USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY07 Final Performance Report (approx. May 07 – April 08)
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Cover Page

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Fiscal Year:	2007
USDA-ARS Agreement ID:	59-0790-4-096
USDA-ARS Agreement Title:	Crop Residue Management and Screening Techniques for Improved Management of FHB.
FY07 ARS Award Amount:	$ 108,780

USWBSI Individual Project(s)

USWBSI Research Area*	Project Title	ARS Adjusted Award Amount
CBCC	Targeting Fusarium-infested Crop Residues in the Control of Fusarium Head Blight.	$34,146
EEDF	Factors Influencing the Accumulation of DON in Fusarium-Infected Wheat.	$ 42,439
HGR	FHB Resistance in Hard Red Spring Wheat Near-Isogenic Lines.	$ 32,195
	Total Award Amount	**$ 108,780**

Principal Investigator   Date

* CBCC – Chemical, Biological & Cultural Control
EEDF – Etiology, Epidemiology & Disease Forecasting
FSTU – Food Safety, Toxicology, & Utilization of Mycotoxin-contaminated Grain
GET – Genetic Engineering & Transformation
HGR – Host Genetics Resources
HGG – Host Genetics & Genomics
IIR – Integrated/Interdisciplinary Research
PGG – Pathogen Genetics & Genomics
VDUN – Variety Development & Uniform Nurseries

(Form FPR07)

Project 1: *Targeting Fusarium-infested Crop Residues in the Control of Fusarium Head Blight.*

1. What major problem or issue is being resolved and how are you resolving it?
Reduced tillage practices, which have been adopted worldwide in agriculture, have undoubtedly contributed to the global upsurge in FHB of wheat and barley. This study is investigating our ability to reduce the inoculum associated with *Fusarium*-infested residues. Targeted are treatments that either a) promote the rate of decomposition of crop residues (particularly the residues of Bt-corn - which decomposes more slowly than those of regular corn residues), or b) reduce the survival of the *Fusarium* spp. which infest crop residues.

2. List the most important accomplishment and its impact (how is it being used?). Complete all three sections (repeat sections for each major accomplishment):

Accomplishment:
Three field experiments (examining crop residues from wheat, barley and corn, respectively) were established during the 2007 growing season in Rosemount, MN. The residues produced were used to establish treatments designed to examine the effect of biological control agents (*Trichoderma* spp. - fall application), fungicides (prothioconazole-tebuconazole mix - spring application) and soil amendments (bentonite clay, urea, and spent lime (spent lime is a byproduct of beet processing and has been shown to reduce Aphanomyces root rot in sugar beets) - fall application). Additionally, in the corn residue trial, fine mechanical chopping of residues was introduced as an additional treatment. The residue cover of the soil surface of these trials was monitored in spring. Additionally the residue in these trials is currently being sampled to determine its inoculum potential. Results from the first sampling this spring indicated that none of the treatments significantly impacted the soil cover provided by the residues before the establishment of the subsequent wheat crop. Assessments of the treatment effects on inoculum potential are ongoing using traditional mycological techniques to examining ascospore production and PCR for the identification of the Fusarium species in the residues. As part of the PCR identification in this study, suitable protocols for extracting DNA from the residues collected on the soil surface, and subsequently PCR testing, needed to be developed. This has now been accomplished. FHB incidence within the wheat sown into each trial in the 2008 season will assessed at the appropriate to stage of crop maturity. The crops which will provide the residues for the planned 2008/2009 field experiments have been established and inoculated in preparation for 2009.

Impact:
Preliminary results indicate that the treatments employed here do not reduce the residues on the soil surface in the spring - this is actually desirable as residue cover is required for soil conservation programs. The effect on the treatments examined on residue decomposition the inoculum load from these residue/treatment combinations, is however still to be determined and the analysis of sampled materials is in progress. The development of practical and repeatable protocols for DNA extraction and PCR testing from residues will enable the planned work in this study to be completed and will greatly aid subsequent work in this area.

As a result of that accomplishment, what does your particular clientele, the scientific community, and agriculture as a whole have now that they didn't have before?:

The findings of this research have the potential to impact our understanding of FHB and may aid in the development of integrated management strategies for FHB. Specifically the study will indicate if the fine chopping of corn residues or the application of soil amendments can be used to accelerate the decomposition of crop residues or the inoculum production of these residues. The study should also indicate if soil amendments, biological control agents, or fungicides, as tested in this study, could be used to target the survival of Fusarium spp. in crop residues.

