U.S. Wheat and Barley Scab Initiative
FY01 Final Performance Report (approx. May 01 – April 02)
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Cover Page

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Grant Number:	**59-0790-9-025**
Grant Title:	**Fusarium Head Blight Research**
FY01 ARS Award Amount:	**$ 176,489**

Project

Program Area	Project Title	Requested Amount
Biotech	Mapping FHB Resistance Genes in the Wheat lines Wuhan 3 and Fujian 5114	$ 64,799
Variety/Uniform	Breeding Fusarium Head Blight Resistant Wheat	$ 88,249
Variety/Uniform	Marker-assisted Selection for an FHB Resistance Gene Derived from Sumai 3	$ 34,049
	Total Amount Requested	**$ 187,097**

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Principal Investigator Date

(Form – FPR01)

Project 1: Mapping FHB Resistance Genes in the Wheat lines Wuhan 3 and Fujian 5114

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

Screening for FHB resistance based on reaction to challenge by the causal organism is difficult due to confounding effects of the environment and multigenic control. DNA markers will rapidly expedite the process of identifying resistant individuals in breeding populations. We have discovered a major QTL for FHB resistance derived from Sumai 3 and are currently testing the feasibility and effectiveness of using it in a marker-assisted selection scheme. Our objectives are to identify and map new FHB resistance genes from two Chinese resistance sources, Wuhan 3 and Fujian 5114, that putatively have high levels of resistance but likely differ from Sumai 3 for one or more genes.

2. What were the most significant accomplishments?

FHB screening in three to four field environments and two greenhouse evaluations have been completed using RIL populations of each resistance line crossed to the susceptible cultivar Norm. The marker mapping effort has been focused on regions containing QTL in Sumai 3 and providing skeleton genome coverage to identify new QTL.

Wuhan3/Norm population

208 markers were screened on the parents. 108 of these were polymorphic and 50 were mapped on the entire population. Two regions were consistently associated with FHB resistance: one on chromosome 3BS and the other on chromosome 5AS. Six other single markers also appeared to be associated with FHB resistance. The 3BS region appears to be the same QTL region as the *Qhfs.ndsu-3BS* marker found in other studies. This region explained between 16 and 42% of the variation. The 5AS region explains between 27 and 30% of the phenotypic variation under field conditions but under greenhouse conditions only between 4 and 20%. This QTL was coincident with heading date. The QTLs identified in this study (3BS, 5AS), in combination with a putative QTL region (Xgwm146) explain as much as 67% of the phenotypic variation when analyzed through multiple regression.

Fujian 5114/Norm

Sixty markers were polymorphic and mapped in the entire population. Interval analysis confirmed the presence of the 3BS resistance QTL in Fujian 5114. This QTL explained up to 28% of the phenotypic variation. An additional QTL was identified on chromosome 5BL, accounting for 25% of the variation in FHB. These two QTL were more strongly expressed in the two greenhouse experiments. The QTL on 5BL appears to be associated with delayed spread of the disease, as the corresponding R^2 values were higher in the 15 versus the 21 days after inoculation greenhouse evaluations. Single marker analysis identified QTL on 5AL, 2AL, 1BS, and 5AS, with R^2 values as high as 12%, however their effects were less consistent over environments. The 3BS and 5BL QTL together accounted for 40% of the variation in FHB resistance. Multiple regression models containing additional markers significant at $p<0.05$ explained 48% of the phenotypic variation.

Project 2: Breeding Fusarium Head Blight Resistant 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 have demonstrated that breeding progress toward resistance to this disease is possible with proper germplasm and screening procedures. The lack of adequate control methods for scab in wheat necessitate that breeding efforts must be accelerated to introgress resistance genes into adapted germplasm. The increased occurrence of scab nationwide, and particularly in the Upper Midwest, is due in part to the increased usage of reduced tillage. Because this is a practice that is not likely to diminish, we can expect future epidemics to occur when favorable weather conditions exist at flowering time.

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?

- One hard red spring wheat line, MN95002 was approved for seed increase in 2001. About 100 acres of Foundation seed are being increased during 2002. A release decision is expected this fall. This line has high grain yield, test weight, and grain protein and is moderately resistant to FHB, similar to the variety 2375. One other line, MN97803 was approved for preliminary increase in 2001. This line is similar to HJ98, but has higher grain protein, test weight, and better FHB resistance, similar to 2375.

- Five experimental lines were grown in the 2001 Uniform Regional Scab Nursery. These lines were identified in 1999 and 2000 as having improved levels of FHB resistance.

- A total of 5,686 plots containing breeding material and FHB resistance sources (excludes mapping populations) were screened in inoculated, misted field FHB nurseries in Crookston, Morris, and St. Paul during the 2001 growing season. These evaluations included 189 lines in advanced yield trials and 382 lines in preliminary yield trials.

- 1,294 early generation (F4:F5) breeding lines were screened during Fall 2001 in the greenhouse for reaction to FHB inoculation. On the basis of the results, about 400 lines were discarded due to susceptibility to scab. An additional 400 were discarded based on plant agronomic type in the 2002 New Zealand winter nursery. The remaining lines were entered into the 2002 preliminary yield trials.

