USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY13 Final Performance Report
July 15, 2014

Cover Page

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Fiscal Year:	FY13
USDA-ARS Agreement ID:	59-0206-9-056
USDA-ARS Agreement Title:	FHB Management Research in New York.
FY13 USDA-ARS Award Amount:	$ 15,487

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
MGMT	Uniform Fungicide and Biological Control Studies in New York.	$ 5,068
MGMT	Integrating Multiple Management Strategies to Minimize Losses Due to FHB and DON in New York.	$ 10,419
	FY13 Total ARS Award Amount	**$ 15,487**

Gary C. Bergstrom July 6, 2014
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: *Uniform Fungicide and Biological 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 25R34' sown at 2 bu/A following soybean harvest (no tillage) on 26 Sep 2012. 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 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 20 May at Feekes growth stage (FGS) 9 (ligule of last leaf just visible), 31 May at FGS 10.5 (heading), and/or 6 Jun at 6 days after the first application depending on treatment. Treatments for the uniform biological control trial were applied on 31 May at Feekes growth stage (FGS) 10.5.1 (anthesis), and 6 Jun at six days after the first application. All plots were inoculated with a conidial suspension of *Fusarium graminearum* (40,000 conidia/ml) on 31 May and again on 6 Jun 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. Incidence and severity of FHB were rated on 7 Jun. Foliar diseases were rated on 26 Jun and 2 Jul as percent disease severity on flag leaves (average rating for whole plot). Grain was harvested on 16 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.

All treatments in the fungicide test resulted in significantly lower severity of powdery mildew and fungal leaf blotches on flag leaves than the non-treated control. All treatments significantly reduced FHB incidence and index compared to the non-treated control. Application of Prosaro® or Caramba® at flowering significantly reduced FHB and DON. Late application of Caramba significantly reduced both FHB and DON, whereas late application of Prosaro reduced FHB but not DON. Application of Tebucon alone or in combination with Thymol at flowering significantly reduced both FHB and DON, but not as well as Prosaro or Caramba. Combining Caramba and Tebucon resulted in no significant increase in control of FHB or DON than application of either product alone. Applications of

Priaxor or Twinline early, followed by Caramba did not enhance the control of FHB or DON. A later infection period after flowering may lend some advantage to later fungicide applications. None of the fungicide applications had a significant effect on yield, or test weight, which ranged from 58 to 59 pounds, nor in percent Fusarium damaged kernels (FDK), which ranged from 1.8 to 5.3%.

All treatments in the biocontrol experiment also resulted in significantly lower severity of powdery mildew and fungal leaf blotches on flag leaves than the non-treated control, with the exception of the late application of Taegro with canola oil and nitrogen. Overall, treatments that included Prosaro resulted in the best control of foliar diseases, and treatments including Tebucon resulted in better control of foliar diseases than any biocontrol alone treatments. FHB developed in all plots at moderately low levels, with significant differences among treatments for FHB incidence and FHB index. Prosaro application at flowering resulted in significant reductions in FHB incidence and index, however only resulted in modest reductions of FDK and DON which may be attributed to later infection after the fungicide applications. Though it did result in significant reductions of FHB incidence and index, Tebucon application did not reduce FDK or DON. The combining of Prosaro or Tebucon with any of the biocontrols neither enhanced nor diminished the fungicide's ability to suppress FHB, FDK, or DON. Taegro applications not combined with either fungicide resulted in no significant reduction of FDK or DON. Only treatments including Prosaro resulted in significantly lower FDK than the non-treated control. There were no statistically significant differences in DON or yield among any of the treatments. Only treatments including Prosaro and the treatment with Tebucon at flowering followed by Taegro resulted in higher test weights than the non-treated control.

2. List the most important accomplishments and their impact (i.e. how are they 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):

Application of Prosaro or Caramba at flowering significantly reduced FHB and DON. Late application of Caramba significantly reduced both FHB and DON, whereas late application of Prosaro reduced FHB but not DON. Application of Tebucon alone or in combination with Thymol at flowering significantly reduced both FHB and DON, but not as well as Prosaro or Caramba. Combining Caramba and Tebucon resulted in no significant increase in control of FHB or DON than application of either product alone. Applications of Priaxor or Twinline early, followed by Caramba did not enhance the control of FHB or DON. A later infection

Impact (Uniform Fungicide):

Caramba and Prosaro applied at flowering remain the most efficacious treatments for suppression of FHB and DON and should continue to be recommended in integrated management programs.

Accomplishment (Uniform Biocontrol):
Taegro applications not combined with fungicide resulted in no significant reduction of FDK or DON.

