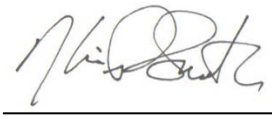
USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY13 Final Performance Report
July 15, 2014

Cover Page

PI:	Kevin Smith
Institution:	University of Minnesota
Address:	Department of Agronomy and Plant Genetics 411 Borlaug Hall 1991 Upper Buford Circle St. Paul, MN 55108
E-mail:	smith376@umn.edu
Phone:	612-625-1211
Fax:	612-625-1268
Fiscal Year:	FY13
USDA-ARS Agreement ID:	59-0206-9-072
USDA-ARS Agreement Title:	Breeding and Genetics of Fusarium Head Blight Resistance in Barley.
FY13 USDA-ARS Award Amount:	$ 149,283

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
BAR-CP	Developing Six-rowed Malting Barley Varieties with Enhanced FHB Resistance and Lower DON.	$ 87,441
BAR-CP	Genomic Selection for FHB Resistance in Midwest Six-row Barley.	$ 61,842
	FY13 Total ARS Award Amount	**$ 149,283**



7/15/14

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

Project 1: *Developing Six-rowed Malting Barley Varieties with Enhanced FHB Resistance and Lower DON.*

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

Our latest release, Quest, has a level of resistance that reduces toxin levels by 40% compared to other popular varieties. Growers continue to need new varieties with greater levels of resistance, higher yield, and acceptable malting quality to create a profitable farm economy and maintain barley production in the Midwest to serve the malting and brewing industries. We are conducting a comprehensive field-based breeding effort and implementing marker assisted selection (MAS) to develop new barley varieties to meet this need. We use genetic markers to select for resistance in early generations followed by extensive field evaluation for FHB resistance in inoculated and mist-irrigated nurseries in two locations in Minnesota. Promising breeding lines that combine improved FHB resistance with superior agronomic and end-use performance are advanced to industry malting and brewing tests and then considered for release as new varieties. We also recently initiated a winter barley breeding program for the Midwest that may provide another way to increase barley production and manage disease through earlier harvest. We are now evaluating facultative lines from our winter program in FHB nurseries and advancing them to multi-location yield testing.

2. List the most important accomplishments and their impact (i.e. how are they being used) to minimize the threat of Fusarium Head Blight or to reduce mycotoxins. Complete both sections; repeat sections for each major accomplishment:

Accomplishment (1):
Variety Quest continues to have reduced DON compared to the dominant six-rowed varieties grown in the Midwest.

Impact:
Quest is still grown on limited acres due to lack of interest by the malting and brewing industries. Most of the barley acres in the region are contracted and specify particular varieties. Quest has slightly higher beta-glucans compared to other varieties which is an undesirable trait for malting barley.

Accomplishment:
Variety candidate M159 was evaluated for the first year in industry malting evaluations. It was rated satisfactory and is now in the 2014 test. Importantly, beta-glucan levels were similar to Lacey. M159 has lower DON levels and higher yields compared to Quest. We initiated a small increase on the St. Paul campus.

Impact:
If released, M159 could be more attractive to growers and industry compared to Quest.

Project 2: *Genomic Selection for FHB Resistance in Midwest Six-row Barley.*

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

   Selecting for FHB resistance in the field is laborious, expensive, and inherently imprecise. Despite these challenges, we have made slow progress enhancing FHB resistance in barley. We have also used traditional marker assisted selection (MAS) to manipulate two modest effect QTLs. However, there are currently no other MAS targets that have been consistently mapped with sufficient effects to warrant MAS. Thus, further progress must be made by exploiting genetic variation controlled by many genes with small effects. To complement phenotypic selection and MAS for targeted QTL, we initiated a genomic selection (GS) approach using large marker and trait data sets to predict breeding values for FHB resistance in early generation breeding lines that have not been phenotyped. This approach dramatically reduces our breeding cycle time from four years to one year and should accelerate development of new varieties. We have completed the 4th cycle of selection using 384 SNP markers on ~ 2,000 breeding lines this past year. We are conducting experiments to directly measure the accuracy of GS in our selection program as well as gain from selection. We are using information from these studies to fine tune our GS methodology.

