USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY09 Preliminary Final Performance Report
No Cost Extension for FY10
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Cover Page

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Fiscal Year:	2009
USDA-ARS Agreement ID:	59-0206-9-069
USDA-ARS Agreement Title:	FHB Resistance and DON Accumulation in Wheat.
FY09- USDA-ARS Award Amount:	$ 44,220

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Adjusted Award Amount
MGMT	Effects of Post-anthesis Moisture, Late Infection and Cultivar on DON in Wheat.	$ 35,783
GDER	A Field Nursery for Testing Transgenic Spring Wheat, Durum and Barley.	$ 8437
	Total Award Amount	**$ 44,220**

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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 Winter Wheat Region
SWW – Southern Sinter Wheat Region

Project 1: *Effects of Post-anthesis Moisture, Late Infection and Cultivar on DON in Wheat.*

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

Few studies have closely examined the development of Fusarium head blight and deoxynivalenol (DON) accumulation in relation to the resistance of wheat cultivars, the relative aggressiveness of *F. graminearum* isolates, and the ability of *F. graminearum* isolates to produce DON, or the impact of environmental conditions, especially moisture, on the accumulation of DON in *Fusarium*-infested wheat. This project aimed to improve our knowledge of the development of Fusarium head blight and the accumulation of DON in wheat. The specific objectives of these collaborative studies were to examine the effects of post-anthesis moisture on FHB development and DON accumulation in wheat and to examine the effects of late infection on FHB development and DON accumulation in wheat.

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 development of FHB and accumulation of DON and related mycotoxins was examined in the three HRS wheat cultivars Wheaton (S), 2375 (MR) and Tom (R) in a 2009 field experiment. Plots were inoculated either at anthesis or 7 days after anthesis (daa) under and subjected to four post-inoculation irrigation duration treatments (14, 21, 28 and 35 days after anthesis). Significant differences in the severity of FHB were observed among the three cultivars with Wheaton, 2375 and Tom averaging 34%, 20% and 12% FHB, respectively. The level of disease in the non-inoculated controls was generally less than 2%. The severity of disease was generally lower at the later inoculation date (7 daa) although significant differences were not always evident. VSK was significantly impacted by irrigation duration, with plots receiving the longer periods of irrigation having grain that was more damaged in appearance. The DON in grain harvested at maturity reflected the cultivar resistance. Few significant differences in the DON levels were observed between treatments inoculated at anthesis and those inoculated a week later. The level of DON was however impacted by the irrigation duration treatments, with the 21 day long irrigation having a somewhat higher level of DON than in either the shorter (14 daa) or longer (28 and 31 daa) irrigation durations and this was most evident in the susceptible cultivar Wheaton. Whole heads, sampled throughout the growing season, indicated that DON in the entire head was generally highest in Wheaton in the 14 daa irrigation treatment. These findings, suggesting different responses within the same plot for the impact of moisture on DON in grain and other floral tissues and confirms our hypothesis that there is a highly complex interaction of host genotype, pathogen isolate and environment which determines the DON level observed in wheat grain. In a second experiment twelve wheat cultivars were examined under a reduced number of irrigation treatments (14 and 35 days after inoculation). Across both these trials it appears there was a reduction in FHB in treatments inoculated 7 daa compared to those inoculated at anthesis, although these reductions are not as large as those observed in the

2008 trial. In 2008, infection at 7 daa resulted in a reduction in severity of 84% and 56% in the cultivars Alsen and Wheaton, respectively. A reduction in the DON in mature grain harvested from the late infection treatments was also recorded in the 2008 experiment although it was not proportional to the reduction in disease, being 65% in Alsen and 15% in Wheaton. Inoculation later than 14 daa resulted in little disease development and significantly lower levels of mycotoxin accumulation. Greenhouse experiments conducted as part of this project have conclusively demonstrated that a significant proportion of DON can be leeched from wheat heads by irrigation events of 6 hours.

Impact:

The study yielded useful data that, along with the results of other work, are helping to improve our understanding of the interaction of factors including; host genetics, pathogen aggressiveness and toxin production capacity; timing of inoculation and the influence of environmental conditions, particularly the time of infection and moisture, on the development of FHB and the accumulation of mycotoxins in FHB-infested wheat. The time course data has proven particularly useful in furthering our understanding of the influence of environmental conditions on mycotoxin accumulation between the time of initial infection and harvest.

