USDA-ARS/
U.S. Wheat and Barley Scab Initiative
FY10 Final Performance Report
July 15, 2011

Cover Page

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Fiscal Year:	FY10
USDA-ARS Agreement ID:	59-0206-9-086
USDA-ARS Agreement Title:	Discovering, Understanding, and Utilizing Wheat Genes for FHB Resistance in Ohio.
FY10 USDA-ARS Award Amount:	$ 126,830

USWBSI Individual Project(s)

USWBSI Research Category*	**Project Title**	**ARS Award Amount**
VDHR-NWW	Breeding FHB Resistant Wheat for Ohio.	$ 59,512
VDHR-NWW	Coordinated Evaluation and Utilization of Marker Assisted Selection.	$ 12,375
VDHR-NWW	Development and Distribution of Male Sterile Facilitated Recurrent Selection Populations.	$ 5,187
VDHR-NWW	Improved Breeding for FHB Resistance by Advanced Genetic and Phenotypic Characterization of Soft Winter Wheat.	$ 30,244
VDHR-NWW	Coordinated Evaluation of FHB Resistance of Advanced Soft Winter Lines and Cultivars.	$ 19,512
	Total ARS Award Amount	**$ 126,830**

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: *Breeding FHB Resistant Wheat for Ohio.*

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

Host resistance is vital to controlling FHB. High levels of resistance are not difficult to obtain, but combing such levels with high yield can be quite difficult. We are fortunate to have high levels of native resistance for FHB in soft winter wheat. This allows us to effectively use phenotypic selection for FHB and to complement that with MAS for select QTL, mostly from exotic sources.

The OSU program strives to phenotype as many breeding lines as possible each year in a misted and inoculated nursery. In addition we are spray inoculating 8,000 head rows each year to select against susceptibility. These lines are all derived from crosses where at least one parent has good FHB resistance. All of our variety development crosses now involve at least one parent with strong FHB resistance.

We have been using MAS to backcross Fhb1, 5AS, and 2D QTL into elite lines that already have moderate FHB resistance. These lines could be released directly as new cultivars or used quickly as parents.

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:

In the 2010 season we rated FHB in a misted and inoculated FHB nursery on 69 elite lines (eg OSU lines that have gone through 2 or more years of yield testing) and 1254 lines from earlier stages of testing. Nearly 15% were ≤ Truman of the elite lines were numerically ≤ to Truman for index, while nearly 50% were ≤ Freedom (Fig 1): a much higher percentage were similar to Freedom. These percentages were a bit lower when we evaluated newer germplasm that has had very little or no previous selection in an FHB nursery. This material has virtually no exotic germplasm in its pedigree. In addition we spray inoculated 8,000 F3:4 or F4:5 head rows and selected for FHB resistance.

We are having some success with combining yield with FHB resistance. Based on 2009 and 2010 data, we have 13 lines with yield ≥ that of Pioneer 25R47 and the average FHB Index of these lines was 3% > than that of Freedom (Fig 2). The best line yielded 9 bu/ac > Pioneer 25R47 and had a FHB index 6% lower than that of freedom.

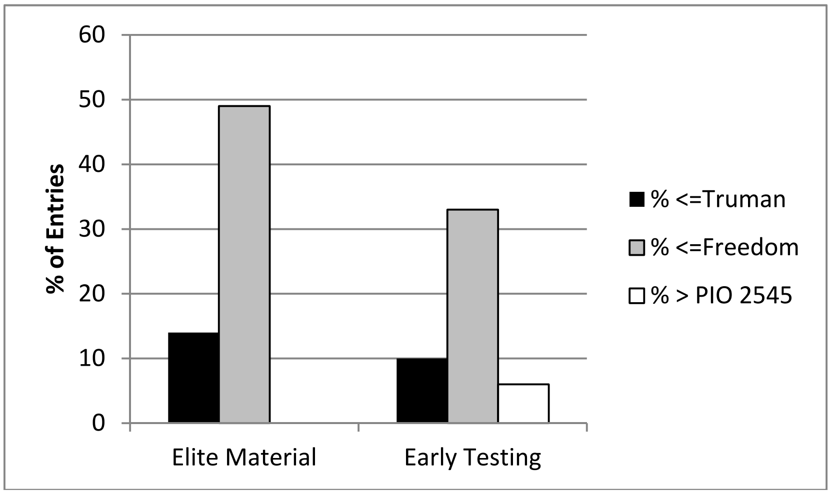

Figure 1. Percentage of OSU breeding lines with FHB index ≤ to that of Truman or Freedom.

