USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY11 Final Performance Report
July 13, 2012

Cover Page

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Fiscal Year:	FY11
USDA-ARS Agreement ID:	59-0790-8-071
USDA-ARS Agreement Title:	Management and Resistance Sources for Control of FHB in Barley.
FY11 USDA-ARS Award Amount:	$ 12,500

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
BAR-CP	Screening Barley for FHB Resistance in ND and Coordination of the NABSEN.	NCE**
BAR-CP	Field Tests of Transgenic Barley Lines.	NCE
BAR-CP	Validation and Refinement of DON Models in Barley for the Northern Great Plains.	NCE
GDER	Mutagenesis and Transposon Tagging of FHB Resistance Genes in Barley.	$ 12,500
	Total ARS Award Amount	**$ 12,500**

7-13-2012

Principal Investigator Date

* MGMT – FHB Management
FSTU – Food Safety, Toxicology, & Utilization of Mycotoxin-contaminated Grain
GDER – Gene Discovery & Engineering Resistance
PBG – Pathogen Biology & Genetics
BAR-CP – Barley Coordinated Project
DUR-CP – Durum Coordinated Project
HWW-CP – Hard Winter Wheat Coordinated Project
VDHR – Variety Development & Uniform Nurseries – Sub categories are below:
SPR – Spring Wheat Region
NWW – Northern Soft Winter Wheat Region
SWW – Southern Soft Red Winter Wheat Region

** NCE –Carryover from previous awards were used to fund FY11 project.

Project 1: *Screening Barley for FHB Resistance in ND and Coordination of the NABSEN.*

1. What major problem or issue is being resolved relevant to Fusarium head blight (scab) and how are you resolving it?

The objective of this project is to coordinate the disease screening of elite barley germplasm in uniform FHB nurseries in North America and China. Advanced barley lines with FHB resistance were tested in mist-irrigated sites, as well as under normal rainfall conditions. Mist-irrigated nurseries were also artificially inoculated with Corn innoculum containing *Fusarium graminearum* spores. The FHB nurseries have been continually established and evaluated for this project for more than 11years and currently is known as the North American Scab Evaluation Nursery (NABSEN). In 2011, we established nurseries at four locations in North Dakota located at Fargo, Langdon, Casselton and Carrington. Other locations established by other cooperators included St. Paul and Crookston, MN, Brandon, Manitoba, and Hangzhou, China. In ND, the Casselton and Carrington nurseries were not misted while the Fargo and Langdon sites were under mist irrigation. The nurseries included breeding lines with putative FHB resistance from the NDSU 2-rowed and 6-rowed breeding programs and lines from the Univ. of Minnesota, Busch Ag, and Agriculture and Agri-Food Canada. FHB parameters, DON, and agronomic factors were recorded.

2. List the most important accomplishment and its impact (i.e. how is it being used) to minimize the threat of Fusarium head blight or to reduce mycotoxins. Complete both sections (repeat sections for each major accomplishment):

Accomplishment: The nursery contained 50 lines, including 6 resistant and susceptible controls. Short rows with three replications were planted at each location. The Carrington location received hail damage in July and no data was taken. Heading dates were recorded at Fargo, Langdon, St. Paul, Crookston and Brandon, Manitoba and FHB incidence were recorded at Fargo, Langdon, and Brandon, Manitoba. FHB severity was recorded at Fargo, Langdon, Brandon, Manitoba, St. Paul and Crookston, MN all five of these locations were under mist irrigation. The DON levels were recorded from all six locations in U.S. and Manitoba, Canada. FHB severity was very low at the dryland location at Crookston and Casselton and no data was recorded, levels were moderate in Langdon and Fargo ND, St. Paul, and in Brandon, Manitoba and high on the misted trial at Crookston, MN. Plants were harvested and samples analyzed for DON in Paul Schwarz's lab at North Dakota State University. DON levels varied between locations with the dryland locations having the lowest levels ranging from 0.3-2.1 ppm and misted nurseries ranged from 8.3 to 22.9 ppm. No two- rowed lines under mist irrigation had lower DON levels than Conlon the two-rowed standard. Two of the six- rowed lines under mist irrigation had lower DON accumulation levels than the six-rowed standard, Quest. Seed was also redistributed and sent to Hangzhou, China for testing.

