USDA-ARS / USWBSI
FY04 Final Performance Report
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Cover Page

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Year:	**FY2004** (approx. May 04 – April 05)
FY04 ARS Agreement ID:	**59-0790-3-083**
FY04 ARS Agreement Title:	**Resistance Screening and Fungicide Application Studies for Control of FHB in Barley.**
FY04 ARS Award Amount:	**$ 44,507**

USWBSI Individual Project(s)

USWBSI Research Area*	**Project Title**	**ARS Adjusted Award Amount**
CBC	Split Fungicide Application and Crop Management to Control FHB in Barley.	$ 17,421
GIE	FHB Resistance Screening of Unique Barley Germplasm from the Dutch Centre for Genetic Resources.	$ 16,585
VDUN	Screening Barley Lines for Scab Resistance in Uniform Nurseries.	$ 10,500
	Total ARS Award Amount	**$ 44,507**

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: *Split Fungicide Application and Crop Management to Control FHB in Barley.*

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

Fusarium head blight (FHB) has reduced the quality of barley grown in the Midwest for the last decade due to fungus infected kernels, pinched grain and most importantly the presence of the toxin, deoxynivalenol (DON). Individual cultural and chemical control measures have reduced disease, but have been unsuccessful in getting the level of control necessary

Barley has a significantly greater FHB problem than wheat because,1)levels below 0.5 µg/g DON are required by the malting industry 2) Fungicides are less effective at reducing FHB on barley 3) No effective resistance has been identified in barley 4) Barley is susceptible from flowering through to harvest.

It is likely that the reduced control with fungicides in barley is due to the long period during which the plant is susceptible to infection and the relatively short period of effectiveness of the fungicides used for control. Field experiments were designed to test the effectiveness of multiple fungicide applications on both FHB disease and DON accumulation by barley. In addition, experiments were undertaken to test the hypothesis that it is the staggered emergence of heads with resulting heads at different stages of maturity at the time of fungicide spraying that result in the disease control ineffectiveness of a single spray of fungicide

2. What were the most significant accomplishments?

Factorial experiments of two cultivars (Robust and Conlon),, two fungicides (Folicur and JAU 6476), two spray regimes (single application, two applications) and two rates (recommended and 1/2 recommended) were established at Langdon and Fargo ND.

FHB disease was found throughout the study but levels were low. For Robust, JAU6476 at all rates and timing treatments significantly reduced disease and increased yield but only the split timing of the highest rate of JAU6476 reduced DON compared to the untreated control. The significant increase in yield with the split timing of the 4.0 fl oz rate of Folicur may have been due to leaf disease control. For Conlon, JAU6476 at all rates and timing, treatments significantly reduced disease and both timings of the highest rates increased yield, but none of the treatments reduced DON. Folicur significantly reduced disease at most rates and timings except for the single timing at the highest rate, although the trend was also for a reduction in that treatment. Increased yield due to the effectiveness of the fungicides against leaf disease would help to offset their and therefore increase adoption by producers.

An experiment was established at both Fargo and Langdon ND where disease was recorded on individual heads which were at various stages of emergence from the boot when fungicide spraying took place. For both Robust barley and Knudson wheat maximum disease control occurred when the head was fully emerged at spraying compared to spraying when the head was in the boot, partially exposed or after the head had been exposed for several days. Other experiments which showed a lack of translocation of the fungicide from one side of the head to the other suggest that the poorer control prior to full head emergence is due to the fungicide only protecting tissue it contacts. It is possible that the increased disease that occurs when the head has been exposed for several days is due to extensive infection occurring before the head is sprayed with fungicide.

These experiments need to be again repeated under a range of environments and under higher disease pressures to confirm the usefulness of split application of fungicides for controlling FHB symptoms and DON accumulation. It is clear that even with split application the fungicides do not give complete control of the disease or DON and need to be combined with cultural or genetic methods of control.

Project 2: *FHB Resistance Screening of Unique Barley Germplasm from the Dutch Centre for Genetic Resources.*

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

To remain economically viable, the malting and brewing industries require a consistent supply of high quality malting barley at reasonable prices. This supply is severely impacted by the FHB epidemic experienced in the mid West which has traditionally been the major supplier of the US's malt barley.

Cultural and chemical controls of FHB in barley have either been unsuccessful or not widely adopted for reasons of reduced flexibility in farm management or economics. Use of cultivars with disease resistance is most favored by farmers because the control obtained is generally free and does not require any changes in crop management practices. Therefore the use of resistant cultivars is the best means of preventing plant disease. There are four breeding programs in the upper Midwest U.S. currently working on developing cultivars with FHB resistance. Development of resistant FHB cultivars by all of these breeding programs requires access to new and better sources of resistance to FHB and its toxins.

