U.S. Wheat and Barley Scab Initiative
FY00 Final Performance Report (approx. May 00 – April 01)
July 30, 2001

Cover Page

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Year:	**FY2000 (approx. May 00 – April 01)**
Grant Number:	**59-0790-9-043**
Grant Title:	**Fusarium Head Blight Research**
2000 ARS Award Amount:	**$130,310**

Project

Program Area	Project Title	Requested Amount
Variety Development & Uniform Nurseries	Accelerate development of resistant varieties.	$70,000.00
Variety Development & Uniform Nurseries	Screening barley lines for scab resistance in uniform nurseries.	$10,000.00
Chemical & Biological Control	Efficacy of folicur in controlling barley scab in lines with partial resistance.	$15,840.00
Vareity Development & Uniform Nurseries	Early generation selection for barley lines with FHB resistance.	$33,568.00
	Requested Total	$129,408.00[1]

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Principal Investigator Date

[1] Note: The Requested Total and the Award Amount are not equal.

FY00 (approx. May 00 – April 01) FY00 Final Performance Report
PI: Richard Horsley
Grant: 59-0790-9-043

Project 1: Accelerate development of resistant varieties.

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

Fusarium head blight (FHB), primarily incited by *Fusarium graminearum*, adversely affected the quality of barley grown in eastern North Dakota and northwestern Minnesota the last eight years. Quality of harvested grain was reduced because of blighted kernels and the presence of deoxynivalenol (DON), a mycotoxin produced by the pathogen. Seeding resistant cultivars is the only promising method of controlling FHB in barley because cultural and chemical controls of FHB have been unsuccessful. Introduced barley cultivars grown in field nurseries in China and North Dakota from 1994 to 1997 were identified with putative FHB resistance. My breeding program is incorporating FHB resistance from several of these sources into elite malting barley germplasm. Production of doubled-haploid (DH) lines and development of markers for molecular marker assisted selection are being used to accelerate development of FHB resistant cultivars.

2. What were the most significant accomplishments?

We released a six-rowed germplasm line this year named 6NDRFG-1. 6NDRFG-1 has partial resistance to FHB that is expressed as reduced numbers of FHB infected kernels and more significantly as reduced concentrations of DON. Unlike many of the six-rowed genotypes with good FHB resistance, 6NDRFG-1 does not derive its resistance from 'Chevron' (PI 38061) or Chevron-derived lines. This may be advantageous because Chevron and resistant Chevron-derived progeny generally have fewer plump kernels and lower malt extract. Thus, 6NDRFG-1 represents a six-rowed source of FHB resistance that may have alleles for acceptable malt quality not found in Chevron.

In 1998, averaged across the three locations, FHB severity and DON concentration were 16.6 % and 5.8 ug g^{-1} for 6NDRFG-1, 4.7 % and 8.4 ug g^{-1} for Chevron, and 52.8 % and 27 ug g^{-1} for Foster, respectively. In Hangzhou, China during winter 1997-98, FHB severity was 10.0 % for 6NDRFG-1, 5.3 % for Chevron, and 19.8 % for Foster. In greenhouse screening at Fargo ND during spring 1999, FHB severity was 16.3 % for 6NDRFG-1, 9.2 % for Chevron, and 41.2 % for Foster. In 1999 screening nurseries at Langdon and Osnabrock, ND, FHB severity averaged 16.3 % for 6NDRFG-1, 18.9 % for Chevron, and 50.5 % for Foster.

We also had breeding materials from the F_1 generation to yield trials grown at our Osnabrock, ND research site. All materials grown at this location were on ground in which wheat was the previous crop. We found that this allows us to screen our germplasm under conditions that are conducive for FHB. Entries in our Preliminary, Intermediate, Advanced, and Varietal Yield Trials were identified that had 25% less FHB than currently grown cultivars. These entries were evaluated for malting quality this winter by the USDA-ARS Cereal Crops Research Unit in Madison, WI and for DON content by the Department of Cereal Sciences at NDSU.

Project 2: Screening barley lines for scab resistance in uniform nurseries.

