USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY11 Final Performance Report
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Cover Page

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Fiscal Year:	FY11
USDA-ARS Agreement ID:	59-0206-9-056
USDA-ARS Agreement Title:	FHB Management Research in New York.
FY11 USDA-ARS Award Amount:	$ 45,403

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
MGMT	Effects of Local Corn Debris Management on FHB and DON Levels.	$ 29,854
MGMT	Integrating Multiple Management Strategies to Minimize Losses due of FHB and DON.	$ 10,471
MGMT	Uniform Fungicide/Biocontrol Studies in New York.	$ 5,078
	Total ARS Award Amount	**$ 45,403**

Gary C. Bergstrom   7/8/2012
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 Soft Winter Wheat Region
SWW – Southern Soft Red Winter Wheat Region

Project 1: *Effects of Local Corn Debris Management on FHB and DON Levels.*

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. The goal of this 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 in 2010, 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 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. There is a strong trend in year one 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.

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 year one 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 in agricultural-scale strip plots, yet there were small, but significant decreases in toxin in moldboard-plowed compared to no-till strips in two environments (MI and NE).

Impact:

Based on year one data, it appears that localized corn debris management prior to wheat planting results, on average, in fairly 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. A second 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 should be noted, however, that while DON analysis has not yet been conducted on the 2012 samples, FHB occurred at very low levels across the Midwest and Northeast in 2012 due to extraordinarily warm and dry conditions through flowering and grain filling. A third year of research to increase the opportunity to encounter more normal and disease-conducive weather patterns may be needed to derive a realistic quantitative answer to the question being addressed.

Project 2: *Integrating Multiple Management Strategies to Minimize Losses due of FHB and DON.*

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 2011, we observed the disease and yield impact of cultivar susceptibility, inoculation with *Fusarium graminearum*, and treatment with Prosaro in two experimental environments. All 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 25R47' (susceptible to FHB), 'SW 80' (susceptible 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 October 13, 2010, 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 replicate blocks.

The average incidence of FHB in the experiment following corn was 7% in non-inoculated plots, 15% in inoculated plots, and 11% overall. The average incidence of FHB in the experiment following soybean was 3% in non-inoculated plots, 11% in inoculated plots, and 7% overall. This suggests that the corn residue provided a slightly more favorable environment and/or higher background inoculum for FHB development. This pattern was observed also for FHB index and DON contamination. The DON contamination exceeded the 2 ppm threshold for sale at flour mills more frequently in the experiment following corn but only in the non-sprayed, inoculated plots. DON concentrations exceeding the threshold occurred in Otsego, Pioneer 25R47, and SW 80 in the environment following corn and in SW 80 in the environment following soybean.

Significant differences in DON contamination between the treatments were observed with Pioneer 25R47, SW 80 and Otsego. DON contamination was significantly greater than all other plots in the non-sprayed, inoculated plots of SW 80 and Otsego following corn and all three cultivars following soybean. When compared to the non-sprayed, inoculated plots, either Prosaro application (with and without inoculation) significantly decreased DON contamination.

When results of all the cultivars were combined, the overall impact of the Prosaro applications varied between the two environments and mirrored the patterns observed when considering the cultivars separately. In the corn debris environment, both Prosaro applications (with and without inoculation) resulted in significantly lower FHB indices and DON concentrations compared to the either non-sprayed plots. In the soybean debris environment, both Prosaro applications resulted in significantly lower FHB indexes and

DON concentrations only when compared to the inoculated non-sprayed plots. While not statistically significant, plots treated with Prosaro were generally higher yielding.

When results of all the treatments were combined, the four cultivars demonstrated some differences in both disease responses and yield capabilities. Significantly greater FHB indices were observed in the susceptible cultivars (Pioneer 25R47 and SW 80) compared to the moderately resistant cultivars (Otsego and Truman) in the corn debris environment. Only Truman had statistically significantly lower levels of DON contamination in the corn debris environment. In the soybean debris environment, SW 80 was the only cultivar that had significantly higher FHB indices and DON concentrations. In summary, SW 80 demonstrated susceptibility in both environments, Pioneer 25R47 demonstrated susceptibility and Otsego demonstrated moderate resistance in the higher disease pressure environment (following corn), and Truman demonstrated moderate resistance in both environments. Although not always statistically significant, the FHB susceptible cultivars had higher yields than the moderately resistant varieties in both environments.

