USDA-ARS / USWBSI
FY04 Final Performance Report
July 15, 2005

Cover Page

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Year:	**FY2004** (approx. May 04 – April 05)
FY04 ARS Agreement ID:	**59-0790-4-091**
FY04 ARS Agreement Title:	**Breeding and Genetics of Fusarium Head Blight Restance in Spring Wheat.**
FY04 ARS Award Amount:	**$ 236,036**

USWBSI Individual Project(s)

USWBSI Research Area*	Project Title	ARS Adjusted Award Amount
BIO	High Resolution Mapping of a Fusarium Head Blight Resistance QTL in Wheat.	$ 58,970
GIE	Maintain a Germplasm Center of Fusarium Head Blight Resistant Spring Wheat.	$ 63,415
VDUN	Assessing the Breeding Value of Fusarium Head Blight Resistance Genes.	$ 41,851
VDUN	Breeding Fusarium Head Blight Resistant Spring Wheat.	$ 71,766
	Total ARS Award Amount	**$ 236,036**

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Principal Investigator Date

* BIO – Biotechnology
CBC – Chemical & Biological Control
EDM – Epidemiology & Disease Management
FSTU – Food Safety, Toxicology, & Utilization
GIE – Germplasm Introduction & Enhancement
VDUN – Variety Development & Uniform Nurseries

(Form – FPR04)

Project 1: ***High Resolution Mapping of a Fusarium Head Blight Resistance QTL in Wheat.***

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

A major QTL (*Qfhs.ndsu-3BS*) for FHB (Fusarium head blight) resistance, derived from 'Sumai 3', has been identified and verified by several research groups via molecular marker analysis. Further detailed mapping and cloning of this major QTL is justified by the significant and consistent effect of this QTL. Previously, we developed a fine map of this QTL region using an F_2 population from a cross of 2 lines near-isogenic for the QTL. This map contained 11 markers.

The objectives of this research were to:
1) Develop and map more DNA markers in the fine map region containing *Qfhs.ndsu-3BS*.
2) Select more recombinants in the *Xgwm533 – Xgwm493* interval from another 1600 F_2 plants, and further narrow down the genomic region containing *Qfhs.ndsu-3BS*.
3) Screen a BAC library and construct a BAC contig spanning the *Qfhs.ndsu-3BS* region.

2. What were the most significant accomplishments?

The high-resolution map of the *Qfhs.ndsu-3BS* region has been completed. A genetic map utilizing 3,155 F_2's from a cross of two lines near isogenic for *Qfhs.ndsu-3BS* was developed that contains 24 markers between *Xgwm533* and *Xgwm493*. Phenotyping of selected homozygous F_3 recombinants using point inoculation in the greenhouse resulted in the placement of *Qfhs.ndsu-3BS* on this fine map between two markers that represent a genetic interval of less than 0.1 cM.

A chromosome 3B – specific BAC library from Chinese Spring was screened using three of these markers and additional markers generated by end sequencing of positive BAC clones. A contig of 11 BACs was assembled based on the PCR fingerprints of markers nearest the QTL position. Two BAC clones believed to span the QTL region are currently being sequenced.

These accomplishments: the positioning of *Qfhs.ndsu-3BS* within a small interval on our genetic map and the completion of a BAC contig containing this QTL represent major milestones in our effort to clone this QTL. Knowledge of a gene that contributes to high levels of resistance should help to develop effective and efficient means to combat FHB in wheat. No disease resistance QTL have been cloned from plants. Therefore, our findings also may have broad impact on developing plants with greater disease resistance.

Project 2: ***Maintain a Germplasm Center of Fusarium Head Blight Resistant Spring Wheat.***

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

Identifying and utilizing new/additional sources of resistance will be critical for enhancing the level of scab resistance and diversifying the current resistance gene pool. The objectives of this project are:1) finding additional/new sources of scab resistance in spring wheat; 2) maintaining and systematically characterizing the resistance; 3) introgressing the resistance into adapted background. We used a multiple nurseries system to handle materials at different stages of screening. Newly introduced spring wheat germplasm is planted in a non-replicated trial and evaluated for scab reaction in the Preliminary Screening Nursery (PSN) in the field. Field selections are evaluated using point-inoculation in the greenhouse. Selections from the PSN are further evaluated in a replicated Elite Germplasm Nursery (EGN) for three consecutive years in three locations. Recombinant inbred lines (RIL) of crosses between the sources of resistance and a spring wheat cultivar Wheaton are advanced, selected, and backcrossed to Wheaton.

