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:	59-0790-4-114
USDA-ARS Agreement Title:	Collaborative Studies of Fungicides and Application Techniques for Improved Control of Fusarium Head Blight.
FY07 ARS Award Amount:	$ 86,201

USWBSI Individual Project(s)

USWBSI Research Area*	Project Title	ARS Adjusted Award Amount
CBCC	Uniform Evaluation of Fungicides for Control of FHB in Multiple ND Grain Classes.	$13,506
CBCC	Uniform Evaluation of IPM Practices for FHB in Multiple Grain Classes, ND.	$ 43,427
EEDF	Greenhouse Studies of DON Development in Spring Grains as Influenced by Infection Timing, Moisture, and Temperature.	$ 29,268
	Total Award Amount	**$ 86,201**

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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

Project 1: *Uniform Evaluation of Fungicides for Control of FHB in Multiple ND Grain Classes.*

1. **What major problem or issue is being resolved and how are you resolving it?**
   Fungicides continue to be one of the important management strategies for wheat and barley producers to reduce yield and quality losses due to FHB infection. Uniform tests of fungicides across multiple grain classes and environments provides information on how registered or experimental fungicides perform on these grain classes common in North Dakota, and multiple testing sites help assure that at least one or more sites may have disease development. In 2007, uniform fungicide tests (using a common protocol developed by the USWBSI management group) were done on spring wheat, durum wheat, and barley, across three sites in ND, sites representing different climatic and soil environments. Data from these trials has been instrumental in providing up-to-date management information to producers and in getting new fungicides registered.

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: Relatively dry weather conditions in ND in 2007 did not favor FHB infection in most commercial fields, but research trials in this study provided added mist and/or inoculum that allowed good separation of efficacy of products on spring wheat, durum, and barley. For example, results indicated that Proline, Prosaro, and a high rate of Caramba fungicide gave superior control of FHB and reduction in DON than other products tested. Compilation of results over multiple locations showed a 10 to 15% greater reduction in DON levels and up to a 10 percent greater yield increase with these better products versus the standard used, Folicur, while Folicur provided an average 15% greater reduction in DON and 6% greater yield than the other product tested, Topguard.

   Impact: Data from these ND fungicide trials, as well as from uniform trials across the US in other grain classes, contributed to the data base that resulted in EPA registrations of the best products available for FHB control. Proline was registered in 2007 and Folicur and Caramba were registered in 2008. Prosaro is a combination product of Proline and Folicur, so successful registration of both of these products allowed Prosaro registration in 2008, as well. The full registration of Folicur, which is off-patent, also opened the door for registration of generic products, six of which currently are now labeled in ND. Increased product availability means increased competition, which has given producers more options at reduced product price.

   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?:
   As indicated in the impact statement, they now have three new fungicides available that are superior for controlling FHB and reducing DON. Under moderate FHB pressure, these products may provide a reduction of DON that meets the grain industry standard, plus provide up to 10-15% yield increase over other products tested.

Project 2: *Uniform Evaluation of IPM Practices for FHB in Multiple Grain Classes, ND.*

1. What major problem or issue is being resolved and how are you resolving it?
A number of management strategies have been demonstrated to reduce FHB and DON, strategies such as use of fungicides, crop rotation, tillage, and tolerant cultivars. However, under severe epidemics, an individual strategy used alone, or even use of two strategies, will not reduce disease severity and DON to levels required by the grain industry. A combination of strategies, each building upon the other, is required for achieving the best management of FHB and for obtaining quality grain. The purposes of this collaborative effort, within ND and across other states and grain classes are:

1. Demonstrate that integrated management is the most effective means of reducing losses to FHB/DON

2. Increase grower adoption of integrated strategies by demonstration of their effectiveness in a wide range of environments

3. Decrease the risk of the development of FHB epidemics and thus reduce losses to FHB and DON.

In ND in 2007, we had a multi-site, multi-grain class study to evaluate the benefits of combining previous crop, host resistance and fungicides for FHB/DON management. The sites and grain classes were: hard red spring wheat at Fargo with 3 strategies; winter wheat at Lisbon and Prosper with variety x fungicide strategies; spring wheat at Carrington with variety x fungicide strategies, durum wheat at Minot with variety x fungicide strategy, durum at Langdon with all three strategies, and barley at Fargo and Langdon with all three strategies. All trials were established under natural rainfall and inoculum conditions (i.e. no mist-irrigation and no inoculation). Under these locations and weather conditions of 2007, successful evaluation of strategies for FHB control and DON reduction were achieved with the spring wheat studies in Fargo and Carrington, the winter wheat studies in two locations, the durum location in Langdon, and the barley study in Langdon. Too dry of environmental conditions at Minot, and field drown out of barley in Fargo, prevented successful FHB evaluations at these locations, indicating the value of multiple locations to obtain data for the research protocol.

