USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY11 Final Performance Report
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Cover Page

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Fiscal Year:	FY11
USDA-ARS Agreement ID:	59-0206-9-069
USDA-ARS Agreement Title:	FHB Resistance and DON Accumulation in Wheat.
FY11 USDA-ARS Award Amount:	$ 27,572

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
GDER	A Field Nursery for Testing Transgenic Spring Wheat, Barley and Durum from the USWBSI.	$ 2,938
MGMT	Integrating Multiple Management Strategies to Minimize Losses due to FHB and DON in Minnesota.	$ 17,317
MGMT	Uniform Fungicide Tests for the Control of FHB in Minnesota.	$ 7,317
	Total ARS Award Amount	**$ 27,572**

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: *A Field Nursery for Testing Transgenic Spring Wheat, Barley and Durum from the USWBSI.*

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

   Developing effective FHB resistance through transgenics is one of the strategies being used by USWBSI researchers to reduce the impact of FHB in wheat and barley. Over the past decade the USWBSI has funded projects seeking to identify and utilize novel sources of resistance to Fusarium head blight. Since 1997, the University of Minnesota has established an annual nursery to provide field testing for transgenic spring wheat and barley lines developed by researchers in the USWBSI. In 2011 we established a single uniform nursery for the testing of transgenic materials from any/all the spring wheat and barley programs. The principle advantage for establishing this nursery was to make available independent testing for transgenic lines produced by researchers in the USWBSI and, perhaps more importantly, to provide comparative data across programs allowing us to more readily establish the merit of individual transgenes.

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 2011 field screening nursery, with 56 wheat and 88 barley plots was located at UMore Park, Rosemount MN. Trial entries and untransformed controls were submitted by the University of North Texas (9+1 wheat), and USDA (17+2 barley). Lines with known reactions to Fusarium head blight (FHB) were also included as checks. The wheat checks used were the moderately resistant Alsen, the susceptible cultivars Wheaton and Roblin, and a non-inoculated Wheaton check. The barley checks were the moderately resistant Quest and the susceptible cultivars Conlon (2-rowed), Robust and Stander. The experimental design was a randomized block with four replicates. Plots were 2.4 m long single rows. The trial was planted on May 18, 2011. All plots, except a non-inoculated Wheaton check, were inoculated twice. The first inoculation was applied at anthesis for wheat and at head emergence for barley. The second inoculation was applied three days after the initial inoculation (dai) for each plot. The inoculum was a composite of 50 *F. graminearum* isolates at a concentration of 100,000 (barley) or 200,000 (wheat) macroconidia.ml^{-1} with Tween 20 (polysorbate) added at 2.5 ml.L^{-1} as a wetting agent. The inoculum was applied using a CO_2-powered backpack sprayer fitted with a SS8003 TeeJet spray nozzle with an output of 10ml.sec^{-1} at a working pressure of 275 kPa. Mist-irrigation was applied from the first inoculation on July 7 till July 25 to facilitate FHB development. FHB incidence and severity were assessed visually 17 d.a.i. for wheat and 13 d.a.i. for barley on 20 arbitrarily selected heads per plot. FHB incidence was determined by the percentage of spikes with visually symptomatic spikelets of the 20 heads observed. FHB severity was determined as the percentage symptomatic spikelets of the total of all spikelets observed. Plots were harvested at maturity on August 5 (barley) and 11 (wheat). Fifty (barley) and 30 (wheat)

heads where harvested from each plot, threshed and the seed cleaned manually. The wheat sub-samples were used to determine the percentage of *Fusarium* damaged kernels (FDK) and then all samples (wheat and barley) were ground and submitted for deoxynivalenol (DON) analysis. FHB incidence (FHBI) for all entries ranged from 89 to 100%. FHB severity (FHBS) ranged from 18% to 76% for wheat entries and 35% to 49% for barley entries examined. The FHBS for the untransformed control Bobwhite was 50% and Conlon was 37%. The FHBS for the moderately resistant check Alsen was 33% and Quest was 42% while FHBS for the susceptible checks Wheaton and Roblin were 58% and 26%, respectively, and Robust and Stander were 52% and 53%, respectively. DON ranged from 18 to 82 ppm for the entries examined. The DON for the untransformed control Bobwhite was 39 ppm and Conlon was 25 ppm. The DON for the moderately resistant check Alsen was 22 ppm and Quest was 32 ppm while DON for the susceptible checks Wheaton and Roblin were 82 and 18 ppm, respectively and Robust and Stander were 49 ppm and 26 ppm, respectively. The level of disease was greater than previous nurseries. The data indicated that resistance was expressed in some of the transformed lines.

Impact:

This trial increased the efficiency of individual programs to develop effective FHB resistance through transgenics. The data collected (FHB incidence, FHB severity, VSK and DON) was forwarded, as soon as practical, to the researchers submitting entries in the nursery. This data helps those researchers verify the efficacy of the new and novel sources of FHB/DON resistance in these transgenes and to make decisions on whether to discard or promote the further development of genes or lines. In association with expression data, the results from this nursery would also have been valuable in improving our understanding of the efficacy and mechanisms regulating the expression of R-genes.