Impact: Significant progress is being made toward developing FHB resistant barley cultivars. All North American barley breeders have access to the data collected in this project. The breeders are able to use the relative performance data to make decisions about

continuing or dropping particular breeding lines. Breeders have: 1) tests of the resistance stability of their breeding lines across a range of environments and disease pressures; 2) a measure of the resistance in their advanced lines compared to those of the other barley breeders in North America; 3) access to unique germplasm with resistance to FHB and DON accumulation. The 11 years of FHB data and SNP genotyping of many of the NABSEN entries also provides the opportunity to conduct an association mapping project to identify FHB resistance QTL. This year we have begun an association mapping project using the historic NABSEN data sets and SNP marker data deposited in the T3 database to identify significant FHB resistance QTL.

Project 2: *Field Tests of Transgenic Barley Lines.*

1. **What major problem or issue is being resolved relevant to Fusarium head blight (scab) and how are you resolving it?**

   Commercially accepted barley lines grown in the upper Midwest are susceptible to FHB and have DON accumulation levels exceeding those acceptable by the malting industry. Breeding programs have made consistent progress to bring DON levels down and some of these lines have been approved for malting quality. However, DON accumulation may still be above acceptable industry standards in these new lines when environmental conditions are conducive for a major FHB epidemic. Transgenic barley lines with novel or synthetic sources of resistance will allow for a boost in resistance and lower DON accumulation that is not available through endogenous genes currently available from the primary barley germplasm pool.

2. **List the most important accomplishment and its impact (i.e. how is it being used) to minimize the threat of Fusarium head blight or to reduce mycotoxins. Complete both sections (repeat sections for each major accomplishment):**

   Accomplishment:
   The NDSU barley pathology program is cooperating with Dr. Lynn Dahleen from the USDA-ARS facility in Fargo, to field screen transgenic materials she has developed. The NDSU barley pathology project planted the transgenic barley, applied corn based inoculum, set up the misting system and maintained the nursery, all in Langdon, ND. Dr. Dahleen evaluated the nursery for disease and harvested the grain for DON evaluation. See Dr. Dahleen's project report for the accomplishments she has achieved with this project.

   Impact:

   See Dr. Dahleen's report on this project.

Project 3: *Validation and Refinement of DON Models in Barley for the Northern Great Plains.*

1. **What major problem or issue is being resolved relevant to Fusarium head blight (scab) and how are you resolving it?**

   Malt and Feed barley producers in the upper Midwest need a prediction model for forecasting the risk of FHB and DON accumulation. An effective FHB risk advisory system is available but the model used to develop the system was based on environmental factors associated with disease occurrence levels in wheat, thus the system is not effective at predicting disease severity for barley because the risk factors and duration of risk to barley differ from those of wheat. Additionally, a model for DON accumulation is not available and this is the most important criteria used by the malting industry when deciding to purchase barley for malt production. Dr. Jeff Stein previously located at South Dakota State University was coordinating a multistate effort to investigate the effect of environmental conditions on FHB severity and the accumulation of DON in barley. The NDSU barley pathology program recorded disease and environmental parameters for 3 six-rowed barley lines (Tradition, Robust, and Quest) and one two rowed variety (Conlon) across 4 locations in North Dakota (Carrington, Dazey, Prosper and Fargo, ND). Disease, heading date and environmental data was collected for these lines across all sites; environmental conditions were natural – no mist irrigation or artificial inoculation. Weather data was collected from nearby NDAWN weather stations.

2. **List the most important accomplishment and its impact (i.e. how is it being used) to minimize the threat of Fusarium head blight or to reduce mycotoxins. Complete both sections (repeat sections for each major accomplishment):**

   Accomplishment:
   Disease and weather data were collected from four North Dakota locations in 2011 representing different environments, soil types and cropping systems (Carrington, Dazey, Prosper and Fargo, ND). The data collected from each location was: heading date, FHB incidence and severity, and DON accumulation in harvested samples. Data on disease severities, DON, and environment were sent to South Dakota State to be included in Dr. Stein's data set. The model has been developed and was operational in 2011 on the North Dakota State University crop disease forecasting web site (www.ag.ndsu.nodak.edu/cropdisease/). This model developed by Dr. Jeff Stein while he was a Plant Pathologist at SDSU has been modified this year to run with national weather forecasting (NWF) data and will be available as a disease forecasting system and will be located on the NDSU barley pathology web site in 2012. The FHB and DON prediction website for barley will be operational as the script, provided by Dr. Kathleen Baker at Western Michigan University, is integrated to run with NWF data and will be fully functional in 2013 and maintained by the NDSU barley pathology program.

