Breeding Fusarium Head Blight Resistant Spring Wheat.*

1. What major problem or issue is being resolved and how are you resolving it?

Wheat varieties with greater resistance to *Fusarium* head blight (FHB) would make a substantial contribution to reducing the losses from this devastating disease. The main objective of this project is to develop Fusarium head blight resistant wheat germplasm and varieties adapted for commercial production in Minnesota and the surrounding region and characterize the level of FHB resistance of all wheat varieties grown in the region.

2. List the most important accomplishment and its impact (how is it being used?). Complete all three sections (repeat sections for each major accomplishment):

Accomplishment: Two new experimental lines were released in 2007. MN99436-6 was publicly released as 'RB07' in January 2007. MN00261-4 was approved for exclusive release in March 2007. These lines have high grain yield, good grain quality, resistance to preharvest sprouting, moderately strong straw, and good resistance to FHB. RB07 has very good leaf rust resistance and MN00261-4 has good tan spot resistance. When rated on a 1 (resistant) to 9 (highly susceptible) scale for FHB resistance, MN00261-4 is a 4 and RB07 a 5 (Table 1). For comparison, Alsen on the same scale is a 4; Glenn, 3; and Knudson, the most widely grown variety in Minnesota, 6. The average of all named varieties that have a rating assigned is 5.6; therefore, these two releases represent an improvement in FHB resistance for the region.

Table 1. Characteristics of 2007 University of Minnesota wheat releases RB07 and MN00261-4 compared to the two most popular varieties in the state in 2006, Knudson and Oklee.

Variety	FHB (1-9)	Grain Yield[1]	Grain Protein[2]	Straw Strength
RB07	5	108	14.9	moderately strong
MN00261-4	4	104	14.8	moderately strong
Knudson	6	107	14.2	moderately strong
Oklee	5	99	14.9	medium

[1] % of trial mean, 2004-2006 northern MN locations (8 environments)
[2] %, 2005-2006 (14 environments)

Impact: These two new releases give wheat growers in the region additional options, both of which improve upon FHB resistance compared to the two most popular varieties in the state, namely Knudson and Oklee.

As a result of that accomplishment, what does your particular clientele, the scientific community, and agriculture as a whole have now that they didn't have before?: The most popular wheat variety in Minnesota in 2006 was Knudson. One of its major weaknesses is moderate susceptibility to scab. Both of these lines represent improvements in scab resistance. RB07 also offers higher grain protein and comparable grain yield compared to Knudson.

Accomplishment: Five new experimental lines were entered in the 2006 Uniform Regional Scab Nursery. These lines were identified in previous testing as having improved levels of FHB resistance and two of them were among the best performers in the nursery. A U of MN experimental line, MN00209-3-1, had the lowest disease index and two lines, MN00209-3-1 and MN02222-1, were in the top five for lowest DON. Impressively, the DON levels of these two lines were about half that of the two resistant checks, BacUp and ND2710.

Impact: These lines combine FHB resistance from different sources and are candidates for germplasm release. These lines are available and have been requested by other wheat breeders in the region for use as crossing parents.

As a result of that accomplishment, what does your particular clientele, the scientific community, and agriculture as a whole have now that they didn't have before?: These materials contain unique combinations of FHB resistance genes and in many cases the resistance levels are superior to the resistant checks used in the nursery. Increasingly, the other important characteristics desired of crossing parents are improving as well (e.g. shorter height, greater straw strength, better leaf rust resistance, better grain yield and quality).

Accomplishment: Scab nurseries were established at 3 field sites in 2006. Inoculum failure and dry, hot weather resulted in no FHB at the Morris location. The St. Paul location experienced lower than desired FHB levels, but highly susceptible materials could be discarded. The Crookston FHB screening nursery was the best I have ever seen, providing highly discriminatory data. As a result of this nursery and results from previous years, the FHB resistance data of 27 spring wheat cultivars was assessed and reported to growers via print media and field day presentations. We simplified our rating scale this year by switching to a 0-9 scale where 0 represents immunity and 9, highly susceptible. Current varieties range from 3 to 8.

Impact: Good field screening nurseries are needed to maintain progress in breeding for FHB resistance. FHB remains a potentially devastating disease in the region as severe damage was inflicted in 2005. Our FHB resistance ratings are an important part of growers' decision regarding which variety they will grow.

As a result of that accomplishment, what does your particular clientele, the scientific community, and agriculture as a whole have now that they didn't have before?: The U of MN FHB variety ratings are based on data from about six FHB inoculated, mist-irrigated nurseries (fewer than six is possible if the nurseries were highly discriminatory). In most cases, we have ratings of new varieties published by December of the year preceding the sale of certified seed to growers.

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.

Peer-Reviewed Articles

Anderson, J.A., R.H. Busch, D.V. McVey, J.A. Kolmer, Y. Jin, G.L. Linkert, J.V. Wiersma, R. Dill-Macky, J.J. Wiersma, G.A. Hareland. 2007. Registration of 'Ada' wheat. Crop Sci. 47:434-435.

Pumphrey, M.O., R. Bernardo, J.A. Anderson. 2007. Validating the *Fhb1* QTL for Fusarium head blight resistance in near-isogenic wheat lines developed from breeding populations. Crop Sci. 47:200-206.

Zhang X., Y Jin, JC Rudd, HE Bockelman. 2007. New Fusarium head blight resistant spring wheat germplasm identified in the USDA National Small Grains Collection. Crop Sci. (in press).

Abstracts/Proceedings

Anderson, J.A. 2006. Marker Assisted Selection for Fusarium Head Blight Resistance in Wheat. *In* Proc. of the OECD International Workshop: *Mycotoxins from the Field to the Table*, Omaha, NE.

Anderson, J.A., and S. Chao. 2006. Overview of marker-assisted selection and its implementation in a wheat breeding project. *In* Proc. of the 40th North American Alfalfa Improvement Conference and 19th *Trifolium* Conference, Bloomington, MN.

Anderson, J.A., S. Chao, and S. Liu. 2006. Molecular Breeding Using a Major QTL for Fusarium Head Blight Resistance in Wheat. Presented at the *International Plant Breeding Symposium*, Mexico City.

Liu, S., M.O. Pumphrey, . S. Gill, M.A. Campbell, J. Hamilton, C.R. Buell, X. Zhang, J. Dolezel, B. Chalhoub, and J.A. Anderson. 2007. Sequence analysis of BACs spanning *Fhb1*, a major QTL for Fusarium head blight resistance on chromosome 3BS in wheat. *In* Plant & Animal Genome XV Abstracts, San Diego, CA.

Zhang X, Y Jin, and JA Anderson. 2006. Molecular marker characterization of Fusarium head blight resistant germplasm. Page 129-130. *In* Proc. 2006 National Fusarium Head Blight Forum. Dec. 10-12, 2006.

Reports

Anderson, J., J. Wiersma, J. Kolmer, and R. Dill-Macky. 2006. Spring Wheat. *In* Preliminary Report 24; 2006 Wheat, Barley and Oat Variety Performance in Minnesota, Preliminary Report, Edited by Jochum Wiersma.

Anderson, J.A., G.L. Linkert, and J.J. Wiersma. 2006. Hard Red Spring Wheat. *In* Minnesota Varietal Trials Results, University of Minnesota Extension Service.