USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY08 Final Performance Report (approx. May 08 – April 09)
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Cover Page

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Fiscal Year:	2008
USDA-ARS Agreement ID:	59-0790-7-074
USDA-ARS Agreement Title:	Heterogeneity & Toxigenic Potential of U.S. Fusarium graminearum.
FY08 USDA-ARS Award Amount:	$ 37,771

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Adjusted Award Amount
BAR-CP	Aggressiveness and Mycotoxin Potential of Fusarium graminearum in Field-grown Barley.	$13,551
PBG	Aggressiveness and Mycotoxin Potential of Fusarium graminearum in Wheat.	$ 24,220
	Total Award Amount	**$ 37,771**

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
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

(Form FPR08)

Project 1: *Aggressiveness and Mycotoxin Potential of Fusarium graminearum in Field-grown Barley.*

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

Our long term objectives are to accurately determine the composition of genetically coherent populations of Fusarium Head Blight (FHB) pathogens in economically important small grain cereals producing areas of the world with special focus on the U.S., to determine their genetic structure, to evaluate their potential to change in composition and genetic structure and to determine the effect of such change on deployed host genotypes and/or other agricultural practices. Our USWBSI-funded research established that U.S. isolates of *Fusarium graminearum*, the main causal agent of FHB in small grains, do not belong simply in a single, homogeneous and inter-breeding population as has been previously assumed, but that the pathogen population composition in the U.S. is both complex and in flux. In addition to a widespread and predominant U.S. *F. graminearum* population (Midwestern 15ADON population) we have identified, molecularly and phenotypically characterized, and geographically and temporally mapped *F. graminearum* populations that are genetically distinct from the MW 15ADON population. Genetically distinct populations have been identified in the Upper Midwestern U.S. (MN, ND, and more recently in SD; UMW 3ADON and UMW 15 ADON populations) and in Louisiana and Arkansas (nivalenol producers). We also learned that differences between populations are not only present at a molecular level, but also at a phenotypic level, affecting traits that are agriculturally and economically important, including types of toxins produced and toxigenic potential. The recent identification and emergence of genetically distinct populations raises important questions for FHB management strategies. Though limited research on wheat to date has not provided evidence to support host genotype by pathogen strain interaction for FHB, if *F. graminearum* chemotypes/genotypes exhibit a differential response to barley host genotypes, then modifications need to be done to existing breeding procedures.

To detect potential differences in phenotypic characteristics between populations that are economically relevant, e.g. aggressiveness and toxigenic potential, we developed a novel approach for *F. graminearum* field research, in which we applied inoculum from synthetic populations that are assumed to represent the population diversity by mixing conidia from 16 – 20 isolates from specific populations. Isolates all have been previously assigned to their respective population by molecular marker characterization and all have been previously evaluated for phenotypic characteristics (aggressiveness and toxigenic potential) in greenhouse experiments.

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 FY08, we completed the first year of a two-year field experiment in St. Paul, MN that in mist-irrigated nurseries evaluates the aggressiveness and mycotoxin potential of emerging populations of *Fusarium graminearum* in field-grown barley. Twelve barley varieties or lines with varying degree of resistance were selected and provided by collaborator Dr. Kevin Smith (barley breeder for the University of Minnesota). The host genotypes were inoculated with three genetically distinct *F. graminearum* populations and a water control in a replicated field experiment with a split plot design. FHB severity was assessed according to previously established procedures. After harvest, samples from individual plots were measured for quantities/concentrations of different trichothecenes using GC/MS at the Mycotoxin Laboratory, University of Minnesota (Director: Dr. Yanhong Dong). Data was analyzed using JMP software with the assistance of Statistician Aaron Rendahl, University of Minnesota.

Impact: Our synthetic population inoculum approach enables us to detect differences in aggressiveness and toxigenic potential that are present at a population level and allows the scientific community to better judge the impact genetically diverse and novel *F. graminearum* populations may have on disease management. Results and conclusions from the first year should be viewed as preliminary as they need to be confirmed by results from the second year. Nevertheless, the first year did not yield significant differences overall between *F. graminearum* populations in terms of FHB severity or DON accumulation. Also, two-way ANOVA did not reveal population*barley host genotype interactions. This experiment and the final results will be useful for the barley breeding community as it will allow for a knowledge-based judgment whether and how genetically distinct population will be of importance in their breeding programs.