   Impact:
   The data collected in North Dakota has helped to develop a prediction model for FHB severity and DON accumulation in barley. The forecasting system has been developed based on the barley model and the data has helped to validate its effectiveness. The information

will be accessible to producers and crop advisors allowing more informed decisions on fungicide use.

Project 4: *Mutagenesis and Transposon Tagging of FHB Resistance Genes in Barley.*

1. **What major problem or issue is being resolved relevant to Fusarium head blight (scab) and how are you resolving it?** The ultimate issue we are resolving through this research project is to identify resistant genes or susceptibility factors that play a role in compatible/incompatible interactions with *Fusarium graminearum* utilizing a reverse genetics approach. Most importantly we would like to use mutagenesis to develop novel resistance by silencing host susceptibility factors that are putatively utilized by the necrotrophic pathogen to establish infection or enhance the production of DON. Mutants with increased disease susceptibility are important genetic resources that can be utilized for gene discovery and validation and more importantly mutants with enhanced resistance can be utilized as novel resistance sources unavailable in the primary barley germplasm pool. These resources are also important for resolving the molecular mechanisms underlying host-pathogen interaction and elucidating gene function in resistant and susceptible reactions.

2. **List the most important accomplishment and its impact (i.e. how is it being used) to minimize the threat of Fusarium head blight or to reduce mycotoxins. Complete both sections (repeat sections for each major accomplishment:**

Accomplishment: In 2010 we established two irrigated FHB nurseries in Fargo and Langdon, ND, containing a total 750 CIho 4196 (resistant) and 2,008 Morex (susceptible) fast-neutron irradiated mutant M_2 single head hill plots and an additional 20,000 CIho 4196 and 20,000 Morex single plants. The nurseries were scored for FHB disease severity at Feekes 11.2 (middle dough stage) using a 0-5 scale. Seed was collected from all CIho 4196 hill plots and individual plants identified with a FHB disease rating score of 3 or higher. Seed was also collected from all Morex (susceptible) plants showing a disease score 2 or lower in Langdon and a score of 1 in Fargo. The mutant material we identified was sent to the 2011 FHB winter nursery in Hangzhou, China for further evaluation. All the selected mutant material was further evaluated in the 2011 Langdon, ND FHB nursery. We selected all mutants that showed a consistent shift in phenotype and collected seed in bulk from the Langdon nursery for DON analysis. Three cv Morex mutants, designated ND-FN28, ND-FN30 and ND-FN32, were identified containing 71%, 69% and 69% less DON accumulation than the cv Morex wildtype, respectively. The three mutants have also shown consistently lower FHB severity for two years of evaluation in three separate FHB nurseries. The lines were sent to the 2012 FHB nursery established in Yangchen, China and data on FHB severity has been recorded and seed was ground into flour for DON analysis in Dr. Paul Schwarz's lab at NDSU.

The three Morex mutants have been crossed with the FHB susceptible check Stander and RIL populations are being advanced to the F_6 to be used for QTL analysis to characterize and genetically map the putative mutations. All three mutant lines have also been crossed amongst one another to determine if the putative mutations are allelic. We have also crossed the mutants with lines showing levels of FHB resistance from the North Dakota State University Breeding program (ND20493) and the recently released line Quest from the University of Minnesota breeding program. Once markers have been developed to track our mutational induced resistance we will use a backcross scheme aided by marker assisted selection to rapidly incorporate the resistance into Midwestern elite malting varieties

currently containing other FHB resistance sources. Additionally we have crossed each of the mutant lines with the CIho 4196 six-rowed *vrs1* mutant identified by Professor Andy Kleinhofs at Washington State University in an attempt to develop six-rowed breeding lines containing the putative mutation induced resistances and the Ch. 2 resistance QTL found in CIho 4196.

Impact: The lines with enhanced disease resistance and significantly reduced DON accumulation have been crossed with adapted malting barley varieties (Stander, ND20493 and Quest) to genetically characterize the mutation/s responsible for the resistant phenotype and to incorporate the resistance into adapted material for rapid deployment. Molecular markers will be developed to track resistance in a backcrossing scheme for the rapid development of breeding lines containing the novel resistance. All genetic materials developed will be freely available to anyone interested.

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.

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