**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:** | 59-0790-6-061 |
| **USDA-ARS Agreement Title:** | Development of FHB Resistant Soft White Wheat Varieties for Michigan and Similar Environments. |
| **FY10 USDA-ARS Award Amount:** | $ 74,071 |

**USWBSI Individual Project(s)**

| USWBSI Research Category* | Project Title | ARS Award Amount |
|---|---|---|
| VDHR-NWW | FHB Resistant Soft White and Red Wheat Varieties for Michigan and Region. | $ 58,691 |
| VDHR-NWW | Development and Distribution of Male Sterile Facilitated Recurrent Selection Populations. | $ 1,951 |
| VDHR-NWW | Coordinated Evaluation of FHB Resistance of Advanced Soft Winter Lines and Cultivars. | $ 1,862 |
| VDHR-NWW | Improved Breeding for FHB Resistance by Advanced Genetic and Phenotypic Characterization of Soft Winter Wheat. | $ 2927 |
| VDHR-NWW | Coordinated Evaluation and Utilization of Marker Assisted Selection. | $ 8,640 |
| | **Total ARS Award Amount** | **$ 74,071** |

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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:** *FHB Resistant Soft White and Red Wheat Varieties for Michigan and Region.*

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

The overall goal of this project is to accelerate development of commercially viable varieties and advanced generation lines of soft white and red winter wheat which exhibit resistance to FHB and are adapted to Michigan and/or the eastern U.S. region. Michigan State University's wheat breeding program is one of two public programs in the eastern U.S. that focuses the majority of the program on soft white winter wheat (SWWW). FHB is a particularly serious threat to the SWWW acreage in Michigan because of the products produced from soft white wheat (SWW), with a large proportion being used by Michigan's cereal food industry. The importance of lowering levels of DON in SWW is amplified by the fact that bran mill fractions are regularly used in ready-to-eat cereal products, and bran fractions have been shown to contain higher levels of DON than flour streams.

We have been addressing this problem through targeted crossing, Marker Assisted Selection, and field phenotypic screening followed by post-harvest toxin evaluation. Our achievements are highlighted below.

**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):**
In the spring of 2011, 175 crosses were conducted, the majority of which were made to combine FHB resistance with high yield. The FHB resistance parents included MSU lines as well as cooperators lines selected from the Northern Uniform Winter Wheat Scab Nursery and the Preliminary Northern Uniform Winter Wheat Scab Nursery.

**Impact (1):**
The emphasis on FHB resistance in the crosses made at MSU will hasten the development of FHB resistant varieties for Michigan. In addition, though many of the MSU sources of FHB resistance are derived originally from the well known Asian sources of resistance, many cooperators have additional native sources of resistance that are now also being incorporated into the MSU germplasm.

**Accomplishment (2):**
Marker Assisted Selection for FHB. In the spring of 2011 we collected 1142 plant samples (from $F_1$s of 3-way crosses and $F_2$s) to be used for marker assisted selection for FHB in cooperation with the USDA/ARS Regional Small Grains Genotyping Lab (RSGGL) at Raleigh, NC. Of the 1142 plants sampled, 877 were evaluated for both at least one known Fhb QTL (such as *Fhb1* and QTL on chromosomes 2D, 5A, 2B, and at 3BSc).

**Impact (2):**
Data of markers linked to FHB QTL in the F1 and F2 will enable us to more effectively select plants with higher levels of FHB resistance. Therefore, we will enrich the populations for FHB resistance – both through selecting lines with the desired marker size, and through

eliminating lines without the desired marker size. In addition, the marker analyses of parents will allow us to design crosses more effectively to pyramid resistance to FHB.

**Accomplishment (3):**
In 2010 we screened F3 and F4 generations for FHB resistance in single row plots in the MSU artificially inoculated FHB nursery. A corresponding plot of each F3 and F4 line was present in the breeding nursery. Many of the F3 and F4 lines evaluated had been selected through Marker Assisted Selection (MAS) in the springs of 2010 and 2009, respectively. Lines that performed well for FHB resistance are the focus of further selection in the breeding nursery (while the vast majority of those that performed poorly in the FHB nursery are discarded). As with selections in previous years, selected lines will be sent for toxin evaluation to the University of Minnesota DON testing lab.