2. What were the most significant accomplishments?

The 2004 field germplasm screening nursery was planted in St. Paul and Crookston, MN. The St. Paul nursery was inoculated with conidial suspension. The Crookston nursery was inoculated with corn spawn. Sprinkler irrigation was used at both locations to promote disease development. A total of 384 accessions of spring wheat originated from Russia, Eastern Europe, and Heilongiang and Sichuan provinces of China were planted in the PSN nursery in St. Paul. Thirty accessions were selected as potential FHB resistant sources. These selections were increased in an off-season breeding nursery in Christchurch, NZ. The EGN consisted of 254 entries from the 2001, 2002 and 2003 PSNs. The St. Paul EGN was planted with at least two replicates. The Crookston nursery consisted of the 2001 PSN selections (106 entry*2 reps) and 190 F4:5 lines of Abura/Wheaton. Thirty-two RIL lines were selected from the Abura/Wheaton cross for further evaluation and potential release as new adapted FHB resistant germplasm.

In the greenhouse, field selections were evaluated by point-inoculation with 5 pots/line in each season. The F4:5 and F5:6 of Abura/Wheaton were point-inoculated. To isolate a promising resistance gene, one line with homogeneous intermediate resistance was backcrossed to Wheaton. Generation advancement was made in crosses of Wheaton/PI 81791 and Wheaton/PI 345731.

To promote the utilization of the newly identified resistance, we have been actively distributing the selections to interested parties. Each year the top 5 selections were sent to the spring wheat breeders for evaluation in the Uniform Regional Scab Nursery. Distributions to winter wheat breeding programs were made upon request. Up to date, the most resistant selections have been sent to Arkansas (Dr. Gene Milus), Nebraska (Dr. Steven Baenziger, Dr. Gary Yuen), North Carolina (Dr. Paul Murphy), and Virginia (Dr. Carl Griffey). Those breeding programs have made crosses with our selections. Besides Sumai 3 resistance, our selections have been the primary scab resistant sources in some breeding programs.

Project 3: ***Assessing the Breeding Value of Fusarium Head Blight Resistance Genes.***

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

With funding from a previous USWBSI grant, we discovered new FHB QTL in the resistance sources Fujian 5114 and Wuhan 3. These QTL explain as much as 20 to 25% of the FHB resistance in greenhouse testing. However, the effect of these QTL in breeding-relevant germplasm must be known before they are subjected to marker-assisted selection.

The objectives of this research were to:

1. Develop near-isogenic lines of major QTLs identified in the resistance sources Fujian 5114 and Wuhan 3.
2. Determine the effects of Fusarium head blight resistance QTL derived from Fujian 5114 and Wuhan 3 in multiple genetic backgrounds.

In addition, we continue to characterize the 3BS QTL for its effects on yield and reaction to other diseases.

2. What were the most significant accomplishments?

Near-isogenic lines (NILs) for QTLs on chromosomes 3BSc (separate from *Qfhs.ndsu-3BS*), 5AS (*Qfhs.ifa-5A* region) and 5BL were developed to determine if these QTL enhanced FHB resistance in multiple genetic backgrounds. These QTL regions were better defined by the addition of 4 new markers to the 3BSc region and 2 markers each for the 5AS and 5BL regions.

Four NIL pairs each were developed to test the effects of both the 5AS and 5BL QTLs and one NIL pair was developed for 3BSc. Pairs were tested utilizing point-inoculation in two greenhouse experiments and using spray-inoculation and grain spawn inoculum, respectively, in two field locations in 2004. The Fujian 5114 alleles at both the 5AS and 5BL QTL did not significantly impact FHB resistance parameters, other than to reduce DON accumulation in the field. At the 5BL QTL, the Fujian 5114 alleles had significant effects on FHB severity in greenhouse experiments, although the effects varied between NIL pairs and experiments. The 3BSc NIL pair showed significant effects on field FHB parameters with resistance derived from MN99112 (MR). However this effect may be confounded by height as the NIL with the MN99112 alleles in this region was taller than its NIL sib. No significant effects were associated with the 3BSc QTL in the greenhouse. Further research regarding the breeding value of both the 5AS and 3BSc QTL regions is warranted, but unless the 5BL QTL region is associated with reductions in VSK or DON, the 5BL QTL is of limited breeding value.