Project 2: *A Field Nursery for Testing Transgenic Spring Wheat, Durum and Barley.*

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 2009 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):**

   <u>Accomplishment:</u>

   The 2009 field screening nursery, with 128 wheat and 208 barley plots was located at UMore Park, Rosemount MN. Trial entries and untransformed controls were submitted by the University of Minnesota (19 + 1 wheat), the Donald Danforth Plant Science Center (4 + 2 wheat) and USDA (48 + 1 barley). Lines with known reactions to Fusarium head blight (FHB) were also included as checks. The wheat checks used were the moderately resistant Alsen and Tom, the moderately susceptible 2375 and the susceptible cultivars Wheaton and Roblin. The barley checks were the moderately resistant line Quest (formerly M122) and the susceptible cultivars Conlon (2-rowed), Robust and Stander (6-rowed). The experimental design was a randomized block with four replicates. Plots were 2.4 m long single rows. The trial was planted on May 6, 2009. 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 (d.a.i.) for each plot. The inoculum was a composite of 50 *F. graminearum* isolates at a concentration of 200,000 macroconidia.ml^{-1} with Tween 20 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 June 26 till July 26 to facilitate FHB development. FHB incidence and severity were assessed visually 20-21 d.a.i. for wheat and 13-14 d.a.i. for barley on 20 arbitrarily selected spikes per plot. FHB incidence was determined by the percentage of spikes with visually symptomatic spikelets of the 20 spikes observed. FHB severity was determined as the percentage symptomatic spikelets of the total of all spikelets observed in the 20 spikes examined. Plots were harvested at maturity, on August 14 (barley) and August 24 (wheat). The harvested seed from each plot was split to obtain a 25 g sub-sample, which was then cleaned by hand. The wheat sub-samples were used to estimate the percentage of visually scabby kernels (VSK) and then all samples (wheat and barley) were ground and submitted for deoxynivalenol (DON) analysis. 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 mycotoxin level) was forwarded, as soon as practical, to the researchers submitting entries in the nursery. This data helped them 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.

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.

Dill-Macky, R. (2010). Fusarium Head Blight (Scab). In: *Compendium of Wheat Diseases and Pests*, *3rd ed.;* Bockus, W.W., Bowden, R.L., Hunger, R.M., Morrill, W.L., Murray, T.D., and Smiley, R.W. Eds.; The American Phytopathological Society, St. Paul, MN.

Dill-Macky, R. (2009). Fusarium head blight: A global threat to food safety in cereals. *Bioforsk Fokus*, **4**:138-139.

Gautam, P. and Dill-Macky, R. (2009). Pre-harvest moisture impacts wheat quality through Fusarium head blight (FHB) development and deoxynivalenol (DON) accumulation. *Phytopathology,* **99**:S159.

Dahleen, L., Dill-Macky, R., Shah, J., Muehlbauer, G., Skadsen, R., Manoharan, M., Abebe. T. and Jurgenson, J. (2009). Transgenic field trials for FHB resistance and related research in wheat and barley. In: *Proceedings of the 6th Canadian Workshop on Fusarium Head Blight Forum*, Ottowa, Ontario, CANADA, November 1-4, 2009, p. 38.

Gale, L.R., Dill-Macky, R., Anderson, J.A., Smith, K.P. and Kistler, H.C. (2009). Aggressiveness and mycotoxin potential of U.S. *Fusarium graminearum* populations in field-grown wheat and barley. In: *Proceedings of the 2009 National Fusarium Head Blight Forum*, Orlando, Florida, USA, December 7-9, 2009, p. 173.

Dill-Macky, R., Wennberg, K.J., Scanlan, T.C., Muehlbauer, G.J., Shin, S., Shah, D., Kaur, J. and Dahleen, L.S. (2009). Testing transgenic spring wheat and barley lines for reaction to Fusarium head blight: 2009 field nursery report. In: *Proceedings of the 2009 National Fusarium Head Blight Forum*, Orlando, Florida, USA, December 7-9, 2009, p. 189.