Sources of moderate levels of resistance to FHB and the toxins it produces were identified in about 0.01% of the barley accessions screened in the US National Small Grains collection. To date the major sources of resistant barley are in the accessions Chevron, CIho4196, Zhedar 1, Imperial and Svanhals. Breeding for resistance is hindered by a lack of adequate resistant sources.

The material which I will be targeting is from 1550 landraces collected in the period 1953 to 1981 in several countries located in the centers of diversity of *Hordeum*, such as Iran, India, Nepal, Pakistan and Ethiopia. The accessions are not represented in other collections in Europe, Japan or the US where the collections have been systematically screened for resistance

2. **What were the most significant accomplishments?**

In May 2004 in replicated trials in Hangzhou China, 350 barley accessions from the Dutch Centre for Genetic Resources were assessed for disease resistance to FHB. Between April 2004 and August 2004, 326 of the barley accessions were screened in Fargo ND and 334 of the barley accessions were screened in Landon ND for disease resistance to FHB. In addition 350 of the barley accessions were screened in the greenhouse. Ten accessions were identified as having good resistance in at least two of the three replicated US trials.

Eight of the ten accessions identified as having good resistance ranked better than Chevron the resistant control which contains a level of resistance that barley breeders would like to incorporate into released lines. The ten accessions were CGN 00483 2-rowed from Turkey, CGN 00590 6-rowed from Sudan, CGN 00642 6-rowed from Pakistan, CGN 00849 2-rowed from China, CGN 02617 2-rowed from Ethiopia, CGN 01365 6-rowed from Pakistan, CGN 02592 6-rowed from Ethiopia, CGN 02605 6-rowed from Ethiopia, CGN 02626 2-rowed from Ethiopia and CGN 13028 6-rowed also from Ethiopia.

The elite material is now being fingerprinted with molecular tools to determine its relationship to the current known sources of resistance. In addition, the material was planted in April 2005 in an elite trial in Fargo and also in Langdon ND involving the best new sources of resistance identified at Minnesota State University and Agriculture Canada, Manitoba.

In the winter of 2004/2005 a further 703 accessions were imported from the Dutch Centre for Genetic Resources and increased in the greenhouse at NDSU so that sufficient material was available for field screening. These accessions were planted in the field in disease screening trials at Fargo and Langdon in April 2005.

Project 3: *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 uniform nurseries for crops are a standard method of comparison of advanced breeding lines. These nurseries provide data on advanced lines in a wide range of environments including environments outside those for which the lines were bred. Regional uniform nurseries allow comparison of the relative advances made in the different breeding programs and foster germplasm exchange between diverse breeding programs. Advanced barley lines with putative FHB resistance were tested in mist-irrigated sites as well as under rainfed conditions. Rainfed conditions represent those experienced by farmers in the year in which the trial is sown. Mist-irrigated nurseries that are artificially inoculated with *Fusarium graminearum* are needed so data can be collected in years when environmental conditions are not conducive for natural infection and to determine the stability of the putative resistance under higher than normal disease conditions. A rainfed and mist-irrigated uniform FHB screening nursery, called the North American Scab Evaluation Nursery (NABSEN) nursery, was grown at Fargo, Langdon, Osnabrock and Carrington, ND; St. Paul and Crookston MN; Brandon Canada and Toluca Mexico. This nursery includes breeding lines with putative FHB resistance from NDSU 2-rowed and 6-rowed, Minnesota State University, Busch-Ag, Agriculture & Agri-Food Canada and CIMMYT/ICARDA barley breeding programs. FHB severity and DON accumulation are determined as well as agronomic characters such as heading date and environmental data.

2. What were the most significant accomplishments?

The 2004 North American Barley Scab Evaluation Nursery (NABSEN) was grown at Fargo, Langdon, Osnabrock and Casselton, ND; St. Paul and Crookston MN, Brandon, Manitoba and Toluca Mexico. The nursery contained 54 lines including 6 resistant and susceptible controls.

In Toluca Mexico, seasonal conditions caused problems in the nursery, so the data is not reliable but is included to make the data set complete. There was much higher than average rainfall and the nursery was hit by hail, causing spike breakage and severe lodging. In Fargo, as a result of the low temperatures and close to average rainfall from flowering to maturity, soils remained cold and wet and conditions were not conducive for high levels of disease. Similar trends were experienced at Casselton, Langdon and Osnabrock.