**Impact (3):**
The identification of FHB resistance and lower DON accumulation in these earlier generations focuses our resources towards developing advanced lines with better FHB resistance.

**Accomplishment (4):**
MSU's preliminary and advanced yield trials were phenotyped for FHB resistance in replicated trials in MSU's artificially inoculated FHB nursery. Selected entries were harvested and sent for DON analysis at the University of Minnesota DON testing lab.

**Impact (4):**
The focused selection of high yielding lines with improved levels of FHB resistance will help us develop FHB resistant varieties adapted to Michigan and help us avoid releasing highly susceptible lines. The use of the University of Minnesota DON testing lab helps ensure that lines with reasonable phenotypic levels of FHB are not high in DON.

**Accomplishment (5):**
In 2010 we assessed Fusarium damaged kernel (FDK) evaluations as part of our FHB screening. White and red grained control standards were used for comparison against samples harvested from the FHB screening nursery, and evaluated the majority of our harvested lines (both early and advanced generations).

**Impact (5)**:
By conducting this additional type of FHB assessment, we will have a better understanding of the effects of FHB on the grain, and further improve our ability to identify lines with better FHB resistance.

**Project 2:** *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 major problem is combining multiple sources of FHB resistance into adapted backgrounds. We are resolving this by using male-sterility to help combine multiple sources of resistance. Recurrent selection is a breeding procedure with 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 the selected parents each generation allows recombination to occur thus combining genes from different sources. Male-sterility in a self-pollinated species greatly facilitates hybridizations without laborious manual emasculation and pollination. Favorable resistance alleles can be accumulated without the requirement for numerous hand pollinations. Male-sterile recurrent selection in wheat derives its power from recombination of multiple sources of genetic variation for a specific trait and intensity of selection. Progress from selection, when recombining genetic sources such as FHB resistance, is directly related to the amount of variation for the trait in the population and heritability of the desired trait. Another benefit of recurrent selection is that there is much more genetic recombination, thus facilitating the reduction in linkage drag that may be associated with some sources of FHB resistance. The objective of this project was to develop male-sterile facilitated recurrent selection populations to combine genes for FHB resistance from multiple sources in soft winter wheat.

**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:**

Multiple sources of resistance were identified from within the Michigan State University wheat breeding program (and/or germplasm adapted to Michigan) and were sent to Wooster, Ohio, for inclusion in the recurrent population being intermated with the help of male-sterility. Seed of these crosses was received and planted in Michigan in a trial in which the male-sterile lines were surrounded by high yielding cultivars in Michigan for cross pollination.

**Impact:**

Several sources of FHB resistance (predominantly those native to Eastern US wheat germplasm) have been combined together in a large population. This population can be further mated and selected for germplasm adapted to Michigan containing multiple sources of resistance and high yield.

**Project 3:** *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?**

The major problem being resolved is FHB evaluation of elite breeding lines that are candidates for release, and cultivars that are grown in Michigan. Such evaluation is necessary so that farmers and industry are aware of the risks of varieties and breeders can make informed decisions before release.

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 Michigan State Performance Trial (the official variety trial of Michigan), as well as multiple regional trials (the Northern Uniform Winter Wheat Scab Nursery, the Preliminary Northern Uniform Winter Wheat Scab Nursery, the Uniform Eastern Soft Red Winter Wheat Nursery, and the Uniform Eastern Soft White Winter Wheat Nursery) were visually evaluated for FHB resistance in replicated trials in MSU's artificially inoculated FHB nursery. Incidence, severity and index data were taken. All but the Uniform Eastern Soft Red Winter Wheat Nursery were harvested, evaluated for Fusarium damaged kernels, and sent for DON analysis at the University of Minnesota DON testing lab.

