USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY12 Final Performance Report
July 16, 2013

Cover Page

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Fiscal Year:	FY12
USDA-ARS Agreement ID:	59-0206-9-056
USDA-ARS Agreement Title:	FHB Management Research in New York.
FY12 USDA-ARS Award Amount:	$ 46,736*

USWBSI Individual Project(s)

USWBSI Research Category**	Project Title	ARS Award Amount
MGMT	Effects of Local Corn Debris Management on FHB and DON Levels (Year Two).	$ 31,234
MGMT	Integrating Multiple Management Strategies to Minimize Losses Due to FHB and DON in New York.	$ 10,429
MGMT	Uniform Fungicide andBiological Control Studies in New York.	$ 5,073
	Total ARS Award Amount	**$ 46,736**

Gary C. Bergstrom July 15, 2013
Principal Investigator Date

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* Partial funding for this research is under ARS agreement # 59-0206-9-059

** 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: *Effects of Local Corn Debris Management on FHB and DON Levels (Year Two).*

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

Reduction or elimination of within-field sources of inoculum of *Fusarium graminearum* is the basis for cultural control measures such as crop rotation sequences in which cereals follow non-cereal crops. In USWBSI-supported microplot experiments conducted in twenty-one winter wheat fields over five states in 2009 and 2010, DON level differed significantly between corn debris and no debris microplots in only one location, strongly suggesting that regional atmospheric inoculum is the strongest contributor to infection even when corn debris is present in a wheat field. Small area sources of debris, however, may result in an underestimation of the contribution of spores from a larger field of corn debris to FHB and DON. The goal of the current USWBSI research project is to provide realistic estimates of 'DON reduction' that can be expected from cultural controls that reduce within-field inoculum sources. We utilized moldboard plowing of corn debris as a proxy for planting after a non-cereal crop to compare directly with wheat planted no-till into corn debris in commercial-scale wheat fields planted following grain corn harvest in Illinois, Kentucky, Michigan, Missouri, Nebraska, New York, and Vermont. Following corn harvest, replicated wide (60 ft) strips were moldboard plowed or left non-plowed prior to sowing wheat over the entire field with a no-till drill. Wheat in each strip was monitored for FHB and sampled for laboratory quantification of head infection by *F. graminearum* and contamination of grain by DON. Results were collected over two years, 2011 and 2012, from winter wheat in six states (IL, KY, MI, MO, NE, and NY) and spring wheat in one state (VT).

In 2011, FHB symptoms at soft dough stage were low to moderate at every location except Missouri. Yet, at crop maturity, a high percentage of wheat heads was found to be infected by *F. graminearum* in all locations except Nebraska and Vermont. Measurable DON was found in grain from every environment and the levels were lowest in Vermont and highest in Kentucky and Nebraska. It is interesting that the Nebraska site showed the lowest disease index and lowest incidence of head infection, but the highest average toxin level. Moldboard plowing resulted in a significant decrease in FHB index in four environments (IL, MO, NY, MI), though the magnitude of the difference was large only in Missouri. In Nebraska, FHB index was significantly higher in the moldboard-plowed treatment in which the wheat crop matured earlier than in the no-till corn debris treatment. Moldboard plowing was associated with a small but significant decrease in recovery of *F. graminearum* from mature heads in three environments (IL, MI, NY). There was no significant effect of plowing on DON level in five environments (IL, KY, MO, NY, VT) and there were small but significant decreases in toxin in moldboard-plowed compared to no-till strips in two environments (MI and NE). An additional treatment of minimum tillage (chisel plow) was added in the Michigan experiment; DON levels in the minimum-till plots were intermediate between moldboard and no-till but not significantly different from no-till.

In 2012, a generally warm and dry cropping season across the experimental region, FHB symptoms at soft dough stage were not observed in four locations (KY, MI, NY, VT) and were observed at low levels at three locations (IL, MO, NE); plowing had no significant effect on FHB index in any location. At crop maturity, a moderate percentage of wheat heads (i.e., greater than 10%) was found to be infected by *F. graminearum* only in Missouri and Vermont; in both environments there was a significantly greater incidence of heads infected in no-till than in moldboard-plowed strips. DON was not detected in Nebraska, and was detected at low levels in all other states. Moldboard plowing resulted in a significant decrease in already low DON levels in New York and Vermont. A similar level of reduction in DON level was observed in wheat from moldboard-plowed strips in Michigan, but DON was assayed in small samples that were pooled from the replicate strips, so no statistical comparison could be made.