Project 2: *Factors Influencing the Accumulation of DON in Fusarium-Infected Wheat.*

1. What major problem or issue is being resolved and how are you resolving it?

Few studies have closely examined the development of Fusarium head blight (FHB) and deoxynivalenol (DON) accumulation in relation to the resistance of wheat cultivars, the relative aggressiveness of *F. graminearum* isolates, and the competence and 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 by examining; i) the effect of environmental conditions, principally moisture between anthesis and harvest, on the development of FHB and the accumulation of DON in wheat; ii) the impact of host genetic resistance on the development of FHB and the accumulation of DON in wheat; and iii) the effect of pathogen variability (aggressiveness and mycotoxin production capacity) on the development of FHB and the accumulation of DON in wheat.

2. List the most important accomplishment and its impact (how is it being used?). Complete all three sections (repeat sections for each major accomplishment):

Accomplishment:

An inoculated, mist irrigated field experiment examining FHB development and DON accumulation was established in St. Paul in 2007. Entries were planted in a randomized split-split-plot design with five replicates. Main plots were irrigation regime (irrigation for 14, 21, 28 and 35 days after inoculation (dai)), subplots were host genetic background and sub-sub-plots were *F. graminearum* isolates. Plots were inoculated at anthesis and mist-irrigated following inoculation for 14 days to facilitate disease development and then irrigation treatments were imposed. Entries were assessed for FHB incidence and severity and grain harvested and assessed for visually scabby kernels (VSK) and DON. Developing spikes were harvested at regular intervals between inoculation and maturity and assessed for FHB symptoms and DON.

Impact:

Severity, VSK and DON, across all isolates, were significantly higher in the susceptible wheat Wheaton. FHB severities were not significantly impacted by irrigation treatments, though this was to be expected as the first irrigation treatments was only imposed 14 days after inoculation and disease assessment was at 21 dai. VSK values were significantly lower in the treatments receiving the least amount of mist-irrigation (14 DAI) suggesting that extended moisture promotes disease development after disease assessment in the field. DON was significantly lower in the longest (35 dai) misting treatment. DON in head samples was reduced with increased durations of irrigation, but was only significantly lower in grain from the 35 dai misting treatment. The reduction of DON was larger in Wheaton than other cultivars. Our results suggest that DON may be reduced by late-season moisture despite increased grain colonization. Leaching may explain the reduction of DON observed with an increased misting duration, and differences in tissue morphology and metabolism may determine the rate of leaching from specific tissues.

As a result of that accomplishment, what does your particular clientele, the scientific community, and agriculture as a whole have now that they didn't have before?:

The finding of this study demonstrate that rainfall prior to harvest influences the DON levels in *Fusarium*-infected grain. The findings increases our understanding of why there are discrepancies between; a) visual evaluations of FHB made in the field prior to head senescence, b) post harvest visual assessment of FHB damage to grain (VSK or FDK), and c) the DON content of harvested grain. These discrepancies are frequently observed in breeder's FHB screening nurseries and in commercial fields where apparently sound grain is found to contain significant levels of *Fusarium*-produced mycotoxins, especially DON. Understanding the impact of different host resistance genes on DON accumulation will be utilized to establish the relationship between resistance to disease development and toxin accumulation and evaluate the value of host resistance genes. An understanding of the impact of the variability within the pathogen population for aggressiveness and DON toxin as measured under controlled environmental conditions on DON production in the field will be used to evaluate the magnitude of the threat posed by potential shifts in the pathogen population with respect to aggressiveness and/or the spectrum and quantities of mycotoxins produced.

Project 3: *FHB Resistance in Hard Red Spring Wheat Near-Isogenic Lines.*

1. What major problem or issue is being resolved and how are you resolving it?

Fusarium head blight (FHB) resistance quantitative trait loci (QTL) have been mapped in a diverse range of common wheat (*Triticum aestivum*) genotypes and related species, but most have not yet been utilized in commercial wheat. This project is developing wheat lines that are principally hard red spring wheat (HRSW), but are near-isogenic for the different reported novel QTLs (QTL NILs) from unadapted or alien germplasm. We are using the most rapid method - marker-assisted backcrossing - to introduce new FHB resistance QTLs into HRSW. Resultant materials can then be used to critically assess whether these presumptive QTLs do actually increase FHB resistance in HRSW. Further, pyramiding FHB resistance QTLs is expected to provide a greater opportunity to increase FHB resistance in HRSW. We will use the QTL NILs with different individual FHB resistance QTLs to pyramid these QTLs, and thus identify favorable QTL combinations.

