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

Cover Page

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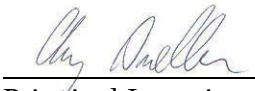
Fiscal Year:	FY12
USDA-ARS Agreement ID:	59-0206-9-086
USDA-ARS Agreement Title:	Discovering, Understanding, and Utilizing Wheat Genes for FHB Resistance in Ohio.
FY12 USDA-ARS Award Amount:	$ 95,359*

USWBSI Individual Project(s)

USWBSI Research Category**	Project Title	ARS Award Amount
VDHR-NWW	Discovering, Understanding, and Utilizing Wheat Genes for FHB Resistance in Ohio.	$ 60,606
VDHR-NWW	Coordinated Evaluation of FHB Resistance of Advanced Soft Winter Wheat Lines and Cultivars.	$ 18,031
VDHR-NWW	Improved Breeding for FHB Resistance by Advanced Genetic and Phenotypic Characterization of Soft Winter Wheat.	$ 13,994
VDHR-NWW	Coordinated Evaluation and Utilization of Marker Assisted Selection.	$ 2,046
VDHR-NWW	Male Sterile Facilitated Recurrent Selection for FHB Resistance (MPI-5).	$ 682
	Total ARS Award Amount	**$ 95,359**



7/16/13

Principal Investigator Date

* Partial funding for this research is under ARS agreement # 59-0206-9-071

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Project 1: *Discovering, Understanding, and Utilizing Wheat Genes for FHB Resistance in 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 is 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.

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 (1):

   The OSU program has obtained a high percentage of lines with acceptable FHB resistance ("acceptable" = FHB Index $\leq$ that of Freedom, the MR check). In the 2012-13 screening of 877 lines in the first year of screening (Fig1. SPN(YR)), 72% of all entries had an FHB index $\leq$ that of Freedom, while 8% had an index $\leq$ that of Truman. This was achieved with little prior selection. This level of resistance is comparable to the level found among lines on the test of commercial lines available in OH (Fig 1. Commercial) and lines in the uniform trials (Fig 1. Uniform). Nearly 90% of the lines in our most advanced trial (ESPN, YR4+) had acceptable FHB index values.

   Impact:

   The high level of FHB resistance in the OSU populations greatly improves the probability of finding lines with acceptable FHB and high yield.

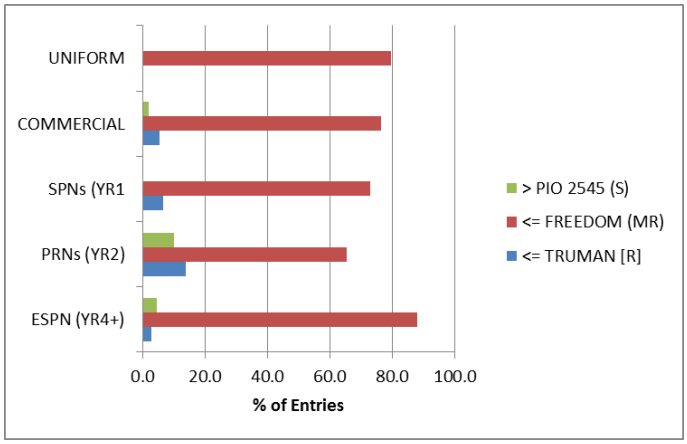

Figure 1. Percentage of entries in different OSU tests that had an FHB index ≤ that of Truman (R check), Freedom (MR check) or and index ≥Pioneer 2545 (S check)

Accomplishment (2):

We are attaining the desired combination of high yield and FHB resistance. In our 2011-2012 test of our most advanced lines, six of seven OSU breeding lines had better yield than Pioneer 25R47 and lower Index than Freedom (Fig 2.). All seven were superior in yield to Branson and the last two OSU releases (Bromfield, Malabar).

Impact:

Seed of four of the most advanced breeding lines is being increased for possible release, pending performance in the 2012-2013 tests. If their performance holds then all four could be released within the next 6-12 months.