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 New York experiment in 2011 illustrated the importance of including an inoculated treatment in order to gain useful data on integrated management methods when the local experimental environment is only moderately favorable for FHB and DON development. Under the added disease pressure created by inoculation, FHB index and DON levels, in the absence of fungicide treatment, were extremely low only in Truman. Prosaro application at flowering caused significant reductions in FHB and DON in the three varieties showing susceptibility greater than Truman. The designation of Otsego as a moderately resistant variety appears justified in comparison to the susceptible variety SW 80. The New York experiment in 2011 further illustrates that crop sequence remains a factor in integrated management of FHB as FHB Index and DON levels in noninoculated plots were elevated in the wheat plots following corn in comparison to those following soybean.

Impact:

Integrated management is the most promising strategy for reducing DON, but when inoculum is prevalent and environment is conducive for disease, we will likely need varieties with DON levels at or below that of Truman, but with higher yield potential than Truman, to consistently produce grain at less than 2 ppm contamination with DON.

Project 3: *Uniform Fungicide/Biocontrol 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 25R39' sown at 2 bu/A following soybean harvest (no tillage) on 27 Sep 2010. For each experiment foliar treatments were arranged in randomized complete blocks with four replicates. The fungicide test included 10 fungicide treatments. The biological test with eight treatments featured Taegro (bacterium *Bacillus subtilis* var. *amyloliquefacians* strain FZB24 containing 5.0 x 10^{10} cfu/g, Novozymes Biologicals Inc.). Some Taegro treatments included chelated manganese (Mn, Pro-manganese 5 chelated manganese solution, Tetra Micronutrients), thought to enhance disease control of the bacterium. These products were compared to an industry standard fungicide, Prosaro, and some treatments included combinations or alternations with Prosaro. All treatments included the adjuvant Induce at 0.125% v/v. Treatments were applied on 20 May at Feekes growth stage (FGS) 9 (ligule of last leaf just visible), 31 May at Feekes growth stage (FGS) 10.5 (heading), 5 Jun at FGS 10.5.1 (begin anthesis), and 10 Jun (1 wk after anthesis began) depending on treatment, depending on the treatment. 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). Incidence and severity (percent of symptomatic spikelets on symptomatic heads) of FHB was rated on 27 Jun. Foliar diseases were rated on 30 Jun as percent disease severity on flag leaves (average rating for whole plot). 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.

Following a wet April and May, the flowering and grain filling period in June and July was drier than normal. The severity of leaf blotch caused by *Stagonospora nodorum* and/or *Septoria tritici* was reduced significantly by all the fungicide and biological treatments when compared to the respective non-treated check, although those including Prosaro always provided more significant control than the biocontrols alone. The fungicide treatments applied at FGS 10.5 and 10.5.1 provided greater control than those applied at FGS 9. There were no statistically significant differences in FHB incidence and FHB index between any of the treatments. Statistically significant lower levels of DON contamination were observed only in the fungicide treatments applied at FGS 10.5.1. Statistically significant lower levels of DON contamination were observed only in the solo triazole fungicide treatments (Caramba, Cogito, and Prosaro) applied at FGS 10.5.1. DON contamination levels of the FGS 10.5 strobilurin treatments (Stratego YLD, Quilt, and TwinLine) were not significantly different than the non-treated check. Within the uniform biological experiment, statistically significant lower levels of FHB incidence, FHB index, and DON contamination were observed only in the Prosaro treatments. The coupling of Prosaro with biocontrols did not enhance nor diminish the fungicide's ability to control FHB. The biocontrol treatments without Prosaro didn't control FHB but also didn't increase FHB. The addition of chelated Mn and application of Taegro approximately one week after flowering also did not improve FHB control nor increase disease. There were no significant differences in yield and test weight between any of the treatments.