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

Regional nurseries for many crops have existed for decades. These nurseries provide data on advanced lines from areas other than where they were developed and foster germplasm exchange. Advanced barley lines with putative FHB resistance and new sources of FHB resistance need to be evaluated in the region where FHB is affecting the crop. Mist-irrigated nurseries that are inoculated with *Fusarium graminearum* are needed so data can be collected even in years when environmental conditions are not conducive for natural infection. A mist irrigated uniform FHB screening nursery, called the MinnDak nursery, has been grown at two sites in Minnesota and two sites in North Dakota the past five growing seasons. This nursery includes breeding lines with putative FHB resistance from four upper Midwest barley breeding programs. Between 25-50 entries have been grown in the nursery each of the past five years. FHB severity and DON accumulation are determined.

2. What were the most significant accomplishments?

The 2000 MinnDak Uniform Barley Fusarium head blight (FHB) nursery was grown at St. Paul and Crookston, MN, and Fargo, Langdon, Osnabrock, and Park River, ND. Dryland nurseries were added in 2000 at Crookston, Langdon, and Park River to provide conditions that growers would observe in their fields. The nurseries at Crookston, Fargo, Langdon, and Park River were inoculated with *Fusarium graminearum* using the grain spawn method. The nursery at St. Paul was inoculated with macroconidia. Drs. Kevin Smith and Don Rasmusson, and staff on their project oversaw the nurseries in Minnesota. Dr. Brian Steffenson and staff on his project oversaw nurseries in Fargo and Langdon; Dr. Linnea Skoglund and her staff oversaw the nursery at Park River; and Dr. Rich Horsley and his staff oversaw the nursery at Osnabrock, ND.

Each nursery included a set of six common checks and 20 experimental breeding lines. The checks were CIho 4196 (resistant two-row check), Chevron (resistant six-row check), Robust and Stander (susceptible six-row checks), MNBrite (moderately resistant six-row check), and Conlon (moderately resistant two-row check). None of the breeders' lines had FHB resistance similar to that of the resistant checks.

A series of correlation tables were added to this year's MinnDak report that indicates the magnitude of relationships in readings between the different nursery locations. In general, the correlations between irrigated nurseries tended to be stronger than those between dryland nurseries or dryland and irrigated nurseries. This can be explained by the fact that infection is more uniform and consistent in the irrigated nurseries. Also, the correlation values for the DON data tended to be greater than those for FHB incidence or FHB severity. The weakest correlations were found for FHB severity data from dryland nurseries and the strongest correlations were found for DON data from irrigated nurseries.

Project 3: Efficacy of folicur in controlling barley scab in lines with partial resistance.

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

Research conducted to test the efficacy of fungicides in controlling FHB and DON levels in barley have been conducted using cultivars (i.e. Robust, Foster, and Stander) that are susceptible to FHB. Results indicate that fungicides had little to no effect in reducing DON concentration to levels acceptable to the malting and brewing industry. Minimal information is available on the efficacy of fungicides in controlling FHB and DON levels on genotypes with partial FHB resistance. Production of barley with low to no FHB symptoms and DON content will require an integrated approach that includes use of proper cultural practices, fungicides, and FHB resistant cultivars.

2. What were the most significant accomplishments>

Environmental conditions at Langdon and Osnabrock, ND were more conducive for development of FHB than conditions at Fargo. Mean FHB severity was 4.8% at Langdon, 4.2% at Osnabrock, and 0.8% at Fargo. At Langdon and Osnabrock, FHB severity and DON accumulation of all plots not sprayed with Folicur was generally at levels unacceptable to the malting and brewing industry. Folicur did not significantly reduce FHB severity or DON accumulation in the resistant or moderately resistant genotypes, but did in the resistant genotypes. Thus, it appears that the integrated use of Folicur and a resistant or moderately genotype may not be sufficient in reducing FHB severity and DON to acceptable. However, Folicur may be useful in reducing FHB severity and DON accumulation in resistant cultivars to acceptable levels.