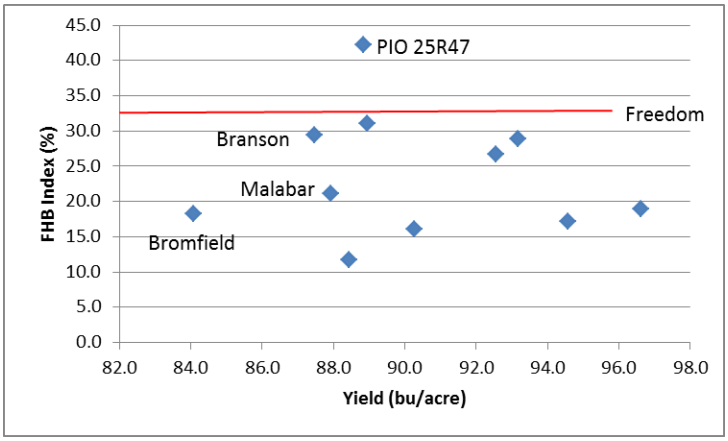

Figure 2. Yield (5 OH environments) and FHB index (from inoculated nursery) of the most advanced breeding lines in the OSU program and selected checks (named in graph).

Project 2: *Coordinated Evaluation of FHB Resistance of Advanced Soft Winter Wheat 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 remains the foundation of controlling FHB and DON. Despite increased use of MAS, phenotyping remains the primary tool to improve host resistance. Phenotyping is difficult and ideally is conducted over multiple environments to provide robust estimates of resistance.

   The phenotyping is even more crucial to growers who need unbiased estimates of host resistance. This project pools all phenotyping of uniform nurseries and state official variety tests into one project. The results are distributed to all breeders and is available to all growers via extension activities and Scab Smart

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:

   We received FHB data (incidence, severity, index, FDK, DON, heading date, height) from all cooperators in the 2011-2012 P+NUWWSN tests. We have compiled a final report on both tests, distributed it to all cooperators, posted on the USWBSI website and included a summary in the 2012 Forum Proceedings. We formed the 2012-2013 tests, packaged all seed, and sent it to all cooperators.

   In addition, all cooperators screened entries in their state's Official Variety Trials as well as several uniform yield tests of breeding lines. Their data was distributed to growers through each state's extension service and through Scab Smart.

   In the 2012 PNUWWSN test, 92% of the entries had a lower FHB index than the moderate resistant check (Freedom) while 42% had a lower index value than the most resistant check (Truman). In the 2012 NUWWSN test, 90% of the entries had a lower FHB index than the moderate resistant check while 23% had a lower index value than the most resistant check.

   Impact:

   These accomplishments have far ranging impacts. Each breeder receives robust estimates of the reaction of their lines to FHB. This includes breeders from private companies that participate in the uniform trials. Much of the germplasm that will be marketed to growers in the NWW-CP region in the next 5 years was evaluated in these tests. In addition the growers are provided unbiased estimate of the FHB resistance of currently available cultivars. This information is vital to reducing FHB as the growers must select and grow lines with FHB resistance for our work to have impact

Project 3: *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 (1):</u>

   We have analyzed all data from the 2010-11, 2011-12 trials and some of the 2012-13 data. There is a wide range of phenotypic data for all FHB traits. There was significant variation within and between crosses (Fig 3.) for all traits. Several projects will cross among the best lines during the 2013-14 greenhouse season.

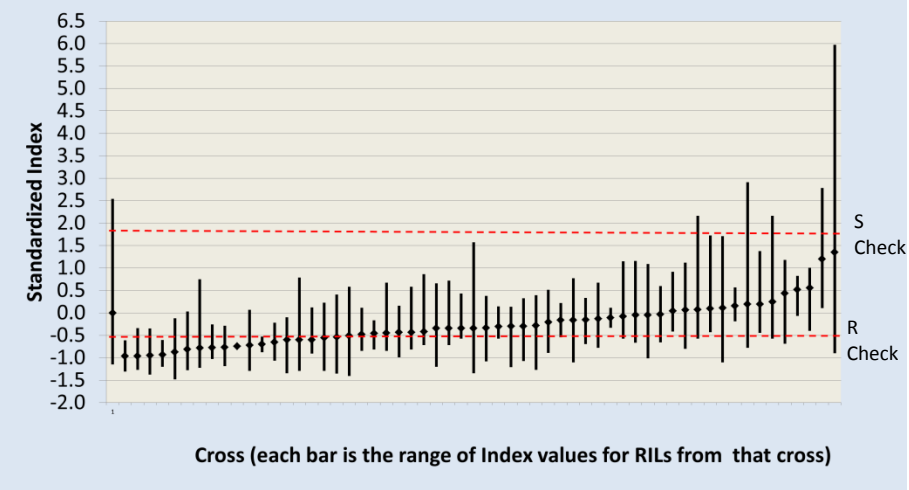

Figure 3. Range and average (diamond) index value of checks (first set of values) and 58 crosses where Index data was collected