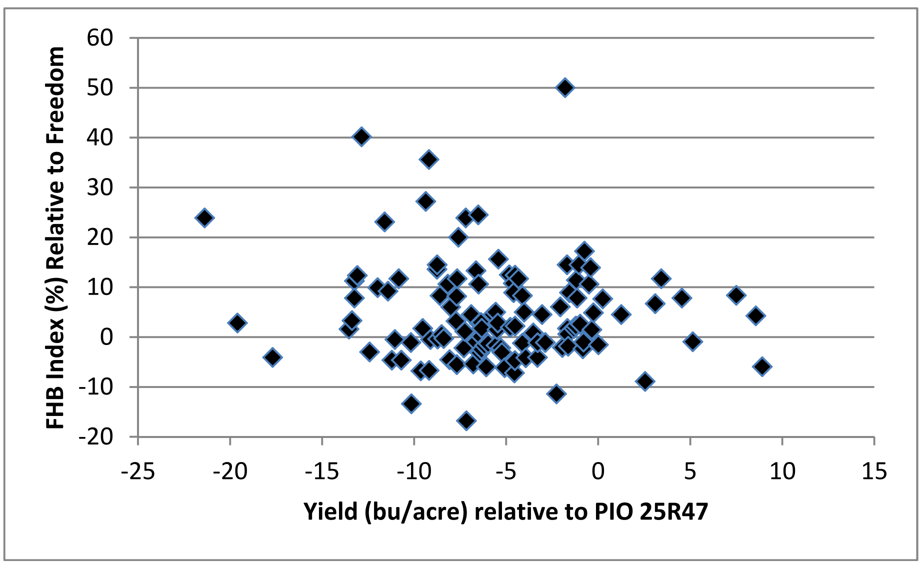

Figure 2. Relative yield and FHB index of 123 OSU breeding lines.

Our recent public release, 'Malabar', performed well in the 2010 Ohio OVT. It was second best for FHB index, and was ranked 13th (out of 52) with a yield of 76 bu/ac whereas the top lines yielded 79 bu/acre. Ample seed of Malabar will be available in the fall of 2011.

We continue to backcross Fhb1 and other QTL into lines with moderate FHB resistance from native sources. So far the results from field trials have been good with Fhb1 lines having significantly less FHB index and DON than their non-Fhb1 counterparts (Fig. 3). We are now increasing seed of some of these and are using them in biparental crosses with one another: in such crosses we do not need to use MAS for these genes

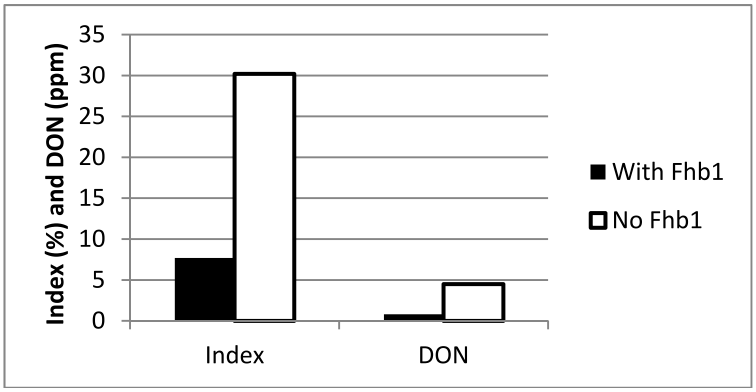

Figure 3. FHB Index and DON of two isolines with and without Fhb1. In this test Truman had an index of 12% and DON of 5.8 ppm, Freedom had an index of 21% and 5.3 ppm DON and Pioneer 2545 had an index of 75%.

Impact:

The ability to screen many lines for FHB resistance and the high frequency of lines with good FHB resistance is an excellent resource for developing high-yielding lines with FHB resistance. The combination of high yield and excellent FHB remains rare due the low frequency of excellent yield. This requires the extensive phenotyping that we perform annually. The program is paying off with the release of Malabar. Another release, Bromfield, is being increased and performed very well in 2011 for FHB (Yield data being compiled. Other germplasm looks very promising. Crosses among parents with FHB1 are advancing and should increase the prevalence of lines with Truman-like FHB (versus Freedom-like levels).