When averaged over all sites, each of the breeding programs had lines with substantially less FHB severity than susceptible controls. The 2-rowed barley resistant controls had a mean severity of 6.8 and the susceptible controls a mean severity of 9.4. The 6-rowed barley resistant controls had a mean severity of 3.6 and the susceptible controls a mean severity of 10. Four of 27 6-rowed lines had a severity rating of less than seven and six of 21 2-rowed lines had a severity rating of less than 8.

When averaged over all sites, each of the breeding programs also had lines with substantially less of the toxin deoxynivalenol (DON) than susceptible controls. The 2-rowed barley resistant controls had a mean DON of 7.3 ppm and the susceptible controls a mean DON of 8.7 ppm. The 6-rowed barley resistant controls had a mean DON of 5.1 ppm and the susceptible controls a mean severity of 11.6 ppm with two lines having DON levels close to the resistant controls. Eleven of 27 6-rowed lines had a DON of less than 9 ppm and 10 of 21 2-rowed lines had a severity rating of less than 8 ppm with three lines having DON levels close to the resistant controls.

Significant progress is being made toward developing FHB resistant barley cultivars. The project has allowed breeding programs with slower progress access to genetic material from the more advanced programs.

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.

Presentations (Scientific and Industry)

Professional Meetings

1. Hangzhou, China, May 2004. Barley Pathology at North Dakota State University. Invited Speaker.
2. Sino-Japan Biotechnology Research Center, Shandong Academy of Sciences. Jinan Shandong China. Microbial manipulation of residues for control of FHB. May 2004. Invited Speaker.
3. Invited Chair, Second International Symposium on Fusarium Head Blight, Food safety and toxicology session, Orlando December 11-15, 2004.

Industry/Technical Meetings

1. Langdon Research and Extension Center Field Day, ND, July 15th 2004.
2. Minot Research and Extension Center Field Day, ND, July 14th 2004.
3. Williston Research and Extension Center Field Day, ND, July 8th 2004.
4. ND State Barley Show, Osnabrock, ND, March 25th 2004.
5. North Dakota Barley Day, Minot North Dakota. Jan 15th 2004.

Publications (peer reviewed)

Publications (non-peer reviewed)

1. Neate, S.M and Gross, P.L. (2003) 2004 North American Barley Scab Evaluation Nursery (NABSEN) Interim Report. 2004 National Fusarium Head Blight Forum, December 11-15, 2004 Orlando.
2. Neate, S.M. and Gross, P.L. 2005. Evaluation of Folicur and JAU 6476 for the control of scab on two barley cultivars, 2004. Fungicide and Nematicide Tests (accepted Jan 2005)
3. **Neate, S. M.,** Schwarz, P B., Hill, N. S. and Horsley, R D. 2004 The relationships between fusarium head blight visual symptoms, *Fusarium* biomass and deoxynivalenol levels in barley. Second International Symposium on Fusarium Head Blight, December 11-15, 2004 Orlando.
4. Franckowiak, J.D., Zhang, B.X., Horsley, R.D., Steffenson, B.J., Smith, K.P. and **Neate, S.M.** (2004) Off-season testing of barley in China for Fusarium Head Blight. Second International Symposium on Fusarium Head Blight, December 11-15, 2004 Orlando.

5. **Neate, S.M.** and Gross, P.L. 2004 Awns reduce FHB infection in near isogenic bowman barley with different awn lengths. Second International Symposium on Fusarium Head Blight, December 11-15, 2004 Orlando.

6. Hill, N.S., Schwarz, P., Horsley, R., **Neate, S.,** Steffenson, B., Dahleen, L., Cooper, B., Kittle, B., and Jones, A. 2004 Simple and rapid immunoquantification of *Fusarium* in barley and its relationship with DON and FHB scores. Second International Symposium on Fusarium Head Blight, December 11-15, 2004 Orlando.

7. Lee S and **Neate, S.M**. 2004 Identification of Molecular Markers Linked to *Septoria passerinii* blotch resistance Genes in Barley. Phytopathology 94 S58.

8. Franckowiak, J.D., Zhang, B.X., Horsley, R.D., Steffenson, B.J., Smith, K.P. and **Neate, S.M.** (2004) Off-season testing of barley in China for Fusarium Head Blight. International Barley Genetics Symposium, Bruno, Czeck Republic June 2004.