Impact (Uniform Biocontrol):
Taegro application under current formulation and application methods does not appear to provide dependable suppression of FDK and DON and should not be recommended for this use.

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 2013, 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' (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 plots, both planted on October 10, 2012, 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 plot with four wheat cultivars as whole plots and inoculation or fungicide application treatments as subplots 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 6/1/13 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 an Almaco plot combine on 7/16/13. Grain moistures, plot yields, and test weights were recorded with the latter two adjusted for moisture at 13.5%. Analysis of DON content in grain was conducted in the USWBSI-supported mycotoxin laboratory of Dr. Dong. Means were calculated and subjected to Analysis of Variance. Fisher's protected LSD was calculated at P=0.05.

The incidence of FHB over all plots in the two experiments ranged from 6 to 35%. The impact of supplemental inoculation with *F. graminearum* was determined by comparing the non-inoculated and inoculated treatments (combining non-sprayed and Prosaro treatments). Inoculation did not significantly affect yield, FHB index, or DON, regardless of treatment or variety in the corn stubble environment, but had a modest effect on FHB incidence for the treatment means in the soybean stubble environment. There were no significant differences in cultivar response to inoculation for FHB index between the two environments. FHB and DON in 2013 are attributed primarily to natural rather than supplemental inoculum.

Under moderately low disease pressure, significant differences were detected in yield potential among the varieties with Pioneer 25R46 consistently yielding highest and Truman yielding lowest. Yield for each cultivar was significantly higher following soybean than following corn. This may be attributable to decreased FHB as well increased nitrogen following soybean.

When results of all the cultivars were combined, the overall impact of the Prosaro applications in both environments was to significantly decrease FHB incidence, index, DON, and foliar diseases, and to significantly increase yield and test weight. Prosaro application significantly reduced FDK only in the corn stubble environment where the disease pressure was highest.

All measures of Fusarium head blight were higher in the presence of corn stubble suggesting a dramatic within-plot increase in available spore inoculum from corn debris. The most striking observation was the average 7-8 fold increase in DON contamination levels in grain where wheat followed no-till after corn as compared to soybean. On the other hand, artificial inoculation at flowering with conidial suspensions had almost no significant effect on FHB parameters following either corn or soybean. The fairly late development of FHB symptoms is consistent with infections occurring during moist conditions after peak flowering and for which spores from within-plot corn debris may have contributed a greater portion than sprayed conidia or regional atmospheric inoculum. Otsego, regarded initially as moderately resistant to FHB, was significantly more susceptible than the other cultivars, thus should be designated as no better than moderately susceptible. Pioneer 25R46 showed reduced levels of FHB and DON and should probably be designated as moderately resistant along with the moderately resistant check cultivar Truman.

2. List the most important accomplishments and their impact (i.e. how are they 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 two New York environments yielded valuable differential results in 2013 with the experiment following soybean having low-moderate FHB and DON levels and the experiment in corn stubble having high FHB and DON levels. It appeared that most symptoms and toxin contamination resulted from infections following peak flowering.

Impact:

The overall impact of the Prosaro applications in both environments was to significantly decrease FHB incidence, index, DON, and foliar diseases, and to significantly increase yield and test weight. Prosaro application significantly reduced FDK only in the corn stubble environment where the disease pressure was highest. The 2013 results solidified resistance designations for some leading varieties in New York. Otsego, regarded initially as moderately resistant to FHB, was significantly more susceptible than the other cultivars, thus should be designated as no better than moderately susceptible. Pioneer 25R46 showed reduced levels of FHB and DON and should probably be designated as moderately resistant along with the moderately resistant check cultivar Truman.

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 FY13 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., M.E. Frodyma, and G.C. Bergstrom. 2014. Nutrient-induced spore germination of a *Bacillus* biocontrol agent on wheat spikes. *J. Applied Microbiology*. doi:10.1111/jam.12480.

Nelson BA, Ramaiya P, Lopez de Leon A, Kumar R, Crinklaw A, Jolkovsky E, Crane JM, Bergstrom GC, Rey MW. 2014. Complete genome sequence for the *Fusarium* head blight antagonist *Bacillus amyloliquefaciens* strain TrigoCor 1448. Genome Announc. 2(2):e00219-14. doi:10.1128/genomeA.00219-14.

Spolti, Pierri, Emerson M. Del Ponte, Jaime A. Cummings, Yanhong Dong, and Gary C. Bergstrom. 2014. Fitness attributes of *Fusarium graminearum* isolates from wheat in New York possessing a 3-ADON or 15-ADON trichothecene genotype. *Phytopathology* 104: 513-519.