Project 3: Marker-assisted Selection for an FHB Resistance Gene Derived from Sumai 3

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

Results of several QTL analysis experiments in several wheat populations indicate a major QTL (*Qfhs.ndsu-3BS*) for Fusarium head blight (FHB) resistance is located on chromosome 3BS of 'Sumai 3'. The consistent ability to detect this major QTL and the magnitude of effect in each population imply that it should be useful for marker-assisted selection (MAS). However, to justify breeding program-scale MAS for the 3BS QTL region, increased levels of resistance due to this QTL should be observed in multiple genetic backgrounds. The objective of this study is to assess the effect of *Qfhs.ndsu-3BS*-derived resistance in multiple genetic backgrounds using QTL near-isogenic lines.

2. What were the most significant accomplishments?

Multiple SSR markers flanking the *Qfhs.ndsu-3BS* region and strongly associated with FHB resistance were selected to develop QTL near-isogenic lines (NILs) in adapted genetic backgrounds. Homozygous types ($F_{4:5}$ sib lines) with alternate marker alleles at the 3BS QTL were later identified by screening the progeny of the single heterozygous plants. Self-pollination of heterozygous plants and marker analysis to identify homozygous types has produced 33 QTL-NILs from 17 unique cross combinations with various inbreeding generations.

Four out of nine NIL pairs tested in our 2001 field inoculated nursery showed significant ($P<0.05$) reduction in FHB severity in lines with the resistance QTL alleles. The remaining five NIL pairs did not show a significant difference in FHB severity. In greenhouse point-inoculation screens, sixteen of twenty-nine pairs had significantly reduced disease spread in homozygous types with the Sumai 3 alleles.

These preliminary results suggest that selecting for this QTL region with molecular markers should be a useful approach to enhance FHB resistance in breeding populations. All currently developed QTL-NIL pairs will be tested in replicated field trials in 2002.

We have crossed F_6 and F_7 derived NILs showing significant differences in FHB severity to create fine mapping populations to further define this QTL region.

Marker-assisted selection using the markers for the QTL on chromosome 3BS was used to screen approximately 500 F4 lines during the summer of 2001.

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:

Busch, R.H., D.V. McVey, G.L. Linkert, J.A. Anderson, J.V. Wiersma, R. Dill-Macky, and G.A. Hareland. 2001. Registration of 'McVey' wheat. Crop Sci. 41:926-927.

Liu, S., and J.A. Anderson. 2002. Marker assisted evaluation of Fusarium head blight resistant wheat germplasm. Crop Sci. submitted.

Abstracts:

McGowan, K.L., S. Liu, R. Dill-Macky, C.K. Evans, and J.A. Anderson. 2001. Mapping of Fusarium head blight QTL in the wheat line Wuhan 3. *In* Agronomy abstracts. ASA, Charlotte, NC.

Proceedings:

Anderson, J.A. 2001. Variety development and uniform nurseries: progress in FHB resistance in hard spring wheat. p. 225 in *Proceedings of The 2001 National Fusarium Head Blight Forum,* edited by S. Canty et al., Kinko's, Okemos, MI.

Bowen, D.E, S. Liu, R. Dill-Macky, C.K. Evans, and J.A. Anderson. 2001. Mapping of Fusarium head blight QTL in the Chinese wheat line Fujian 5114. p. 175 in *Proceedings of The 2001 National Fusarium Head Blight Forum,* edited by S. Canty et al., Kinko's, Okemos, MI.

Liu, S., and J.A. Anderson. 2001. Characterization of wheat germplasm for SSR marker alleles near the Fusarium head blight resistance QTL on chromosome 3BS. p. 192 in *Proceedings of The 2001 National Fusarium Head Blight Forum,* edited by S. Canty et al., Kinko's, Okemos, MI.

McGowan, K.L., S. Liu, R. Dill-Macky, C.K. Evans, and J.A. Anderson. 2001. Mapping of Fusarium head blight QTL in the wheat line Wuhan3. p. 193 in *Proceedings of The 2001 National Fusarium Head Blight Forum,* edited by S. Canty et al., Kinko's, Okemos, MI.

Pumphrey, M.O., and J.A. Anderson. 2001. Development and characterization of wheat lines near isogenic for a Fusarium head blight QTL. p. 271 in *Proceedings of The 2001 National Fusarium Head Blight Forum,* edited by S. Canty et al., Kinko's, Okemos, MI.

Invited Presentations:

"Breeding Fusarium Head Blight Resistant Wheat" given at University of Saskatchewan, Saskatoon, Canada (5/30/01)

"Progress in Marker-Assisted Selection of a Major Fusarium Head Blight Resistance QTL in Wheat" given at American Society of Agronomy Annual Meetings, Minneapolis, MN (10/24/01)

"Mapping and Marker-Assisted Selection of Fusarium Head Blight Resistance Genes in Wheat" given at 2nd Canadian Workshop on Fusarium Head Blight, Ottawa, Canada (11/05/01)

Reports:

Anderson, J., J. Wiersma, D. McVey, and R. Dill-Macky. 2001. Wheat. *In* Preliminary Report 24; 2001 Wheat, Barley and Oat Variety Performance in Minnesota, Preliminary Report, Edited by Jochum Wiersma.