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: Successful evaluation of use of multiple strategies was achieved on four spring grain classes in ND. Results showed that multiple strategies improved FHB control, DON reduction, and yield and quality parameters over single strategies, even with some of the more FHB resistant spring wheat varieties available. These results were presented at two invited presentations (Canadian and US Fusarium workshops), as well as presented at many producer meetings in the region. Winter wheat results were published in the Agronomy

Journal. Our data helps meet the goals 1 and 3 of this coordinated project and we need to further measure grower adoption of the strategies.

Impact: Growers have been provided information demonstrating that multiple strategies are most effective. For example, an FHB susceptible durum variety planted into hard red spring wheat stubble, and not treated with a fungicide, had 3x higher FHB field severity, 3x higher DON levels, a reduction in yield of 19 bushels, and a 2.8 lb lighter test weight than when a more FHB resistant durum cultivar had been planted on canola ground and treated with an effective fungicide at flowering. No single strategy in this study approached the gains made by multiple strategies. In spring wheat at Carrington, an FHB resistant cultivar and fungicide treatment resulted in a 10x reduction in FHB field severity and a 13 bushel yield increase over using a susceptible cultivar and no fungicide, while use of a resistant cultivar alone resulted in an 8x reduction in FHB field severity and an 8 bushel yield increase. Similar results were observed in the other grain classes where FHB developed. Surveys by the ND Wheat Commission indicating varieties grown indicate that growers are quickly adopting use of more FHB resistant varieties, and recent availability of superior fungicides may indicate more use when FHB disease forecasting sites indicate that fungicides are warranted.

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?:
Data that supports the use of multiple strategies improve FHB control. Integrated strategies have been demonstrated in 2007. Additional tests in 2008 will show how these multiple strategies work with possibly different environments and/or different varieties and fungicide products available. Results of individual trials in 2007 may be found at:
North Dakota State University Small Grain Fungicide Field Trials compilation. NDSU Dept. of Plant Pathology, Fargo, ND. 82 pages. On-line at:
http://www.ag.ndsu.nodak.edu/extplantpath/programs.html

Project 3: *Greenhouse Studies of DON Development in Spring Grains as Influenced by Infection Timing, Moisture, and Temperature.*

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

Deoxynivalenol (DON) accumulation in wheat has been shown to be positively correlated with visible scab, but correlations between disease severity and DON levels are not always high. DON accumulation has been reported in asymptomatic winter wheat, raising questions about how time of infection, environmental conditions, or genetics influence DON production. We conducted greenhouse studies in 2003 and 2004 with hard red spring wheat that indicated that single post-anthesis (Feekes 10.54) inoculations with *Fusarium graminearum* did not result in appreciable visible symptoms of FHB, but we did not measure DON levels. New cultivars of spring wheat are now commercially grown in ND that have Sumai-3 germplasm as a source of resistance, and the effect of timing of infection on these also need to be evaluated.

Data from this research has several implications. For example, if late infections and prolonged moisture increase risk of DON in certain grain classes or cultivars, this information may be used: 1) to incorporate weather prediction into current FHB forecasting models for spring and winter wheat; 2) to prompt further evaluation of post-flowering fungicide efficacy and provide data on how close to fungicide pre-harvest intervals may fungicides be applied to be effective and yet follow label restrictions on these intervals (current superior FHB fungicides have a 30 day PHI); and 3) to assist breeders in incorporating DON resistance into their germplasm.

Greenhouse experiments on two varieties of each of two wheat classes, hard red spring wheat and durum wheat, at four infection timings (Feekes 10.5, 10.51, 10.54 and 11.1) and three misting durations (intermittent mist for 2 days, 5 days or 10 days following inoculation) were done in a controlled greenhouse environment at NDSU during the winter of 2007-2008. At least two trials with each variety per grain class (representing two levels of FHB resistance) were done over the course of the winter/spring. FHB was assessed at soft dough stage and then plants were allowed to grow to maturity for hand harvesting and DON determination. DON, 3ADON, 15ADON and Nivalenol were measured by the NDSU Toxicology Laboratory, using gas chromatography and electron capture techniques.

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: Trials evaluating the effect of inoculation timing and mist duration were successfully completed on Glenn spring wheat (moderately resistant) and Trooper spring wheat (susceptible), and on Monroe durum (susceptible) and Divide durum (best available resistance among durums). Although all data has not been analyzed, preliminary results indicate that late inoculations produce substantial DON in more susceptible cultivars if mist duration is extended. Long durations of wetness are critical for DON development at all growth stages in the more resistant varieties.

Impact: Data gathered from these trials will indicate the relative risk of DON accumulation in two spring grain classes when extended periods of moisture occur, no matter what the growth stage of infection, and provide data that will allow development of management strategies for possible late infections. Data accumulated also will indicate the presence or absence of DON derivatives.

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?:

Data indicating that late infections may be as damaging as infections at flowering, if extended periods of moisture occur following flowering. Management strategies still have to be developed for these late infections, or breeders will need to consider these late infections 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.