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:

There is a strong trend in two years of data suggesting that inoculum from area atmospheric sources exerts a far greater effect than inoculum from in-field corn residue on the level of DON contamination. A third year of experimentation in three additional wheat environments in 2013, in Illinois, Nebraska and New York, will provide increased evidence of the magnitude of the effect of corn residue management on DON reduction.

Impact:

Based on two years of data in 14 wheat growing environments, but especially on data from 2011, it appears that localized corn debris management prior to wheat planting results, on average, in relatively small reductions in FHB and in DON contamination in wheat. Regional atmospheric inoculum appears to play a far greater role in corn-dominated landscapes, thus prioritizing the need for resistant wheat varieties and effective fungicides as the main pillars of integrated management in corn production regions. Collection of useful data to address the research question was challenging in the warm and dry cropping season of 2012 as FHB and DON levels were low in most locations. A third year of experimentation in seven additional wheat environments in 2012 is being conducted to provide increased evidence of the magnitude of the effect of localized corn residue management on DON reduction. It appears that this third year of data collection will pay off since significant FHB development occurred in each of the three locations in 2013 and presumably there will be measureable levels of DON in each of the corresponding grain samples.

Project 2: *Integrating Multiple Management Strategies to Minimize Losses Due to FHB and DON in New York.*

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

In response to the USWBSI goal to validate integrated management strategies for FHB and DON, the Disease Management RAC of USWBSI initiated a multi-state, multi-year, coordinated field study. In New York during 2012, we observed the disease and yield impact of cultivar susceptibility, inoculation with *Fusarium graminearum*, and treatment with Prosaro® fungicide in two different experimental environments. Both experiments were performed at the Musgrave Research Farm in Aurora, NY following cultural practices recommended for soft red winter wheat in the region. The four cultivars included were 'Pioneer 25R34' (classified as moderately susceptible to FHB), 'Pioneer 25R46' (classified as moderately resistant to FHB), 'Otsego' (classified initially as moderately resistant to FHB), and 'Truman' (established as moderately resistant to FHB). The two experimental environments, both planted on September 26, 2011, were characterized by the planting of winter wheat no-till into 1) soybean residue and 2) corn residue in immediately adjacent parcels of land. Each experimental design was a split-split plot with four wheat cultivars as whole plots, inoculation treatment as subplot, and fungicide treatment as sub-subplot, in four replicated blocks. Main plots were planted with a 10 ft wide commercial grain drill and were 20 ft long. Spray treatments applied at Feekes GS10.5.1 on 5/23/12 were 1) non-sprayed, non-inoculated 2) Prosaro 6.5 fl oz/A & Induce 0.125%, non-inoculated 3) non-sprayed and inoculated with *F. graminearum*; and 4) Prosaro 6.5 fl oz/A & Induce 0.125% and inoculated with *F. graminearum*. Treatments 3 and 4 were inoculated with a conidial suspension of *F. graminearum* (40,000 conidia/ml) on the same day as the Prosaro application after the fungicide had dried and in early evening to provide a better environment for infection. Prosaro and *F. graminearum* applications were applied with a tractor-mounted sprayer with paired Twinjet nozzles mounted at an angle (30^{o} from horizontal) forward and backward and calibrated to deliver at 20 gallons per A. FHB and foliar diseases were assessed at soft dough stages. Grain was harvested from a 4 ft wide x 20 ft long area in each subplot using a Hege plot combine on July 3, 2012. Grain moistures, plot yields, and test weights were recorded with the latter two adjusted for moisture. Means were calculated and subjected to Analysis of Variance. Fisher's protected LSD was calculated at $P = 0.05$. Analysis of DON content in grain was conducted in the USWBSI-supported mycotoxin laboratory of Dr. Dong.

Both experimental environments were located in the same field that in the previous year was split, growing corn in one half and soybean in the other. Flowering occurred simultaneously in both environments during a relatively dry period, considered low risk for FHB infection. FHB incidence at soft dough stage was well below 1% in all plots so was recorded as zero.