**Impact:** The evaluation of regional trials provides useful data to all contributors not only of the lines that each contributor submitted, but also of the performance of each other's germplasm across regions. For the MSU Wheat Breeding Program, valuable data is collected from collaborating sights about MSU's germplasm. These data help confirm the performance of MSU's lines for FHB over multiple environments. In addition, MSU benefits from evaluating collaborator's entries, helping us to easily identify germplasm that would be effective for using as an FHB resistance donor parent in crossing, or as a potential variety for cultivation in Michigan. Both FHB and DON data are used in considering variety release and characterization of varieties when released for the knowledge of growers and the use of breeders.

**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?**

The major problem being resolved is the identification of QTL contributing FHB resistance within Eastern Soft Wheat germplasm. There are many sources of resistance that have been identified that we expect, according to pedigree, to be independent of the frequently used and well-characterized Chinese sources of resistance. Early generation populations were identified having parents with native sources of resistance. These populations were combined and distributed to multiple participating breeders for phenotyping.

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:**
Early generation breeding materials were identified, and seed was distributed for phenotyping to collaborating institutions. A set of common genotypes were planted at each location and a subset of genotypes were divided amongst the locations. The overlap of a set

of common genotypes will enable comparisons of the FHB performance between those evaluated in multi-sites and reduced sites. At each site, three replications were planted in a randomized design. To map resistance, genotypic and phenotypic data of the lines will be combined.

**Impact:**
Mapping Eastern Soft Wheat native resistance is necessary to expedite the use of these sources of resistance and better enable breeders to combine multiple sources of resistance in a single cultivar. The inclusion of multiple sources of resistance will lead to greater and more robust levels of FHB resistance.

**Project 5:** *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?**

Chinese spring wheat sources of resistance have been well characterized for the levels of FHB resistance that they provide, but have not been characterized for their impact on other traits, such as yield and grain quality, in Eastern soft winter wheat. The objectives of this project are to 1) evaluate the effectiveness of use of FHB-resistance QTL in the NWW breeding programs through marker assisted selection (MAS); 2) quantify the effects of these QTL in reducing FHB and DON, and 3) measure their impact on other important traits such as yield and milling and baking quality.

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:**
Molecular marker analysis was used to identify sister lines were identified at Michigan State University (and other collaborating programs) with and without QTL from Chinese sources of resistance. Increased seed of the identified sister lines were harvested and planted at in Michigan and Kentucky for yield trial evaluation. An additional seed increase is underway for the inclusion of additional sister lines for which sufficient seed was not available for planting in 2010. Phenotyping for FHB related traits is also being conducted in 2011.

**Impact:**
This project will result in immediate sharing of germplasm lines with QTL-derived resistance, often paired with native resistance. The extensive phenotyping and testing of these lines should expedite the release of those lines with variety release potential. Beyond individual institution releases, it is possible that the regional evaluation of these lines will identify some candidates for joint release as improved FHB-resistant, low DON varieties. Finally, this project will provide crucial information on the variability of QTL effects across genetic backgrounds. This will inform breeders in the SWW region on the probability of

success of deploying these QTL in high yielding resistant, low DON varieties and thus make the breeding process more efficient.

**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.**

MSU Line 'E5024' was released in 2011. The cross made in 2000: (POP# Z10024) MSU D6234 / Pioneer Brand 25W33

Summary of E5024 Performance:
E5024 is a soft white winter wheat. It has good yield in Michigan, has improved resistance to Fusarium head blight when compared with many other high yielding soft white wheats, has high test weight, is short, and shows some Preharvest sprouting resistance according to sprout count. Fusarium head blight symptoms are summarized in the table below against several other high yielding white wheat cultivars grown in Michigan. 'Caledonia' has been a prominent white wheat cultivar in Michigan for many years, though its popularity is now in decline. 'Ambassador', 'D8006' and 'Coral' are MSU releases, with Coral being released in 2008. 'Aubrey' is a cultivar from a private company with good FHB resistance.