Project 2: *Integrating Multiple Management Strategies to Minimize Losses due to FHB and DON in Minnesota.*

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

The USWBI has funded research on a number of different approaches to the control of Fusarium head blight (FHB). The research on fungicides, which has largely been conducted through the annual uniform collaborative fungicide trials (UFTs), has supported the finding that the triazoles are the most effective fungicides against FHB. The research has also provided us with a better understanding of application technologies for fungicides, including nozzle configurations appropriate for spraying fungicides onto heads and an appreciation for the importance of timing fungicide applications with respect to growth stage. Research has also resulted in the identification of host resistance and the development of moderately resistant cultivars of wheat and barley that are now available to growers. Several cultural and biological control strategies have also been evaluated and shown to contribute to a reduction of both FHB and DON under certain conditions. In addition, a weather-driven, Web-based risk assessment model was developed and deployed and is currently available in 24 states.

The model serves as a tool aiding growers and industry personnel to make informed management and marketing decisions.

The ultimate goal of this project was to increase growers' adoption of an integrated management approach for FHB and DON. We recognize that a growers' willingness to adopt new technologies in agriculture is often driven by the effectiveness, convenience, practicality and economic benefit of using such technology. This project is, as a part of a large collaborative project, aimed to generate the data that will provide a sufficiently convincing body of evidence that will promote the adoption of best management practices for the control of FHB.

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 field experiments, with hard red spring wheat and spring barley, respectively, were conducted in St Paul Minnesota to investigate the effects of variety resistance and fungicide application on FHB and DON accumulation. The experimental design used in each case was a split-split-plot, with variety as the whole-plot, inoculation as sub-plot and fungicide treatment as the sub-sub-plot. Each experiments had four replicates. The HRSW varieties included were Samson (S), Briggs (S), Steele-ND (MR) and Glenn (MR). The barley varieties included were Lacey (S), Robust (S), Tradition (S) and Quest (MR). The plots were planted on April 27, 2011 on land previously planted to soybeans. The trial was managed according to the standard agronomic practices for hard red spring wheat and barley. We followed the recommended design, so that in each whole plot, there were two sub-plots, one spray-inoculated and the other un-inoculated. Plots were inoculated with a spore suspension (100,000 spores/ml) of macroconidia inoculen consisting of multiple *F. graminearum* isolates. Fungicide treated plots were sprayed at early anthesis (Feekes GS 10.5.1) with Prosaro (6.5 fl oz/A + 0.125% Induce).

FHB was assessed in each plot at the soft dough growth stage (Feekes 11.2) on July 14, 2011. At each assessment, FHB was determined visually and incidence, diseased head severity, and index calculated. The presence and flag leaf severity (%) of any foliar diseases (wheat, tan spot and bacterial leaf streak; barley, powdery mildew and leaf rust) was also assessed. Plots were harvested (barley - August 1; wheat - August 8) with a plot combine and yield and test weight determined. The wheat samples were rated to determine the percentage of visually scabby kernels (VSK) and then all grain samples (wheat and barley) were sent to the USWBSI-funded mycotoxin laboratory in St. Paul for deoxynivalenol analysis. Weather data (temperature, relative humidity, surface wetness, rainfall, wind speed, and solar radiation) was obtained from the St. Paul Climatological Observatory at hourly intervals from Feekes GS 7 (stem elongation) to harvest. The data were submitted to the project coordinator for use in combined analyses and to support national recommendations for best management practices.

The incidence of FHB ranged from 10% to 80% in the wheat and 11% to 85% in the barley, while the FHB severities ranged from 0 to 17% in the wheat and 0 to 6% in the barley. In both trial the fungicide treatments significantly reduced FHB incidence and severity and lowered DON in harvested grain. Differences among variety treatments were also evident although the differences more pronounced in the wheat than in the barley.

Impact:

No single management strategy is fully effective in controlling FHB or the contamination of *Fusarium*-infected grains with mycotoxins. The current recommendations for FHB management include the use of fungicides, genetic resistance, and cultural practices targeting residue management, including crop rotation or tillage. This cooperative research effort has generated the data that supports our understanding that integrating the use of cultivar resistance and fungicide applications provides greater control than either strategy used in isolation. The ultimate goal of this collaborative project is to increase growers' adoption of an integrated management approach for the control of FHB. We recognize that a growers' willingness to adopt new technologies is driven by the effectiveness, convenience, practicality and the economic benefit of a given technology. The additional data from these trials adds to the body of knowledge that we can use to support our efforts to promote an integrated approach to the management of FHB.