The impact of *F. graminearum* inoculation was determined by comparing the non-inoculated and inoculated treatments (combining non-sprayed and Prosaro treatments) in both experiments (environments). Inoculation did not significantly affect yield, FHB index, or

DON in either experiment. Cultivars did not respond differentially to inoculation in either environment.

Significant differences in yield were detected among cultivars in each environment. Following soybean, only Otsego had significantly higher yield than that of all other cultivars. Following corn, Otsego had the highest yield, which was significantly higher than Pioneer 25R34 and Pioneer 25R46; and Pioneer 25R34 had the lowest yield, which was significantly lower than Otsego and Truman. Yield for each cultivar was significantly higher following soybean than following corn. This may be attributable to increased nitrogen following soybean, but this was not measured. However, within each environment, there was no significant difference in yield within each cultivar, regardless of spray treatment or inoculation, except for the non-inoculated, non-sprayed P25R34. For some unknown reason this treatment resulted in a yield significantly lower than all other treatments for this variety. In the virtual absence of disease pressure, cultivars differed significantly in yield with Otsego consistently yielding highest.

When results of all the cultivars were combined, the overall impact of the Prosaro applications was not significant, regardless of environment, for yield or FHB index. No significant difference was detected for DON contamination among any of the spray treatments in either environment. The only significant difference in DON contamination of grain was for the cultivar Pioneer 25R34, which although still far below the threshold of agronomic importance, i.e., 2 ppm, was significantly higher than that of the other varieties following corn. In this experiment, with little to no fungal disease pressure, the Prosaro application caused no significant improvement of yield or reduction in FHB index or DON contamination of grain.

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:
An unusually hot and dry environment during the grain filling period in 2012 prevented significant development of FHB and DON in the New York experiments.

Impact:
This was a case where neither inoculation nor Prosaro treatment had an effect on grain yield or toxin, and the wheat cultivars with the highest yield potential in the absence of disease did best. This is a circumstance not unlike what farmers experience and one that influences them greatly in choosing cultivars. It is good for the national dataset to include disease non-conducive environments as well as those where environment is highly favorable for disease and toxin. Early observation from the New York site in 2013 is showing high disease incidence and likely elevated toxin levels.

Project 3: *Uniform Fungicide andBiological Control Studies in New York.*

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

   Improved chemical and/or biological control strategies are necessary for reducing yield and quality losses from FHB. In New York, we have observed that timely and efficacious fungicide application is a key factor in reducing DON levels down to the 2 ppm required by the local milling industry. This coordinated project validates that chemical and biological control strategies contribute to reducing FHB and DON and to increasing yield and quality. In New York, adjacent experiments of the uniform fungicide and uniform biological control tests were conducted at the Musgrave Research Farm in Aurora in a Kendaia silt loam soil planted with the soft red winter wheat variety 'Pioneer 25R47' sown at 2 bu/A following soybean harvest (no tillage) on 26 Sep 2011. For each experiment foliar treatments were arranged in randomized complete blocks with four replicates. The fungicide test included 12 fungicide treatments. The biological test with ten treatments featured Taegro (bacterium *Bacillus subtilis* var. *amyloliquefacians* strain FZB24 containing 5.0 x 10^{10} cfu/g, Novozymes Biologicals Inc.) alone or in combination or alternation with industry standard fungicides, Prosaro and Tebuconazole and also commercially available canola oil. Treatments for the uniform fungicide trial were applied on 7 May at Feekes growth stage (FGS) 9 (ligule of last leaf just visible), 23 May at FGS 10.5 (heading), and/or 30 May at FGS 10.5.1 (begin anthesis) depending on treatment. Treatments for the uniform biological control trial were applied on 7 May at Feekes growth stage (FGS) 10.5.1 (anthesis), and 23 May at seven days after the first application. All plots were inoculated with a conidial suspension of *Fusarium graminearum* (40,000 conidia/ml) on 23 May to initiate development of Fusarium head blight (FHB). Treatments were applied with a backpack sprayer with 8002DG flat fan nozzles, 18.5-in. apart, pressurized at 34 psi, and calibrated to deliver 20 gal/A. All plots were inoculated with a conidial suspension of *Fusarium graminearum* (40,000 conidia/ml) on 6 Jun to initiate development of Fusarium head blight (FHB). The *F. graminearum* was applied by a tractor-mounted sprayer with TJ-60 8003vs nozzles, 20-in. apart, pressurized at 30 psi, and calibrated to deliver 20 gal/A. Incidence and severity of FHB were rated on 7 Jun. Foliar diseases were rated on 7 Jun as percent disease severity on flag leaves (average rating for whole plot). Grain was harvested on 3 Jul from a 20 x 4 ft area in each subplot using a Hege plot combine. Grain moistures, grain yields, and test weights for individual plots were recorded and yield was recalculated to bu/A at 13.5% moisture. Means were calculated, subjected to analysis of variance, and separated by Fisher's protected LSD (P=0.05) test. Analysis of DON content in grain was conducted in the US Wheat and Barley Scab Initiative-supported mycotoxin laboratory of Dr. Dong. The growing season was drier than normal and not conducive for FHB or other disease development. As a consequence, no significant differences in yield were discerned in 2012.