2. **List the most important accomplishments and their impact (i.e. how are they being used) to minimize the threat of Fusarium Head Blight or to reduce mycotoxins. Complete both sections; repeat sections for each major accomplishment:**

   Accomplishment:
   We have directly compared genomic selection to phenotypic selection in five sets of breeding lines developed over a five year period. The effectiveness of selection for both yield and DON levels was on average equal between genomic selection and phenotypic selection.

   Impact:
   It appears our current approach to using genomic selection is equivalent to our standard method of phenotypic selection. However the cost of prediction with markers is about ¼ the cost of doing field evaluations and laboratory DON testing. In addition, we can impose genomic selection one year after we make a cross as opposed to 3-4 years for phenotypic selection. Thus, we expect using genomic selection will reduce costs and speed up breeding progress.

   Accomplishment:
   We have initiated a study to compare the base breeding population and three cycles of genomic selection for lower DON levels and increased yield. In 2013, we conducted FHB trials at 2 locations. In 2014, we planted 2 more trials for FHB and three locations for yield trials.

Impact:

Initial results suggest we are making gains using genomic selection and will continue using this approach and collecting more data to document gain from selection. Through reports and presentations of this work other breeding programs are considering using similar approaches in their breeding programs.

Include below a list of all germplasm or cultivars released with full or partial support of the USWBSI during the FY13 award period. List the release notice or publication. Briefly describe the level of FHB resistance.

None

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 FY13 grant. Please reference each item using an accepted journal format. If you need more space, continue the list on the next page.

Peer-reviewed Publications

Navara, S. and K.P. Smith. 2014. Using near-isogenic barley lines to validate deoxynivalenol (DON) QTL previously identified through association analysis. DOI: 10.1007/s00122-013-2247-x. Theor. Appl. Genet. 127: 633-645.

Fang, Z., A. Eule-Nashoba, C. Powers, T. Y. Kono, S. Takuno, P. L. Morrell, and K. P. Smith. 2013. Comparative Analyses Identify the Contributions of Exotic Donors to Disease Resistance in a Barley Experimental Population. G3 3:1945-1953.

Oral Presentations

Smith, K.P., V. Vikram, A. Sallam, A. Lorenz; J. Jannink, J. Endleman, R. Horsley, S. Chao, and B. Steffenson. 2013. Using Genomic Selection in Barley to Improve Disease Resistance. 2013 Borlaug Global Rust Initiative Technical Workshop, August 19-22, 2013, Taj Palace Hotel, New Delhi, India.

Poster Presentations

Sallam, A., J. Endelman, J. Jannink, and K. P. Smith. 2013. Genomic Selection and Model Accuracy in Barley for Deoxynivalenol (DON). Plant & Animal Genome XXI Conference, January 12-16, 2013, Town & Country Convention Center, San Diego, CA.

Vikram, V., A. Lorenz, R. Horsely, J. Jannink, and K. P. Smith. 2013. Impact of Training Population Composition on Prediction Accuracy: Genomic Selection for Barley Scab Resistance in Upper Midwest. Plant & Animal Genome XXI Conference, January 12-16, 2013, Town & Country Convention Center, San Diego, CA.

Tiede, T., A. Sallam, E. Scheifelbein, K. Beaubian, G. Velasquez, S. Chao, A. Lorenz and K.P. Smith. 2013. "Transitioning from Phenotypic Selection to Genomic Selection for Lower Deoxynivalenol in Barley." In: S. Canty, A. Clark, Y. Salat, and D. Van Sanford (Eds.), *Proceedings of the 2013 National Fusarium Head Blight Forum*. East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative. P. 43

Huang,Y., Lin Li, Kevin P. Smith and Gary J. Muehlbauer. 2013. "RNA Sequencing Analyses of Two Barley Near-Isogenic Line Pairs Identify Genes Associated with Resistance to Fusarium Head Blight." In: S. Canty, A. Clark, Y. Salat, and D. Van Sanford (Eds.), *Proceedings of the 2013 National Fusarium Head Blight Forum*. East Lansing, MI/Lexington, KY: U.S. Wheat & Barley Scab Initiative. P. 69

Other Presentations:

Initiative Aids in Development of Barley Varieties with Improved Scab Resistance. Press Release: U.S. Wheat & Barley Scab Initiative - 4/1/2014.