Twenty-five pairs of NILs for *Qfhs.ndsu-3BS* were measured for grain yield at 3 locations in 2004. NILs containing the Sumai 3 allele for *Qfhs.ndsu-3BS* yielded 2.6% more than the NIL containing an alternative allele at this locus. However, there was a significant difference in yield (higher for the NIL with the favorable QTL locus) for only one of the 25 pairs. Overall, there was no significant difference for test weight, though six lines each had significantly ($P < 0.05$) higher or lower test weight than their corresponding pair. There was no significant difference in grain protein concentration for any of the NIL pairs. These results, along with previous findings that there are no negative consequences regarding plant height, heading date, leaf rust or stem rust resistance, indicate that this QTL has no known negative effects and should be broadly suitable for incorporation into breeding programs.

Project 4: ***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. Research in our program and other breeding programs has demonstrated that breeding progress toward resistance to this disease is possible with proper germplasm and screening procedures.

The specific objectives and long-term goals of this research are the same because of the long period of time required for these activities. These objectives are:
1. Screen new putative FHB resistance sources and develop improved spring wheat germplasm containing enhanced levels of FHB resistance.
2. Develop *Fusarium* head blight resistant wheat varieties adapted for commercial production in Minnesota and the surrounding region.

2. What were the most significant accomplishments?

Note: In-house funds also contributed to these accomplishments.

- One experimental line, MN97803-A, was released in January 2005 as 'Ulen'. This line is similar to HJ98, but has higher grain protein and test weight. Ulen is resistant to leaf rust and has moderate resistance to FHB.
- Two additional lines, MN99436-6 and MN95229-A underwent seed increase in California during the winter of 2004/2005 and both lines will be candidates for release within the next year. Both lines have high grain yield, good grain quality, resistance to leaf rust and moderate resistance to FHB.
- Five new experimental lines were grown in the 2004 Uniform Regional Scab Nursery. These lines were identified in previous testing as having improved levels of FHB resistance and were among the best performers in the nursery. Five new resistant lines were entered in the 2005 nursery. These lines combine FHB resistance from different sources and are candidates for germplasm release.
- A major publication, Fuentes et al. (2005) is in press and reports on resource allocation and cultivar stability in breeding for FHB resistance.
- The FHB reaction of 25 spring wheat cultivars was assessed and reported to growers via print media and field day presentations.
- During the 2004 growing season, *Fusarium* head blight-inoculated, misted replicated nurseries were established at Crookston, Morris, and St. Paul (Table 1). Our project has placed more emphasis on field-based screening for FHB resistance and less emphasis on greenhouse-based screening. A generation previously screened by greenhouse point inoculation (pre-yield trial lines in Table 1) are now screened in the field.

Table 1. 2004 Wheat Breeding Project Field FHB Screening Nurseries (excludes genetic studies and germplasm screening).

	No. Entries	— No. of Rows Evaluated per Location —		
Material	+ checks	Crookston	St. Paul	Morris
Yield Trial Lines	204	454	408	454
Pre-Yield Trial Lines	1,212		1,212	
Regional Nurseries	90	224	178	

FHB severity (spread of disease symptoms within the spike) and visual scabby kernels from harvested grain was collected for all materials.

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 you 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, G.L. Linkert, J.V. Wiersma, R. Dill-Macky, J.J. Wiersma, and G.A. Hareland. 2005. Registration of Oklee' wheat. Crop Sci. 45:784-785.

Fuentes-Granados, R.G., H.R. Mickelson, R.H. Busch, R. Dill-Macky, C.K. Evans, W.G. Thompson, J.V. Wiersma, W. Xie, Y. Dong, and J.A. Anderson. 2005. Resource allocation and cultivar stability in breeding for Fusarium head blight resistance in spring wheat. Crop Sci. in press.