Project 2: *Coordinated Evaluation and Utilization of Marker Assisted Selection.*

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

Promising QTL for FHB resistance have been indentified, generally in crosses of resistant exotic line with susceptible adapted lines. We need to determine though the value of these QTL in soft winter wheat lines that already have good levels of native resistance. In addition, we must know the impact of these QTLs on other traits. Anecdotally, some breeders believe that the presence of Fhb1 decreases yield and quality, though published reports suggest there is little if any yield drag from Fhb1. The impact of Fhb1 and other QTL on yield needs to be determined.

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 OSU program contributed germplasm and phenotyping to this project. The OSU program contributed four pairs of related lines that differed for the presence/absence of Fhb1. The entire test consisted of 70 entries. We added several local checks and tested all entries in a two rep test in a misted inoculated nursery. Disease pressure was moderate. Initially, incidence was low so to increase sampling (and reduce error) we evaluate index only by visually assessing three regions of each plot. Grain was harvested from each plot and will be assessed for FDK and DON.

Impact:

Collectively, this project will determine the positives and negatives associated with using MAS for these QTL. It will determine their impact on multiple FHB traits as well as yield and quality.

Project 3: *Development and Distribution of Male Sterile Facilitated Recurrent Selection Populations.*

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

The cooperative male sterile facilitated recurrent selection populations were developed as a way to generate FHB resistant breeding lines and facilitate the combination of FHB resistant genes from different sources. Recurrent selection has the objective of increasing the frequency of desirable alleles for one or more traits while maintaining a high level of variability in the population. Intermating among selected parents each generation allows recombination to occur thus combining genes from different sources. Male sterility provides a mechanism to easily allow recombination among FHB resistance sources. The dominant male-sterile gene was utilized to create recurrent selection populations segregating for FHB resistance because the progenies of the male-sterile plants always segregate 1:1 for sterility and a generation of selfing is not required to obtain true-breeding fertile genotypes. Our objective was to create four populations with FHB resistance adapted to different regions of the eastern U.S. Seed from the sterile heads were planted, and their sterile offspring were tagged for harvest to repeat the process. These populations were developed over several seasons at the Ohio Agricultural Research and Development Center in Wooster, Ohio. Breeding programs in the eastern U.S. contributed FHB resistant lines to serve as pollinators. Sterile plants were selected; those highly susceptible to FHB were discarded.

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:

In 2009, male-sterile populations were grown in the field at Wooster, OH. From this, four populations were developed in 2009-2010:

1. The early maturity selections from the male-sterile population were planted with pollinator parents for a southern-mid-Atlantic soft red wheat population.
3. Two-thirds of the seed from the mid-maturity selections from the male-sterile population were planted with pollinator parents for an early Midwest soft red wheat population.
4. One-third of the seed from mid-maturity selections from the male-sterile population and some from the late selections were planted with pollinator parents for a late Midwest soft red wheat population.
5. Late maturity selections from the male-sterile population were planted with pollinator parents for a late soft winter wheat population, including white winter wheat genotypes.

In summer 2010, sterile heads were identified and tagged at four different maturity dates. Sterile heads that were very susceptible to *Fusarium graminearium* were removed on June 14 (early Midwest and mid-Atl.) and June 17 (late Midwest and white). After being harvested and threshed, *Fusarium* damaged kernels were removed by aspiration, removing approximately 50% of the kernels.

A bulk from each population was distributed to cooperating breeding programs in Fall 2010. Cooperating breeding programs have been provided information on procedures to assist them in utilizing the populations in their individual breeding programs, continuing cycles of mating and selection for FHB resistance within their target environments.

Impact:

Breeding programs in the eastern soft wheat region have male-sterile facilitated recurrent selections populations that can be used with local FHB resistant breeding lines as pollinators to further develop recurrent selection populations as a source of potential FHB resistant breeding lines with resistance from different sources.

Project 4: *Improved Breeding for FHB Resistance by Advanced Genetic and Phenotypic Characterization of Soft Winter Wheat.*

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

Host resistance is vital for controlling FHB. Soft winter wheat contains a high level of native resistance. There have been several efforts to map QTL associated with native resistance and for the most part these efforts have discovered a few QTL with modest effect despite ample phenotypic variation. While more mapping in bi-parental populations derived from elite parents may yet uncover QTL with greater impact, association analyses (AA) may uncover these QTL more efficiently as it evaluates alleles from many parents at one time.