Spolti, Pierri, Emerson M. Del Ponte, Yanhong Dong, Jaime A. Cummings, and Gary C. Bergstrom. 2014. Assessment of triazole sensitivity in a contemporary population of *Fusarium graminearum* from New York wheat fields and competitiveness of a tebuconazole-resistant isolate. *Plant Disease* 98: 607-613.

Keller, M.D., G.C. Bergstrom, and E.J. Shields. 2013. The aerobiology of *Fusarium graminearum*. *Aerobiologia* DOI 10.1007/s10453-013-9321-3.

Publications (non-peer reviewed):

Bergstrom, Gary C. 2013. Local corn debris management: What does it contribute to head blight and mycotoxin reduction? Page 94 in S. Canty, A. Clark, Y. Salat, and D. Van Sanford (Eds.) Proc. 2013 National Fusarium Head Blight Forum, East Lansing MI/Lexington, KY: U.S. Wheat and Barley Scab Research Initiative.

Bergstrom, G.C., J.A. Cummings, K.D. Waxman, C.A. Bradley, S.N. Wegulo, A.L. Hazelrigg, D.E. Hershman, M. Nagelkirk, and L.E. Sweets. Effects of local corn debris management on FHB and DON levels in seventeen U.S. wheat environments in 2011-2013. Pages 92-93 in S. Canty, A. Clark, Y. Salat, and D. Van Sanford (Eds.) Proc. 2013 National Fusarium Head Blight Forum, East Lansing MI/Lexington, KY: U.S. Wheat and Barley Scab Research Initiative.

Bleakley, B.H., N.K.S. Murthy, E. Byamukama, G. Redenius, K. Ruden, G.C. Bergstrom, J. Cummings, G.Y. Yuen, and C. Jochum. 2013. Uniform tests of biological control agents for management of FHB and DON, 2013. Pages 97-98 in S. Canty, A. Clark, Y. Salat, and D. Van Sanford (Eds.) Proc. 2013 National Fusarium Head Blight Forum, East Lansing MI/Lexington, KY: U.S. Wheat and Barley Scab Research Initiative.

Cummings, J.A., and G.C. Bergstrom. 2013. Evaluation of integrated methods for managing FHB and DON in winter wheat in New York in 2013. Pages 100-103 in S. Canty, A. Clark, Y. Salat, and D. Van Sanford (Eds.) Proc. 2013 National Fusarium Head Blight Forum, East Lansing MI/Lexington, KY: U.S. Wheat and Barley Scab Research Initiative.

Kuhnem, P.R., E.M. Del Ponte, and G.C. Bergstrom. 2013. Frequencies of 3-ADON and 15-ADON *Fusarium graminearum* from corn stubble, atmosphere, and wheat heads in three agricultural regions in New York in 2013. Page 57 in S. Canty, A. Clark, Y. Salat, and D. Van Sanford (Eds.) Proc. 2013 National Fusarium Head Blight Forum, East Lansing MI/Lexington, KY: U.S. Wheat and Barley Scab Research Initiative.

Paul, P.A., G. Bergstrom, C. Bradley, E. Byamukama, J.A. Cummings, A. Grybauskas, L. Madden, G. Milus, K. Ruden, J.D. Salgado, L. Sweets, S. Wegulo, and K. Wise. 2013. FHB integrated management: A 2013 update. Pages 110-11 in S. Canty, A. Clark, Y. Salat, and D. Van Sanford (Eds.) Proc. 2013 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:
Local corn debris management: What does it contribute to head blight and mycotoxin reduction? 2013 National Fusarium Head Blight Forum, Milwaukee, WI. December 2103.

Extension presentations by Gary C. Bergstrom in 2012-13 that included updates on Fusarium head blight research:

Delaware County Crops Meeting, Delhi, NY. (3/18/14)

Crop Protection Meeting, Orchard Vali Golf Club, Lafayette, NY.

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

Small Grains Meeting, Watertown, NY. (2/26/14)

Small Grains Day, Richfield Springs, NY. (2/18/14)

Finger Lakes Soybean and Small Grains Congress, Waterloo, NY. (2/6/14)

Western New York Soybean and Small Grains Congress, Batavia, NY. (2/5/14)

Southern Tier Crop Congress, Belfast, NY. (1/16/14)

Oneida County Crop Congress, Waterville, NY (1/7/14)

Organic Small Grains Field Day, Freeville, NY. (7/12/13)

Hudson Valley Grains Day, Red Hook, NY. (6/24/13)

Small Grains Twilight Meeting, Hilton, NY. (6/20/13)

Small Grains Management Field Day, Cornell Musgrave Farm, Aurora, NY. (6/6/13)