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):
For the test in New York in 2011, statistically significant lower levels of DON contamination were observed only in the solo triazole fungicide treatments (Caramba, Cogito, and Prosaro) applied at FGS 10.5.1. DON contamination levels of the FGS 10.5 strobilurin & triazole treatments (Stratego YLD, Quilt, and TwinLine) were not significantly different than the non-treated check.

Impact (Uniform Fungicide):
The New York fungicide test in 2011 provides further evidence that solo triazole fungicides, rather than strobilurin plus triazole products, applied at flowering are necessary to significantly reduce levels of DON in harvested grain.

Accomplishment (Uniform Biocontrol):
The *Bacillus* biological control treatments did not result in significant incremental suppression of FHB or DON in the 2011 New York environment that was only mildly favorable for disease. More favorable results with *Bacillus* were seen in North Dakota and Missouri.

Impact (Uniform Biocontrol):
Bacillus biological control treatment is still considered a potential tool for organic production and for extended post-flowering protection of heads in conventional production. While the 2011 New York results were not promising, results from other states provided an incentive for further field testing in 2012.

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):

Willyerd, K. T., C. Li, L.V. Madden, C.A. Bradley, G.C. Bergstrom, L.E. Sweets, M. McMullen, J.K. Ransom, A. Grybauskas, L. Osborne, S.N. Wegulo, D.E. Hershman, K. Wise, W.W. Bockus, D. Groth, R. Dill-Macky, E. Milus, P.D. Esker, K.D. Waxman, E.A. Adee, S.E. Ebelhar, B.G. Young, and P.A. Paul, P. A. 2012. Efficacy and stability of integrating fungicide and cultivar resistance to manage Fusarium head blight and deoxynivalenol in wheat. *Plant Disease* 96:957-967.

Publications (non-peer reviewed):

Bergstrom, G.C. 2012. New insights on cereal debris management for the reduction of head blight and mycotoxins. Abstract 22.3, Page 39 in: Proceedings of the 7th International IPM Symposium, Memphis, TN [www.ipmcenters.com/ipmsymposium12]

Waxman, K.D., G.C. Bergstrom, R.J. Richtmyer III, and R.R. Hahn. 2012. Evaluation of foliar fungicides for control of Fusarium head blight of winter wheat in New York, 2011. Plant Disease Management Reports 6: CF009.

Waxman, K.D., G.C. Bergstrom, R.J. Richtmyer III, and R.R. Hahn. 2012. Evaluation of foliar fungicides for control of foliar diseases and Fusarium head blight of winter wheat in New York, 2011. Plant Disease Management Reports 6: CF007.

Waxman, K.D., G.C. Bergstrom, R.J. Richtmyer III, and R.R. Hahn. 2012. Evaluation of integrated methods for management of Fusarium head blight and foliar diseases of winter wheat in New York, 2011. Plant Disease Management Reports 6: CF010.

Waxman, K.D., G.C. Bergstrom, R.J. Richtmyer III, and R.R. Hahn. 2012. Evaluation of a biological control agent and an isoparaffin oil for management of Fusarium head blight of winter wheat in New York, 2011. Plant Disease Management Reports 6: CF008.

Bergstrom, G.C., K.D. Waxman, C.A. Bradley, A.L. Hazelrigg, D.E. Hershman, M. Nagelkirk, L.E. Sweets, and S.N. Wegulo. 2011. Effects of local corn debris management on FHB and DON levels in seven U.S. wheat environments in 2011. Page 125-126 in Proc. 2011 National Fusarium Head Blight Forum, Hyatt Regency St. Louis at the Arch, St. Louis, MO, Dec 4-6, 2011.

Bradley, C.A., E.A. Adee, S.A. Ebelhar, G.C. Bergstrom, R. Dill-Macky, J.J. Wiersma, A.P. Grybauskas, W.W. Kirk, M.P. McMullen, S. Halley, E.A. Milus, L.E. Osborne, K.R. Ruden, and K.A. Wise. 2011. Effects of triazole, strobilurin, and triazole & strobilurin fungicides on Fusarium head blight and associated mycotoxins. Pages 119-121 in Proc. 2011 National Fusarium Head Blight Forum, Hyatt Regency St. Louis at the Arch, St. Louis, MO, Dec 4-6, 2011.