Marker-assisted selection for individual genes is a useful strategy when QTL with large effects are present but is less effective when a trait is controlled by many genes with small effects. Genomic selection (GS) is a new approach to breeding that assigns value to whole genomes instead of individual genes and can hasten selection by reducing the number of years in a breeding cycle. It is possible that GS may be very useful for native FHB resistance in soft winter wheat if that resistance is controlled primarily by many genes of small effect.

This project will conduct both AA and GS in a broad population derived from soft winter wheat with the objective of 1) doing AA to assess the presence of QTL useful in MAS, and 2) establish the feasibility of GS for FHB resistance.

Soft winter wheat also seems to have considerable genetic variation for many types of resistance including resistance to infection and spread (type I and II). Variation for FDK and DON are also commonly seen and not all of that variation is account for by variation for type I and II resistance. This suggests variation for resistance to kernel infection and toxin accumulation (RKI, RTA). Phenotyping of large populations for many traits may allow us to determine the coincidence of QTL for all mechanism of resistance and more detailed investigation into variation for RKI and RTA.

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):

<u>Accomplishment:</u>
The study was first planted in the fall of 2010 and data collected in June of 2011. We have created a population of 749 soft winter wheat lines. This includes 700 RILs derived from 64 crosses and 69 parents as listed in their pedigrees. Several of the parents of the 700 lines have been used as parents in bi-parental mapping. The parentage is listed in Table 1. The other 49 lines consist of checks and some of the parents of the RILs. The 49 checks were phenotyped at 7 locations in June of 2011 and the each cooperator tested 100 of the RILs ate their location. Each cooperator was to collect data on severity, incidence, index, FDK and DON.

Table 1. Summary of the percentage of total parentage of 700 RILs based on provided pedigrees.

Source	% of Parentage	Source	% of Parentage
***MO11769/MADISON	14.19	***INW0412	1.07
IL00-8061	6.07	D9044-1	0.93
***NY91017-8080	4.29	MO001655	0.86
BRANSON	4.21	BW402	0.86
B980582	3.57	IL01-15511	0.86
IL00-8109	3.43	MO001409	0.79
IL96-6472	3.00	96214	0.71
M99-2408	3.00	INW0303	0.71
OH02-12686	2.93	INW0316	0.71
PIONEER 25W41	2.86	MO002049	0.71
D8006	2.71	MCCORMICK	0.61
KY93C-1238-17-1	2.57	IL79-002DH	0.57
IL96-3073	2.50	KY93C-17-1	0.57
KY97C-0519-04-05	2.50	IL99-15867	0.54
2754	2.14	TRIBUTE	0.50
***ERNIE	2.14	KY98C-1169-06	0.43
TRUMAN	2.14	VA98W-591	0.43
97397	1.79	KY97C-0232-2-2	0.43
97462	1.79	98134	0.36
OH02-3409	1.71	98134W	0.36
CECIL	1.64	IL99-12976	0.36
99751	1.43	MO000969	0.36
CALEDONIA	1.43	MO001164	0.36
***HARUS	1.43	MO981029	0.36
NY87048w-7388	1.43	OH708	0.29
NY88046-8138	1.43	79-008T-B-B	0.21
PIONEER 2737	1.43	IL00-8530	0.21
IL97-1828	1.39	IL01-11934	0.21
GOLDFIELD	1.36	IL01-36115	0.21
***ROANE	1.29	KY93C-0378-5-2	0.21
PIONEER 25R37	1.21	MO000119	0.14
MO960903	1.14	ALLIGIANCE	0.07

*** Indicates a parent used in bi-parental mapping
MO11769/Madison = Truman, Bess, MO980829, MO980725

Impact:
This project was initiated in 2010 and we are just now collecting data. If successful it may allow us to efficiently identify and pyramid QTL from native sources for multiple mechanisms of FHB resistance. In addition we may be able to initiate crossing programs for genomic selection to rapidly improve FHB resistance in soft winter wheat.

Project 5: *Coordinated Evaluation of FHB Resistance of Advanced Soft Winter Lines and Cultivars.*

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

   Host resistance is the foundation of controlling FHB and reducing DON. Phenotyping is crucial to developing new varieties. Unfortunately, obtaining good FHB data can be difficult and unreliable. Thus multi-environment testing is very useful in case one location fails to produce useful data.

   The breeders in eth NWW CP participate in several cooperative trials including two dedicated to FHB (NUWWSN, PNUWWSN) and several that focus on yield (5 State Preliminary (5STP), 5 State Advanced (5STA), Uniform Eastern (UE), Mason Dixon (MSDX), and Uniform Eastern White Wheat(UEWW). In addition each state conducts an official variety trial (OVT) that focus on the yield of commercial lines available to their growers.