Project 3: *Uniform Fungicide Tests for the Control of FHB in Minnesota.*

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

Fusarium head blight (FHB), caused predominantly by *Fusarium graminearum*, remains a disease of significance, limiting the production capacity of wheat in Minnesota in years when environmental conditions favor initial infection and disease development. Since the resurgence of FHB in the Upper Midwest in the early 1990's, fungicides have proven to be effective and have subsequently been widely adopted as a tool for the management of both FHB and the foliar diseases of wheat. This project represents Minnesota's contribution to the multi-state cooperative uniform fungicide trial. This cooperative effort helps determine the efficacy of registered, unregistered and experimental fungicides on multiple classes of wheat and in barley across diverse environments. The data are used to identify compounds, mixtures of compounds, and to determine the most appropriate rates and timing of application of these fungicides to best manage FHB development and reduce DON accumulation in grain. The data generated by this project may be used to support the registration of new chemistries and to provide recommendations at the regional and national level for best management practices.

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 effect of fungicides on Fusarium head blight (FHB) and deoxynivalenol (DON) levels was examined in the cultivar 'Samson', a regionally-adapted FHB susceptible hard red spring wheat in an inoculated and mist-irrigated trial. The trial was located in Crookston Minnesota. To help ensure development of FHB the trial was inoculated with *Fusarium graminearum*-colonized corn kernels, which were spread throughout the trial shortly before heading. Irrigation during head development through soft dough (Feekes 11.2) was used to supplement natural rainfall to provide a favorable environment for *F. graminearum* infection and disease development.

The experimental design was a randomized complete block with 4 replications, with plot being 5 ft wide x 20 feet long. The 12 fungicide treatments, established cooperatively by the project participants, were applied at flag leaf fully emerged and at the beginning of flowering (Feekes Growth Stages 9 and 10.51, respectively). At soft dough (Feekes 11.2), FHB incidence and severity were assessed for each plot by examining 100 heads per plot. Additionally, the incidence and severity of foliar diseases (predominately tan spot and bacterial leaf streak) were assessed on the flag leaves. Plots were harvested to determine yield, test weight, thousand kernel weight, and grain protein. Grain samples from each plot were used to evaluate the percentage of Fusarium-damaged kernels (VSK) and were then submitted to the mycotoxin laboratory at the University of Minnesota for deoxynivalenol (DON) analysis. The data were submitted to the project coordinator for use in combined analyses and to support national recommendations for best management practices.

Impact:

The results of this experiment contribute to our ability to determine the efficacy of fungicides in the management of FHB and determine if they are able to reduce the level of DON in harvested grain. This information had already been used regionally as the results have been made available to growers, extension agents and others in the wheat industry through the University of Minnesota Extension Service. The results have also been used to support the chemical control component of SCABSMART and thus are part of our national effort to provide information on the best management guidelines for the control of FHB and DON.

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.

Anderson, J.A., Wiersma, J.J., Linkert, G.L., Reynolds, S.K. and Springer, C.A. 2010. Wheat, hard red spring. In: *Varietal Trials Results 2010*. Minnesota Agricultural Experiment Station, University of Minnesota. p. 36-41.

Anderson, J.A., Wiersma, J.J., Linkert, G.L., Reynolds, S.K., Springer, C.A., Kolmer, J.A., Jin Y., Dill-Macky R., Wiersma J.V. and Hareland G.A. 2011. Wheat, hard red spring. In: *Varietal Trials Results 2011*. Minnesota Agricultural Experiment Station, University of Minnesota, p. 41-46.

Bradley, C.A., Adee, A.E., Ebelhar, S.A., Bergstrom, G.C., Dill-Macky, R., Wiersma, J.J., Grybauskas, A.P., Kirk, W.W., McMullen, M.P., Halley, S., Milus, A.E., Osborne, L.E., Ruden, K.R. and Wise, K.A. (2011). Effects of triazole, strobilurin, and triazole + strobilurin fungicides on Fusarium head blight and associated mycotoxins. In: *Proceedings of the 2011 National Fusarium Head Blight Forum*, Saint Louis, Missouri, USA, December 4-6, 2011, p. 125-126.

Syverson, R.L., Elakkad, A.M., Dahleen, L.S., Nalam, V.J., Klossner, G., Shah, J. and Dill-Macky, R. (2011). Testing transgenic spring wheat and barley lines for reaction to Fusarium head blight: 2011 field nursery report. In: *Proceedings of the 2011 National Fusarium Head Blight Forum*, Saint Louis, Missouri, USA, December 4-6, 2011, p. 97.

Wiersma, J.J, Dai, J., Dahlen, R.B.A. and Dill-Macky, R. 201-. Control of leaf spotting diseases and Fusarium head blight with Caramba, Headline, and Twinline, 2010. *Plant Disease Management Reports, submitted.*

Willyerd, K.T., Bergstrom, G.C., Bradley, C.A., Dill-Macky, R., Gross, P., Grybauskas, A.P., Halley, S., Hershman, D.E., Madden, L.V., McMullen, M.P, Milus, A.E., Osborne, L.E., Ruden, K.R., Salgado, J.D., Sweets, L.E., Wegulo, S.N., Waxman, K.D., Wise, K.A. and Paul, P.A. (2011). Uniform Fusarium head blight trials; a 2011 update. In: *Proceedings of the 2011 National Fusarium Head Blight Forum*, Saint Louis, Missouri, USA, December 4-6, 2011, p. 161-166.