Proceedings:

Anderson, J.A., S. Liu, and M.O. Pumphrey. 2004. Perspectives on FHB Resistance Breeding and Research on DNA Marker Assisted Selection. pp. 30-33 In *Proceedings of the JIRCAS Workshop on Collaborative Research on Fusarium Head Blight Resistance in Wheat and Barley*, Tsukuba, Japan, ed. T. Ban, Japan Intl. Res. Center for Agric. Sci., Tsukba, Japan.

Anderson, J.A., S. Liu, and M.O. Pumphrey. 2004. DNA Marker Discovery, Validation, and Deployment in the University of Minnesota Wheat Breeding Program. pp. 74-76 in *Proceedings of the 54th Australian Cereal Chemistry Conference and the 11th Wheat Breeders Assembly*, Canberra, Australia, ed. C.K. Black et al, Royal Australian Chem. Inst, North Melbourne, Australia.

Anderson, J.A. 2004. A Wheat Breeder's Perspective on Selecting for Complexly Inherited Traits with DNA Markers. pp. 77-79 in *Proceedings of the 54th Australian Cereal Chemistry Conference and the 11th Wheat Breeders Assembly*, Canberra, Australia, ed. C.K. Black et al, Royal Australian Chem. Inst, North Melbourne, Australia.

Abstracts:

Liu, S., M.O. Pumphrey, X. Zhang, B.S. Gill, R.W. Stack, and J.A. Anderson. 2004. Fine Mapping of *Qfhs.ndsu-3BS*, a Major QTL for Fusarium Head Blight Resistance in Wheat. in *Proceedings of the International Triticeae Mapping Initiative 2004 Summer Workshop*, Minneapolis, MN, ed. J. Anderson, University of Minnesota, St. Paul, MN.

Liu, S., M.O. Pumphrey, X. Zhang, R.W. Stack, B.S. Gill and J.A. Anderson. 2004. Towards Map-Based Cloning of the *Qfhs.ndsu-3BS* QTL that Confers Resistance to Fusarium Head Blight in Wheat. p. 98 In *Proceedings of the 2nd International Symposium on Fusarium Head Blight; incorporating the 8th European Fusarium Seminar*, Orlando, FL, USA, ed. by S.M. Canty et al., Michigan State University, East Lansing, MI.

Reynolds, S.K., and J.A. Anderson. 2004. Assessment of the Breeding Value of QTLs for Fusarium Head Blight Resistance in Wheat. p. 154 In *Proceedings of the 2nd International Symposium on Fusarium Head Blight; incorporating the 8th European Fusarium Seminar*, Orlando, FL, USA, ed. by S.M. Canty et al., Michigan State University, East Lansing, MI.

Zhang, X., Y. Jin, R. Dill-Macky and J.A. Anderson. 2004. Screening for Fusarium Head Blight

Resistance in Spring Wheat Germplasm. p. 227 In *Proceedings of the 2nd International Symposium on Fusarium Head Blight; incorporating the 8th European Fusarium Seminar*, Orlando, FL, USA, ed. by S.M. Canty et al., Michigan State University, East Lansing, MI.

Soria, M.A., J.A. Anderson, G. Brown-Guedira, K.G. Campbell, E.M. Elias, A.K. Fritz, B.S. Gill, K.S. Gill, S. Haley, S.F. Kianian, K. Kidwell, N.L.V. Lapitan, H. Ohm, J.D. Sherman, M.E. Sorrells, E. Souza, L. Talbert, and J. Dubcovsky. 2005. The MASwheat project. Impact of genomics on wheat breeding. *In* Plant & Animal Genome XIII Abstracts, San Diego, CA.

Reports:

Anderson, J., J. Wiersma, J. Kolmer, and R. Dill-Macky. 2003. Spring Wheat. *In* Preliminary Report 24; 2004 Wheat, Barley and Oat Variety Performance in Minnesota, Preliminary Report, Edited by Jochum Wiersma.

Anderson, J.A., G. Linkert, and R. Fuentes. 2004. Hard Red Spring Wheat. *In* Minnesota Varietal Trials Results, University of Minnesota Extension Service.