   This project focuses on determining the FHB resistance of lines in those trials.

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):**

   <u>Accomplishment:</u>
   In the 2010 nurseries we evaluated the FHB resistance of 792 entries in 14 different tests (see Table 1) (note some genotypes were evaluated in more than on test so not all 792 entries were unique). Data the OVT from each state was posted on Scab Smart.

   The data from the NUWWSN and PNUWWSN was compiled, analyzed and summarized in the annual report that was presented at the 2010 Forum and pasted on the USWBSI website. Data from the other uniform trials was distributed to all cooperators through mechanisms associated with those trials.

Table 1. Summary of FHB testing of entries in the 2010 uniform trials.

	NUWWSN	PNUWWSN	UE	5STA	5STP	UEWW	MSDX	Seven OVTs (one per state)
# Locations	13	8	4	3	3	3	2	na
# Entries	60	51	46	25	25	25	85	475
# Traits	7	6	5	5	5	2	3	1-2
%Similar to most resistant checks	15	8	2	8	17	na	27	na
% Similar to susceptible check	7	6	na	na	na	na	26	na

na = not applicable (eg no such check was included, or not available

A principal component analyses was conducted on data from the P+NUWWSN, UE, and the 5ST trials where either Truman or Bess served as a resistant check. From 2-17% of the entries in those tests plot close to Truman or Bess (Table 1). Many other lines also had good FHB resistance as scored in one dimension or another. This percentage was greatest in the NUWWSN and the 5STP and lowest in the UE test.

Impact:
Many of the lines in these trials are candidates for release as new cultivars. The data provided by these cooperative Tests are vital to breeder's selecting and releasing new cultivars with good FHB resistance.

It appears that new cultivars combining acceptable yield and good FHB resistance are now available to grower in the NWW CP region. Getting grower's to select and grow wheat cultivars with good FHB resistance may be one of the greatest hurdles right now to controlling FHB. The data collected from the OVT is a crucial to grower's choosing resistant cultivars. Each state widely disseminates this information via extension websites, grower meetings, newsletters, media releases, and through grower organizations.

Include below a list of all germplasm or cultivars released with full or partial support of the USWBSI. List the release notice or publication. Briefly describe the level of FHB resistance.

No new releases in this period. Most recent releases
Malabar, public, similar to Truman
Bromfield, public, similar to Truman
OH04-264-58, exclusive license, a bit worse than Freedom

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.

Sneller, CH, M Guttieri, P Paul, G Broders, and R Jackwood. 2011. Variation for resistance to kernel infection and toxin accumulation in wheat lines infected with Fusarium graminearum. Phytopathology (accepted)

Sneller, C, P Paul, and M Guttieri. 2010. Characterization of resistance to Fusarium Head Blight in an Eastern US soft red winter wheat population. *Crop Science* 50:123-133.

Benson, J., G. Brown-Guedira, J. Holland, J.P. Murphy, and C. Sneller. 2010. ASSOCIATION ANALYSIS OF MARKERS FOR BREEDING SCAB RESISTANCE IN WINTER WHEAT [Abstract]. *Proceedings of the National Fusarium Head BlightForum; 2010 Dec 7-9; Milwaukee, WI. Lexington, KY: University of Kentucky*: University of Kentucky: 128-128. (Published)

C.H. Sneller, P. Paul, M. Guttieri, L. Herald and B. Sugerman. 2010. REPORT ON THE 2009-2010 NORTHERN UNIFORM WINTER WHEAT SCAB NURSERIES [Abstract]. *Proceedings of the National Fusarium Head BlightForum; 2010 Dec 7-9; Milwaukee, WI. Lexington, KY: University of Kentucky*: University of Kentucky: 167-167. (Published)

J. Shoots, M. Guttieri, F. Kolb, J. Lewis, A. McKendry, H. Ohm, C. Sneller, M.E. Sorrells, E. Souza, D. Van Sanford, J. Costa,C. Griffey, S. Harrison, J. Johnson and P. Murphy. 2010. DEVELOPMENT AND DISTRIBUTION OF MALE-STERILE FACILITATED RECURRENT SELECTION POPULATIONS [Abstract]. *Proceedings of the National Fusarium Head BlightForum; 2010 Dec 7-9; Milwaukee, WI. Lexington, KY: University of Kentucky*: University of Kentucky: 165-165. (Published)