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 (Uniform Fungicide):
Because of very dry conditions in New York in 2012, none of the fungicide applications had a significant effect on yield, DON, test weight or disease ratings as compared with the corresponding non-treated control.

Impact (Uniform Fungicide):
Though results from New York in 2012 were not promising, useful results were recorded from other test locations. Early observation from the New York site in 2013 is showing high disease incidence and likely elevated toxin levels.

Accomplishment (Uniform Biocontrol):
The incidence of FHB or foliar diseases did not exceed 1% for any treatment. The coupling of Prosaro with biocontrols did not enhance or diminish the fungicide's ability to control FHB under little to no disease pressure. There were no statistically significant differences in yield and test weight among any of the treatments in the uniform biocontrol trial. Statistically significant differences in DON contamination of grain were detected among treatments, though no plot was contaminated at a level that was of agricultural significance.

Impact (Uniform Biocontrol):
While the 2012 New York results were not promising, *Bacillus* biological control treatment is still considered a potential tool for organic production and for extended post-flowering protection of heads in conventional production. Testing of *Bacillus* continued in 2013 and significant FHB has developed in New York in 2013.

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.

Publications (peer-reviewed journals):

Crane, J.M., D.M. Gibson, R.H. Vaughan, and G.C. Bergstrom. 2013. Iturin levels on wheat spikes linked to biological control of Fusarium head blight by *Bacillus amyloliquefaciens*. *Phytopathology* 103:146-155.

McMullen, M., G. Bergstrom, E. De Wolf, R. Dill-Macky, D. Hershman, G. Shaner, and D. Van Sanford. 2012. A unified effort to fight an enemy of wheat and barley: Fusarium head blight. *Plant Disease* 96: 1712-1728.

Publications (non-peer reviewed):

Bergstrom, G.C., J.A. Cummings, K.D. Waxman, C.A. Bradley, A.L. Hazelrigg, D.E. Hershman, M. Nagelkirk, L.E. Sweets, and S.N. Wegulo. 2012. Effects of local corn debris management on FHB and DON levels in fourteen U.S. wheat environments in 2012. Pages 5-6 in S. Canty, A. Clark, A. Anderson-Scully, and D. Van Sanford (Eds.) Proc. 2012 National Fusarium Head Blight Forum, East Lansing MI/Lexington, KY: U.S. Wheat and Barley Scab Research Initiative.

Cummings, J.A., K.D. Waxman, and G.C. Bergstrom. 2012. Evaluation of integrated methods for managing FHB and DON in winter wheat in New York in 2011. Pages 13-15 in S. Canty, A. Clark, A. Anderson-Scully, and D. Van Sanford (Eds.) Proc. 2012 National Fusarium Head Blight Forum, East Lansing MI/Lexington, KY: U.S. Wheat and Barley Scab Research Initiative.

McMullen, M., G. Bergstrom, J. Cummings, C. Jochum, G. Yuen, B.H. Bleakley, N.K.S. Murthy, and K. Ruden. 2012. Uniform tests of biological control agents for management of FHB and DON in 2012. Page 21 in S. Canty, A. Clark, A. Anderson-Scully, and D. Van Sanford (Eds.) Proc. 2012 National Fusarium Head Blight Forum, East Lansing MI/Lexington, KY: U.S. Wheat and Barley Scab Research Initiative.