Genotypes sprayed with Folicur generally had greater yield, test weight, and kernel plumpness than unsprayed genotypes. Much of the improvements in these traits were due to reductions of foliar disease in genotypes sprayed with Folicur. Significant yield increases were observed only for the cultivars developed and released from upper Midwest barley breeding programs (i.e.6B93-2978, Conlon, Drummond, Foster, Logan, MNBrite, and Stander.) This suggests that factors other that foliar diseases were limiting yield in the other genotypes. Foliar disease severity data were collected at Langdon and Osnabrock. The predominant foliar disease at each location was septoria leaf blotch, incited by *Septoria spp*. Foliar diseases were not prevalent at Fargo. Based on the yield increases observed in this study, the cost of Folicur and its application was recovered only when applied to the adapted cultivars 6B93-2978, Conlon, Foster, Logan, MNBrite, and Stander.

Project 4: Early generation selection for barley lines with FHB resistance.

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

Efficient development of improved barley cultivars with FHB resistance is dependent on a breeding strategy that maximizes selection of resistant genotypes in each generation. Advancement of susceptible lines for further evaluation is expensive and inefficient because it takes up needed space in the greenhouse and mist-irrigated FHB epidemic nurseries. Based on discussions with other small grain breeders, we established a mist-irrigated FHB epidemic nursery near Osnabrock, ND for selecting resistant barley plants in the F_3 and F_4 generations. The disease pressure is so high in this nursery that seed often does not develop on susceptible plants. This led us to think that we could make selections for FHB resistance in the F_2 generation by either selecting individual plants, or by harvesting the entire population with a plot combine and removing the thin, light seed with slotted sieves and a gravity table.

To test this hypothesis, three F_2 selection strategies are being compared. The selection strategies are 1) selection and harvest of individual plants with putative FHB resistance grown in a mist-irrigated FHB epidemic nursery, 2) bulk harvest of seed from all F_2 plants grown in a mist-irrigated FHB epidemic nursery (thin and light seed will be removed using sizing equipment and a gravity table), and 3) bulk harvest of spikes from F_2 plants with putative FHB resistance grown in an uninoculated dryland nursery (thin and light seed will be removed using sizing equipment and a gravity table). All populations are handled similarly afterward using methods routinely used for the breeding program.

2. What were the most significant accomplishments?

$F_{3:4}$ families from two crosses were grown in our inoculated/mist-irrigated nursery near Osnabrock, ND for this project. The population ND15483/C97-21-38 had families derived using all three F_2 selection strategies. The population derived from the cross ND15483/C97-21-63 had families derived using F_2 selection strategies 1 and 3. At the soft dough stage, families were selected that had FHB resistance similar to the resistant checks. In general, the percent of families selected (about 18%) was the same regardless of the F_2 selection strategy. The maturity of the selected families tended to be later than the susceptible check 'Stander'. DON accumulation was determined using a sample of grain from each selected family. The percent of FHB resistant families selected that had DON similar to the check was greatest for those derived using method 2 (29%), followed by those derived using method 1 (16%), and method 3 (4%). Thus, preliminary results suggest that F_2 selection strategy 2 results in a higher frequency of families with lower DON accumulation.

All families with FHB resistance and DON accumulation similar to the resistant checks were sown in replicated yield trials at two locations in North Dakota in May 2001. Data will be collected on heading date; plant height; resistances to lodging, foliar diseases, and FHB; grain yield; DON accumulation; and malt quality.

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-review

Rudd, J.C., R.D. Horsley, A.L. McKendry, and E.M. Elias. 2001 Host plant resistance genes for Fusarium head blight: sources, mechanisms, and utility in conventional breeding systems. Crop Sci. 41:620-627.

Urrea, C.A., R.D. Horsley, B.J. Steffenson, and J.D. Franckowiak. 2001. Registration of 6NDRFG-1 six-rowed barley germplasm line with partial Fusarium head blight resistance. Crop Sci. (submitted).

Urrea, C.A., R.D. Horsley, B.J. Steffenson, and P.B. Schwarz. 2001. Heritability of Fusarium head blight resistance and deoxynivalenol accumulation from barley accession CIho 4196. Crop Sci. (submitted).

Non-peer reviewed

Horsley, R.D. 2000. 1999 MinnDak uniform Fusarium head blight nursery report. http://www.scabusa.org/pdfs/99_MinnDak_Barley_Nur_Rpt.PDF.

Horsley, R.D. 2000. 1999-2000 Hangzhou, China Fusarium head blight nursery report. http://www.scabusa.org/pdfs/2000_Hangzhou_Barley_Rpt.PDF.