Regarding visual symptoms of FHB (incidence, severity, index), E5024 is moderately susceptible, and is significantly better than Ambassador, Caledonia and D8006 for various measures of FHB. E5024 is significantly worse than Aubrey for % incidence and DON (ppm).

Fusarium head blight data (2008-2010 average). + and – indicate differences of an $LSD_{0.05}$ or more, such that the value is significantly higher (+) or lower (-) than E5024.

| | *% Incidence* | | *% Severity* | | *% Index* | | *DON ppm (2008-09)* | |
|---|---|---|---|---|---|---|---|---|
| E5024 | 88.6 | | 31.9 | | 28.5 | | 8.1 | |
| Ambassador | 86.3 | | 61.9 | + | 53.7 | + | 12.3 | + |
| Aubrey | 75.6 | - | 39.2 | | 30.6 | | 5.1 | - |
| Caledonia | 85.8 | | 55.5 | + | 48.8 | + | 12.2 | + |
| Coral | 81.9 | | 47.5 | + | 38.6 | + | 6.7 | |
| D8006 | 88.1 | | 49.9 | + | 44.4 | + | 7.8 | |
| Trial Mean | 83.1 | | 41.8 | | 35.6 | | 6.7 | |
| LSD (0.05) | 10.8 | | 7.7 | | 7.9 | | 2.8 | |
| CV (%) | 8 | | 11.3 | | 13.5 | | 20.8 | |

**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.**

Lewis, Janet M., Siler, Lee, Souza, Edward, Ng, Perry K.W., Dong, Yanghong, Guedira, Gina B., Jiang, Guo L., Ward, Richard W. 2010. Registration of 'Ambassador' Wheat. *Journal of Plant Registrations* Vol. 4 (No. 3): 195-204.

Lewis, Janet M., Siler, Lee, Souza, Edward, Ng, Perry K.W., Dong, Yanhong, Guedira, Gina B., Jiang, Guo L., Ward, Richard W. 2010. Registration of 'Coral' Wheat. *Journal of Plant Registrations* Vol. 4 (No. 3): 205-214.

Lewis, Janet M., Siler, Lee, Souza, Edward, Ng, Perry K.W., Dong, Yanhong, Guedira, Gina B., Jiang, Guo L., Ward, Richard W. 2010. Registration of 'Red Amber' Wheat. *Journal of Plant Registrations* Vol. 4 (No. 3): 215-223.

Roman B., J.M. Lewis, Kelly, J.D., *Fusarium* Genetic Control: A Long Term Strategy (2011) Chapter In: Control of Fusarium Diseases. Alves-Santos, F. M. and J.J. Diez (Ed.)

**Abstract and Poster Presentation:**

Lewis J., L. Siler, S. Hammar, R. Laurenz, T. Dietz, E. Falconi, S. Mishra, Y. Su, N. Yu (2011), The Challenges and Value of White Wheat in Michigan. Poster presented at the Plant Animal Genome Conference, San Diego, California, January 2011.

Lewis J., T. Dietz, L. Siler, Y. Dong, S. Hammar, S. Mishra, R. Laurenz (2010) Efficacy of Near-Infrared Reflectance Spectroscopy to Predict Fusarium Damaged Kernels and Deoxynivalenol in Red and White Wheat in Michigan. Poster presented at the National Fusarium Head Blight Forum, Milwaukee, WI, Dec. 2010.

Mishra, S. Siler, L., Hammar S., Lewis J. M. (2010) Comparison of Different Inoculation Methods for Evaluation of FHB Resistance in Wheat Varieties. Poster presented at the National Fusarium Head Blight Forum, December 2010, Milwaukee, WI.

**Reports:**

Lewis, J., Siler, L., Hammar, S., Laurenz, R., Dong, Y., Souza, E. (2010) Michigan State Wheat Variety Trial Report (http://www.css.msu.edu/varietytrials/wheat/Variety_Results.html).