McMullen, M., A. Friskop, J. Jordahl, S. Meyer, G. Bergstrom, C.A. Bradley, R. Dill-Macky, M. Smith, J. Wiersma, S. Haley, A. Arens, G. Milus, K. Ruden, and B. Shatz. 2012. Uniform fungicide trial results for management of FHB and DON in 2012. Pages 19-20 in S. Canty, A. Clark, A. Anderson-Scully, and D. Van Sanford (Eds.) Proc. 2012 National Fusarium Head Blight Forum, East Lansing MI/Lexington, KY: U.S. Wheat and Barley Scab Research Initiative.

Spolti, P., E.M. Del Ponte, and G.C. Bergstrom. 2012. The 3-ADON and 15-ADON genotypes of *Fusarium graminearum* in New York are not discriminated by pathogenic or sexual reproductive fitness. Page 124 in S. Canty, A. Clark, A. Anderson-Scully, and D. Van

Sanford (Eds.) Proc. 2012 National Fusarium Head Blight Forum, East Lansing MI/Lexington, KY: U.S. Wheat and Barley Scab Research Initiative.

Willyerd, K., K. Ames, G. Bergstrom, C. Bradley, J. Cummings, P. Gross, R. Dill-Macky, P. Gross, L. Madden, J. Ransom, K. Ruden, J.D. Salgado, L. Sweets, K. Wise, and P. Paul. 2012. Uniform FHB integrated management trials: A summary from 2012. Pages 29-33 in S. Canty, A. Clark, A. Anderson-Scully, and D. Van Sanford (Eds.) Proc. 2012 National Fusarium Head Blight Forum, East Lansing MI/Lexington, KY: U.S. Wheat and Barley Scab Research Initiative.

Cummings, J.A., G.C. Bergstrom, R.J. Richtmyer III, and R.R. Hahn. 2013. Evaluation of foliar fungicides for control of Fusarium head blight and foliar diseases of winter wheat in New York, 2012. Plant Disease Management Reports 7:CF009.

Cummings, J.A., G.C. Bergstrom, R.J. Richtmyer III, and R.R. Hahn. 2013. Evaluation of Evaluation of a biological control agent for management of Fusarium head blight and foliar diseases of winter wheat in New York, 2012. Plant Disease Management Reports 7:CF010.

Cummings, J.A., G.C. Bergstrom, R.J. Richtmyer III, and R.R. Hahn. 2013. Evaluation of integrated methods for management of Fusarium head blight and foliar diseases of winter wheat in New York, 2012. Plant Disease Management Reports 7:CF011.

Invited research presentation by Gary C. Bergstrom:
4th Joint Meeting of the Alberta Society of Plant Pathology and the Saskatchewan Chapter of the Canadian Phytopathological Society. Lloydminster, Alberta, Canada. Keynote speaker. Explorations in Fusarium head blight: Epidemiology, management, and biological control. November 6, 2012.

Extension presentations by Gary C. Bergstrom in 2012-13 that included updates on Fusarium head blight research:
Ochs Consulting/Pioneer Grower Meeting, Trumansburg, NY. (3/7/13)

Ochs Consulting/Pioneer Grower Meeting, Penn Yan, NY. (3/6/13)

Jefferson County Pest Management Workshop, Watertown, NY. (3/5/13)

Finger Lakes Soybean and Small Grains Congress, Waterloo, NY. (2/7/13)

Western New York Soybean and Small Grains Congress, Batavia, NY. (2/6/13)

Oneida County Crop Congress, Clinton, NY. (1/11/13)

Cayuga County New and Re-occurring Pests in Corn, Wheat, and Soybeans Meeting. Auburn, NY. (1/9/13)

BASF/Oxbo Growers Meeting, Oxbo International Corp., Byron, NY. (1/8/13)

Capital District Improving Your Business With On-Farm Research Meeting, Century House, Latham, NY. (12/18/12)

Organic Small Grains Field Day, Freeville, NY. (7/12/12)

Seed Growers Field Day, Ithaca, NY. (7/3/12)

Small Grains Management Field Day, Cornell Musgrave Farm, Aurora, NY. (6/7/12)