Refereed:

Ransom, J.K., and McMullen, M.V. 2008. Yield and disease control on hard winter wheat cultivars with foliar fungicides. Agronomy J. 100:1130-1137.

Paul, P.A., Lipps, P.E., Hershman, D.E., McMullen, M.P**.,** Draper, M.A., and Madden, L.V. 2007. A quantitative review of tebuconazole effect on Fusarium head blight and deoxynivalenol content in wheat. Phytopathology 97:211-220.

R. R. Burlakoti, S. Ali, G. A. Secor, S. M. Neate, M. P. McMullen, and T. B. Adhikari. 2008. Genetic Relationships among populations of *Gibberella zeae* from barley, wheat, potato, and sugar beet in the Upper Midwest of the United States. Phytopathology, accepted on 2 June 2008.

Abstract:

Burlakoti, R.R., Ali, S. , Secor, G.A., Neate, S.M., McMullen, M**.**, and Adhikari, T. 2007. Impact of cereal and non-cereal hosts on trichothecene producing genotypes of *Fusarium graminearum*. Phytopathology 97:S15.

Proceedings:

McMullen, M. 2007. Integration - The key to managing Fusarium head blight (FHB = scab) in wheat. Pages 26-28 *in*: Proc. 2007 Illinois Crop Protection Technology Conf., Jan. 3-4, 2007. Univ. of Illinois, Champaign, IL.

McMullen, M. 2007. Integrated strategies for FHB management, a Northern Great Plains perspective. Pages 82-82 *in*: Proc. 5th Canadian Workshop on Fusarium head blight. Winnipeg, Manitoba, Nov. 27-30, 2007. Canadian Grain Commission, Winnipeg, Manitoba.

McMullen, M. 2007. Experiences in reducing disease and DON through components of FHB management. Pages 102-103 *in*: Proc. 2007 National Fusarium Head Blight Forum. Dec. 2-4, 2007, Kansas City, Kansas. US Wheat and Barley Scab Initiative, Michigan State Univ., East Lansing, MI.

McMullen, M., Jordahl, J., and Meyer, S. 2007. Differential effects of infection timing on Fusarium head blight and on DON and DON derivatives in three spring grains. Page 100 *in*: Proc. 2007 National Fusarium Head Blight Forum. Dec. 2-4, 2007, Kansas City, Kansas. US Wheat and Barley Scab Initiative, Michigan State Univ., East Lansing, MI.

McMullen, M., Meyer, S., and Jordahl, J. 2007. Effects of fungicide timing on Fusarium head blight and on DON and DON derivatives in three spring grains. Pages 101 *in*: Proc. 2007 National Fusarium Head Blight Forum. Dec. 2-4, 2007, Kansas City, Kansas. US Wheat and Barley Scab Initiative, Michigan State Univ., East Lansing, MI.

Paul, P., Madden, L., McMullen, M., Hershman, D., Sweets, L., Wegulo, S., Bockus, W., Halley, S., and Ruden, K. 2007. An integrated approach to managing FHB and DON in wheat: Uniform trials 2007. Pages 117-122 *in*: Proc. 2007 National Fusarium Head Blight Forum. Dec. 2-4, 2007, Kansas City, Kansas. US Wheat and Barley Scab Initiative, Michigan State Univ., East Lansing, MI.

Paul, P., Lipps, P., Hershman, D., McMullen, M., Draper, M., and Madden, L. 2007. A quantitative synthesis of the relative efficacy of triazole-based fungicides for FHB and DON control in wheat. Pages 115-116 *in*: Proc. 2007 National Fusarium Head Blight Forum. Dec. 2-4, 2007, Kansas City, Kansas. US Wheat and Barley Scab Initiative, Michigan State Univ., East Lansing, MI.

Paul, P., Madden, L., McMullen, M., Hershman, D., Brown-Rytlewski, D., Sweets, Adee, E., Bradley, C., Padgett, B., and Ruden, K. 2007. Fungicide effects on FHB and DON in wheat across multiple locations and wheat classes: Uniform fungicide trials 2007. Pages 123-127 *in*: Proc. 2007 National Fusarium Head Blight Forum. Dec. 2-4, 2007, Kansas City, Kansas. US Wheat and Barley Scab Initiative, Michigan State Univ., East Lansing, MI.

Extension:

McKay, K., et al. 2007. 2007 Winter wheat variety by fungicide trial, Berthold, ND. Page 573 i*n:* Crop Production Guide 2008, No. 18. NDSU Extension Service Publication. Fargo, ND. 575 p.

McKay, K., et al. 2007. 2007 Winter wheat variety by fungicide trial, Roseglen, ND. Page 574 *in:* Crop Production Guide 2008, No. 18. NDSU Extension Service Publication, Fargo, ND. 575 p.

McMullen, M., et al. 2008. 2007 North Dakota State University Small Grain Fungicide Field Trials compilation. NDSU Dept. of Plant Pathology, Fargo, ND. 82 p. Found on-line at: http://www.ag.ndsu.nodak.edu/extplantpath/programs.html