Crane, J.M., D.M. Gibson, and G.C. Bergstrom. 2011. Ecology of *Bacillus amyloliquifaciens* on wheat florets in relation to biological control of FHB/DON. Page 131 in Proc. 2011 National Fusarium Head Blight Forum, Hyatt Regency St. Louis at the Arch, St. Louis, MO, Dec 4-6, 2011.

Halley, S., G. Yuen, C. Jochum, B.H. Bleakley, N.K.S. Murthy, K.R. Ruden, K.D. Waxman, G.C. Bergstrom, and L.E. Sweets. 2011. Uniform biological fungicide evaluations for control of Fusarium head blight and deoxynivalenol in wheat. Pages 140-141 in Proc. 2011 National Fusarium Head Blight Forum, Hyatt Regency St. Louis at the Arch, St. Louis, MO, Dec 4-6, 2011.

Waxman, K.D. and G.C. Bergstrom. 2011. Evaluation of integrated methods for managing FHB and DON in winter wheat in New York in 2011. Pages 154-158 in Proc. 2011 National Fusarium Head Blight Forum, Hyatt Regency St. Louis at the Arch, St. Louis, MO, Dec 4-6, 2011.

Willyerd, K., G. Bergstrom, C. Bradley, R. Dill-Macky, P. Gross, A. Grybauskas, S. Halley, D. Hershman, L. Madden, M. McMullen, G. Milus, L. Osborne, K. Ruden, J.D. Salgado, L. Sweets, S. Wegulo, K. Waxman, K. Wise, and P. Paul. 2011. Uniform integrated management trials: A 2011 update. Pages 161-166 in Proc. 2011 National Fusarium Head Blight Forum, Hyatt Regency St. Louis at the Arch, St. Louis, MO, Dec 4-6, 2011.

Bergstrom, G.C., and K.D. Waxman. 2011. Flowering time application of triazole fungicides reduce vomitoxin levels in wheat. *What's Cropping Up?* Volume 21, No. 3:14-15. [www.fieldcrops.org]

Extension presentations by Gary C. Bergstrom in 2011-12 that included updates on Fusarium head blight research:

7th International IPM Symposium, Memphis, TN. Symposium on "Success in integrated management of wheat in the U.S." (3/27/12)

Cayuga County Grain Day, Auburn, NY. (3/16/12)

Great Lakes Wheat Workers Meeting, Ridgetown College of University of Guelph, Chatham, Ontario, Canada. (3/13/12)

Small Grains Seed Committee, New York Seed Improvement Cooperative, Geneva, NY (3/8/12)

Crop Protection Meeting, Lafayette, NY (3/2/12)

Southern Tier Field Crops Meeting, Horseheads, NY (2/28/12)

Finger Lakes Soybean and Small Grains Congress, Waterloo, NY. (2/9/12)

Western New York Soybean and Small Grains Congress, Batavia, NY. (2/8/12)

Madison County Crop Congress, Cazenovia, NY (1/11/12)

Carolina Eastern Crocker LLC Invitational Grower Meeting, Mt Morris, NY. (1/31/12)

Northeast Certified Crop Advisors Conference, Syracuse, NY. (11/29/11)

Field Crop Dealer Meeting, Live in Geneva, NY and Webinar Broadcast in Auburn, Batavia, Ellicottville, Oriskany, Plattsburgh, Voorheeseville and Watertown, NY. New insights on the epidemiology and management of wheat scab. (11/21/11)

Mid-Atlantic Crop School, Ocean City, MD. New insights on wheat scab: How much are mycotoxin levels reduced by cultural practices? (11/15/11)

2011 Agriculture and Food Systems Cornell Cooperative Extension In-Service, Ithaca, NY. (11/16/11)

Advanced Wheat Seminar, Batavia, NY. (9/8/11)

Agricultural Research Field Tour (including FHB research) for Cornell President David Skorton and Provost Kent Fuchs, Ithaca. (7/22/11)

Seed Growers Field Day, Ithaca, NY. (7/7/11)

Farming for Success Field Day, Penn State University Southeastern Agricultural Research and Extension Center, Manheim, PA. (6/30/11)

Small Grains Management Field Day, Aurora, NY. (6/2/11)