2. List the most important accomplishment and its impact (how is it being used?). Complete all three sections (repeat sections for each major accomplishment):

Accomplishment:

Introgression of exotic Fusarium head blight (FHB) resistance QTLs into elite wheat gene pools is expensive and time consuming, and so it is beneficial to know in advance if the effort to deploy a new QTL in a breeding program is worth the effort. Greenhouse and field studies using multiple backcross near-isolines of hard red spring wheat identified individual exotic FHB resistance QTLs that appear to improve FHB resistance, as well as a set of QTLs that do not. Pyramided combinations of two QTLs that appear to be effective individually and linked to the markers use for their introgression were developed, and sets of F_3 families with 0, 1 or 2 of the QTLs were developed. These materials will be used for future studies of FHB resistance in the field. One promising new putative FHB resistance QTL is not linked to the introgressed marker, leading us to embark on a marker identification effort so that it can be used for further gene pyramiding.

Impact:

These near-isolines provide FHB resistance QTL validation for U.S. hard red spring wheat breeding programs, and thus are a prebreeding resource for them. They represent useful genetic stocks for a plethora of uses in the exploration of wheat-Fusarium interactions. Materials have been distributed to wheat researchers in 6 U.S. states and the U.K. for a diversity of research uses.

As a result of that accomplishment, what does your particular clientele, the scientific community, and agriculture as a whole have now that they didn't have before?:

This is, to our knowledge, the largest available set of wheat backcross near-isolines for different reported FHB resistance QTLs. The information gained on individual QTL effects provides a breeding guide to FHB resistance QTL selection and introgression efforts. The wheat FHB research community also has access to these materials for additional experimental purposes.

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.

Di, R., Blechl A., Dill-Macky, R., Tortora, A. and Tumer N.E. (2007). Expression of the N-terminal 99 amino acids of yeast ribosomal protein L3 in transgenic wheat confers resistance to Fusarium head blight. *Mol. Plant Breed.*, **5**:283.

Di, R., Blechl, A., Dill-Macky, R., Tortora, A. and Tumer, N. (2007). Expression of a truncated form of ribosomal protein L3 in transgenic wheat confers resistance to deoxynivalenol and Fusarium Head Blight. In: *Proceedings of the 2007 National Fusarium Head Blight Forum*, Kansas City, Missouri, USA, December 2-4, 2007, p. 48.

Dill-Macky, R., Dong, Y. and Schwarz, P. (2007). Sampling Grain for Deoxynivalenol (DON) Analysis: A Researchers Guide. (PDF) Posted 7/16/07 on the US Wheat and Barley Scab Initiative Website. (http://www.scab.usa.org)

Gautam, P. and Dill-Macky, R. (2007). Fusarium Head Blight infection and deoxynivalenol production by Fusarium graminearum in wheat. *Phytopathology*, 97:S39.

Gautam, P. and Dill-Macky, R. (2007). Effect of post inoculation moisture on deoxynivalenol accumulation in *Fusarium graminearum*-infected wheat. In: *Proceedings of the 2007 National Fusarium Head Blight Forum*, Kansas City, Missouri, USA, December 2-4, 2007, p. 75-77.

Makandar, R., Nalam, V., Essig, J.S., Schapaugh, M.A. Trick, H., Dill-Macky, R. and Shah, J. (2007). Enhancing Fusarium Head Blight resistance in wheat by manipulating mechanisms contributing to host resistance and susceptibility. In: *Proceedings of the 2007 National Fusarium Head Blight Forum*, Kansas City, Missouri, USA, December 2-4, 2007, p. 52-53.

Schwarz, P., Dong, Y. and Dill-Macky, R. (2007). Deoxynivalenol measurement: Sources of error and sampling recommendations. In: *Proceedings of the 2007 National Fusarium Head Blight Forum*, Kansas City, Missouri, USA, December 2-4, 2007, p. 13.

Shin, S.H., Lewis, J.M., Mackintosh, C.A., Elakkad, A.M. Wennberg, K.J., Heinen, S.J., Dill-Macky, R. and Muehlbauer, G.J. (2007). Transgenic wheat with enhanced resistance to Fusarium Head Blight. In: *Proceedings of the 2007 National Fusarium Head Blight Forum*, Kansas City, Missouri, USA, December 2-4, 2007, p. 63.

Rojas-Barros, P., Blankenheim, Z.J., Wennberg, K.J., Elakkad, A.M., Dill-Macky, R. and Garvin, D.F. (2007). Fusarium head blight resistance of wheat lines near-isogenic for five different FHB resistance QTLs. In: *Proceedings of the 2007 National Fusarium Head Blight Forum*, Kansas City, Missouri, USA, December 2-4, 2007, p. 226.