Impact:

The variation makes this population very well suited for our association Analysis and Genomic Selection objectives. The population will form the foundation of a new proposal to implement GS for the FHB.

Accomplishment (2):

We have analyzed the population for evidence of resistance to toxin accumulation (RTA) and kernel infection (RKI). We found that some lines repeatedly had lower DON levels than expected based on the level of kernel infection (assessed via qPCR). This shows that there is genetic variation for RTA in soft winter wheat.

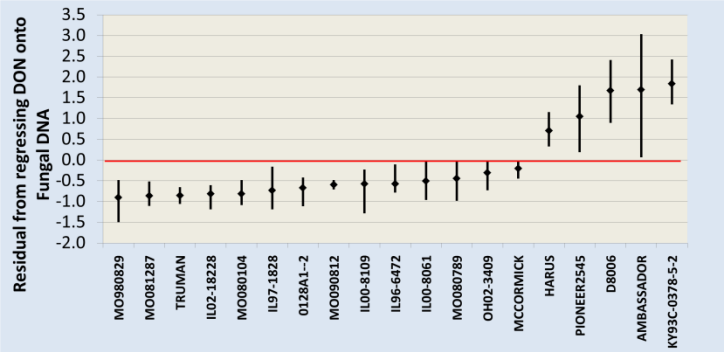

Figure 2. Range and average (diamond) residual from regressing grain DON level on grain fungal DNS levels for 19 check entries.

Impact:

The existence of variation for RTA provides an explanation for the fact that some lines with good type I or II resistance still have high DON levels, and why some lines with only moderate type I and II resistance have low DON. This should provide breeders with further impetus to screening for DON and FDK.

Project 4: *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?**

Markers associated qith QTLs can be useful in breeding but their effectiveness needs to be verified in multiple genetic backgrounds. In addition the chromosome segment with the marker and QTL can sometimes affect other traits, often in a deleterious fashion. This multi-PI project lead by David Van Sanford is designed to evaluate the impact of several major QTL for FHB resistance in soft winter wheat genetic backgrounds.

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:

OSU provided data to the PI from the 2010-11 and 2011-12 seasons. The data was used in an analysis conducted by the PI.

Impact:

The impact will be reported by the PI.

Project 5: *Male Sterile Facilitated Recurrent Selection for FHB Resistance (MPI-5).*

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

   Resistance to FHB in soft winter wheat is primarily controlled by many genes with small effect. Recombination is required to produce new gene combination that will produce superior resistance. The frequency of favorable alleles can be increased by going through multiple cycles of recombination and selection (recurrent selection). Recurrent selection can be facilitated by using male sterility which allows crossing to occur without laborious emasculations.

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 has advanced the MS-RS population through another cycle of recombination. The MS plants were plant adjacent to a mixture of plants that derive from high-yielding OSU lines with good FHB resistance. Seed is then harvested from the MS plants.

   Impact:

   The process should enhance recombination and thus increase our probability of creating novel genotypes with superior FHB resistance.

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.

None were released in 2012-13

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. "Report on the 2011-2012 Northern Uniform Scab Nurseries." In: Proceedings of the 2012 US National Scab Forum. (Dec 2012).

Sneller,C., A Cabrera. "Phenotypic analysis of a population that will be used in association analysis and genomic selection." In: Proceeding of the 2012 US National Scab Forum. (Dec 2012)

Hoffstetter, A., C. Sneller, and A. Cabrera. "Using association analysis to detect regions of the genome that confer resistance to Fusarium head blight in eastern U.S. soft red winter wheat." In: Proceedings of American Phytopathological Society North Central Meeting. (May 2012).