Project 2: *Aggressiveness and Mycotoxin Potential of Fusarium graminearum in Wheat.*

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

   Our long term objectives are to accurately determine the composition of genetically coherent populations of Fusarium Head Blight (FHB) pathogens in economically important small grain cereals producing areas of the world with special focus on the U.S., to determine their genetic structure, to evaluate their potential to change in composition and genetic structure and to determine the effect of such change on deployed host genotypes and/or other agricultural practices. Our USWBSI-funded research established that U.S. isolates of *Fusarium graminearum*, the main causal agent of FHB in small grains, do not belong simply in a single, homogeneous and inter-breeding population as has been previously assumed, but that the pathogen population composition in the U.S. is both complex and in flux. In addition to a widespread and predominant U.S. *F. graminearum* population (Midwestern 15ADON population) we have identified, molecularly and phenotypically characterized, and geographically and temporally mapped *F. graminearum* populations that are genetically distinct from the MW 15ADON population. Genetically distinct populations have been identified in the Upper Midwestern U.S. (MN, ND, and more recently in SD; UMW 3ADON and UMW 15 ADON populations) and in Louisiana and Arkansas (nivalenol producers). We also learned that differences between populations are not only present at a molecular level, but also at a phenotypic level, affecting traits that are agriculturally and economically important, including types of toxins produced and toxigenic potential. The recent identification and emergence of genetically distinct populations raises important questions for FHB management strategies.

   To detect potential differences in phenotypic characteristics between populations that are economically relevant, e.g. aggressiveness and toxigenic potential, we developed a novel approach for *F. graminearum* field research, in which we applied inoculum from synthetic populations that are assumed to represent the population diversity by mixing conidia from 16 – 20 isolates from specific populations. Isolates all have previously been assigned to their respective population by molecular marker characterization and all have been previously evaluated for phenotypic characteristics (aggressiveness and toxigenic potential) in greenhouse experiments. -

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 #1:**</u> We completed the second year of a greenhouse experiment that determined that members of the emergent populations have a higher toxigenic potential on popular spring wheat cultivars under experimental conditions used. For example, members of UMW 3ADON population produced on average 82% more DON on tested cultivars (Alsen, Knudson, Briggs, Oklee, Granite, Freyr) than members of the MW 15ADON population; members of the UMW 15ADON population produced 41% more DON than members of the MW15ADON population. An additional outcome of this research was also that even though there were significant differences in disease spread between the cultivars, no significant

differences in toxin accumulation were identified between the cultivars in inoculated spikelets.

Impact: For the first time it was established that the increased toxigenic potential of the emergent populations in greenhouse experiments is also observed for commercially relevant cultivars.

Accomplishment #2: In FY08, we completed the first year of a two-year field experiment in St. Paul, MN that in mist-irrigated nurseries evaluates the aggressiveness and mycotoxin potential of emerging populations of *Fusarium graminearum* in field-grown wheat. Twelve wheat varieties or lines with varying degree of resistance were selected and provided by collaborator Dr. James Andesron (wheat breeder for the University of Minnesota). The host genotypes were inoculated with three genetically distinct *F. graminearum* populations and a water control in a replicated field experiment with a split plot design. FHB severity and VSK was assessed according to previously established procedures. After harvest, samples from individual plots were measured for quantities/concentrations of different trichothecenes using GC/MS at the Mycotoxin Laboratory, University of Minnesota (Director: Dr. Yanhong Dong). Data was analyzed using JMP software with the assistance of Statistician Aaron Rendahl, University of Minnesota.

Impact: Results and conclusions should be viewed as preliminary as they need to be confirmed by results from the second year. The first year yielded significant differences between populations in terms of DON accumulation: the synthetic “Emergent Population” (consisting both of UMW 3ADON and UMW 15ADON isolates) overall averaged 30% more DON across all cultivars than the other two synthetic populations (MW 15ADON and UMW 3ADON). Otherwise, no differential response of wheat host genotypes to inoculation with the different populations was identified. Also, no significant differences were observed bin VSK or FHB severity values. This experiment and the final results will be useful for the wheat breeding community as it will allow for a knowledge-based judgment whether and how genetically distinct population will be of importance in their breeding programs.

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.

Gale, L. R., and Kistler, H.C. 2009. Does toxic synergy explain the co-existence of two emergent populations of *Fusarium graminearum* in the Upper Midwest. Fungal Genet. Newsl. 56 (Suppl.):224.

Gale, L. R., Harrison, S. A., Milus, E. A., O'Donnell. K., Ward, T. J., and Kistler, H. C. 2008. Genetic characterization of predominantly nivalenol-producing populations belonging to the *Fusarium graminearum* species complex from the Southern U.S. Phytopathology 98:S56.

Gale, L. R., Dill-Macky-R., Anderson, A. A Smith, K. P., Lysoe, E., and Kistler, H. C. 2008. Links between population affiliation and toxigenic potential in *Fusarium graminearum.* Page 27 in 2008 National Fusarium Head Blight Forum Proceedings.

If your FY08 USDA-ARS Grant contained a VDHR-related project, include below a list 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. If this is not applicable (i.e. no VDHR-related project) to your FY08 grant, please insert 'Not Applicable' below.

Not Applicable.