USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY12 Final Performance Report
July 16, 2013

Cover Page

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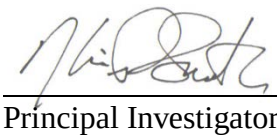
Fiscal Year:	FY12
USDA-ARS Agreement ID:	59-0206-9-072
USDA-ARS Agreement Title:	Breeding and Genetics of Fusarium Head Blight Resistance in Barley.
FY12 USDA-ARS Award Amount:	$ 149,429[*]

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.	$ 87,527
BAR-CP	Genomic Selection for FHB Resistance in Midwest Six-row Barley.	$ 61,902
	Total ARS Award Amount	**$ 149,429**



Principal Investigator 7/16/13 Date

[*] Partial funding for this research is under ARS agreement # 59-0206-9-070

[**] 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?

Currently, the most popular six-rowed barley varieties in the Midwest have insufficient resistance to Fusarium head blight to consistently produce grain with acceptable levels of deoxynivalenol. 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 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 variety Quest with lower DON accumulation is now used as the resistant six-row standard in many disease trials.
- Three new lines were entered into 2013 industry malt evaluations with slightly lower DON than the variety Quest.
- Line M149, lower in DON (similar to Quest), is being considered for industry plant-scale brewing evaluations.

Impact:

The variety Quest was grown commercially on six thousand acres in Minnesota and North Dakota in 2012.

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 multiple genes with small effects. To complement phenotypic selection and MAS for targeted QTL, we initiated a genomic a 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 third cycle of selection using 384 SNP markers on ~ 2,000 breeding lines this past year. We published a study measuring the accuracy of GS by cross-validation using a large data set generated as part of the Barley CAP (Lorenz et al., 2012). 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 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:

- Two lines from cycle 1 of the genomic selection program have been advanced to the 2013 industry malt evaluations.
- 3 breeding cycles of genomic selection have been completed (1 cycle per year; 2010, 11, 12). Selection was based on predicting yield and DON on F2 or F3 plants.
- The accuracy of GS predictions has been assessed based on both cross-validation and by predicting progenies of breeding populations. Predictions for DON using cross validation were slightly higher (0.7) than when the model was used to predict actual breeding progenies (0.58) as would be expected.

Impact:

Current assessment of selection accuracy of genomic selection indicates that we should be able to substantially increase gain from selection in breeding compared to traditional phenotypic selection. We are currently conducting experiment to empirically measure and compare gain from selection.

Include below a list of all germplasm or cultivars released with full or partial support of the USWBSI. 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 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:

Smith, K.P., A. Budde, R. Dill-Macky, D.C. Rasmusson, E. Schiefelbein, J.J. Wiersma, J.V. Wiersma, B.J. Steffenson. 2013. Registration of 'Quest' Spring Malting Barley with Improved Resistance to Fusarium Head Blight. J. Plant Reg. 7:125-129 doi:10.3198/jpr2012.03.0200crc, Published: January 25, 2013.

Fisk, S., A. Cuesta-Marcos, L. Cistue, J. Russell, K.P Smith, P. Baenziger, Z. Bedo, A. Corey, T. Filichkin, I. Karsai, R. Waugh, P. Hayes. 2012. FR-H3: A New QTL to Assist in the Development of Fall-Sown Barley with Superior Low Temperature Tolerance. Theor. Appl. Genet. DOI 10.1007/s00122-012-1982-8.

Huang, Y., B. Millet, K. Beaubien, S. Dahl, B. Steffenson, K. Smith, G. Muehlbauer. 2012. Haplotype diversity and population structure in cultivated and wild barley evaluated for Fusarium head blight responses. Theor. Appl. Genet. DOI 10.1007/s00122-012-2006-4.

Blake V.C., J.G. Kling, P.M. Hayes, J. Jannink, S.R. Jillella, J. Lee, D.E. Matthews, S. Chao, T.J. Close, G.J. Muehlbauer, K.P. Smith, R.P. Wise and J.A. Dickerson. 2012. The Hordeum Toolbox: The Barley Coordinated Agricultural Project Genotype and Phenotype Resource. The Plant Genome 5:81-9.

Oral Presentations:

Smith, K.P., Vikram, V., Lorenz, A., and Jannink, J. 2012. Implementing Genomic Selection in Barley. 6th International Crop Science Congress, Bento Goncalves, Brazil, 8/6/12 – 8/10/12.

Smith, K. P. 2012. Genomic Selection for Fusarium Head Blight Resistance in Barley. 2011 National Fusarium Head Blight Forum, December 4-6, 2011, Hyatt Regency St. Louis at the Arch, St. Louis, Missouri.

Smith, K.P. Winter Malting Barley Variety Development Progress and Challenges. Next Generation Barley Varieties III, Jan 16, 2012, Hacienda Hotel, San Diego, CA.

Smith, K. P. 2012. The Breeders' Eye: Can More Data Improve Our Vision. 2012 University of Minnesota Plant Breeding Symposium "Riding the Data Wave: Utilization of Large Datasets in Plant Breeding" . March 9th, 2012. St Paul, MN

Smith, K. P. 2012. Implementing and Evaluating Genomic Selection in Barley. Plant Breeding & Genetics Spring 2012 Seminar Series. Cornell University, March 27, 2012.

Smith, K. P. 2012. Application of Genomic Selection in Barley Improvement. 11th International Barley Genetics Symposium, Hangzhou, China, April 15-20, 2012.

Smith, K. P. 2012. Barley Variety Update. Crops and Soils Day, Northwest Research and Outreach Center, 7/18/12.

Presentation on barley disease resistance breeding to five recipients of the 2012 USDA Norman E. Borlaug International Agricultural Science and Technology Fellowship Program. June 20, 2012.

Abstracts:

Menke, J., K. Beaubien, T. Szinyei, Y. Dong, S. Chao, P. Olivera, B. Alsop, S. Dahl, K. Smith and B. Steffenson. 2012. Mapping of Fusarium Head Blight Resistance in Wild Barley Accession PI 466423. 2012 National Fusarium Head Blight Forum, December 4-6, 2012, Wyndham Orlando Resort, Orlando, Florida.

Smith,K. P., V. Vikram, A. Lorenz, J. Jannink, S. Chao and R. Horsley. 2012. Evaluating Genomic Selection for DON in a Collaborative Barley Breeding Effort. 2012 National Fusarium Head Blight Forum, December 4-6, 2012, Wyndham Orlando Resort, Orlando, Florida.

Gross, P.L., R.D. Horsley, K.P. Smith, J. Menert, W.G. Legge, J.R. Tucker and R. Brueggeman. 2012. Historical Comparison of the North American Barley Scab Evaluation Nursery (NABSEN). 2012 National Fusarium Head Blight Forum, December 4-6, 2012, Wyndham Orlando Resort, Orlando, Florida.

Smith, K.P. Implementing Genomic Selection in Barley. 2012. 6th International Crop Science Congress, Buento Goncalves, Brazil, 8/6 – 8/10/2012.

Smith, K.P., Sallam, A., J. Jannink, and C. Sneller, 2012. Evaluating Genomic Selection For Applied Plant Breeding. Annual AFRI Project Director Meeting, Town & Country Convention Center, San Diego, CA. January 13, 2012.