Project FY22-NW-006: Development of FHB resistant wheat varieties for Michigan and the Great Lakes Region

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1. What are the major goals and objectives of the research project?

The mission of the Michigan State University Wheat Breeding and Genetics program is to develop high-yielding, high-quality soft red and soft white winter wheat varieties with strong resistance to FHB. Breeding populations are developed with parents having both high yield potential and FHB resistance. Speed breeding is implemented in the greenhouse to quickly advance early generations while implementing selection for FHB resistance. Genomic selection is used to advance inbred lines with high yield potential and resistance to FHB into replicated yield testing.

Major project goals:

1. *Develop and apply selection to wheat breeding populations segregating for FHB resistance using a combination of phenotypic and genomic selection strategies.*
2. *Evaluate resistance levels of early generation selection candidates and entries in replicated breeding yield trials, regional germplasm and commercial wheat varieties in a misted FHB nursery.*
3. *Enrich populations for the Fhb1 gene using marker assisted selection.*
4. *Disseminate resistant germplasm through regional testing networks.*
5. *Communicate levels of FHB resistance and susceptibility in Michigan wheat varieties and regional breeding germplasm.*

2. What was accomplished under these goals or objectives? *(For each major goal/objective, address these three items below.)*

What were the major activities?

1. Development of breeding populations and early generation selection.

MSU25 crossing cycle. A total of 273 unique crosses were made in fall 2024 and spring 2025 to develop segregating breeding populations. All crosses included at least one FHB-resistant parent and 119 (44%) included *Fhb1* from at least one parent and 17 populations included *Fhb1* from more than one parent. Leaf rust and stripe rust susceptible individuals were culled from the F_2 and F_3 generations as populations are advanced in the greenhouse using the Minibulk system. The F_4 seed will be planted in the field in bulk plots in fall, 2024. Marker assisted selection will be used to identify $F_{4:5}$ lines carrying *Fhb1*.

MSU24 generation advance. The minibulk system is being used to advance a total of 436 populations from crosses made in fall 2023 and spring 2024. Leaf rust and stripe rust susceptible individuals have been culled during inbreeding. Populations of 300 F_4 individuals will be space-planted at 8" spacing in 50' x 6 row plots at Mason, MI in fall 2025 to undergo selection in spring 2026.

MSU23 F_4 line derivation. In September, 2024, 280 bulk F_4 populations from the 2023 crossing cycle were planted at Mason, MI. Each population was comprised of 300 F_4 individuals space-planted at 8" spacing in 50' x 6 row plots. A total of 1,152 single plants were harvested on July 7, 2025. All new lines will be planted in 5'x5' plots in an observation nursery and two rows in the FHB

nursery for selection in 2026. New derived lines will be genotyped with SNPs and genomic predictions will be made for FHB severity, DON accumulation, grain yield and preharvest sprouting.

MSU22 advance to replicated yield testing. A set of 800 $F_{4:5}$ lines derived from MSU21 populations were evaluated in a single plot observation nursery in 2023. F_4-derived lines were selected as single plants in 2024 based on genomic predictions. Lines were tested in two replicates in the FHB nursery and susceptible individuals were culled. A set of 266 lines have been harvested and will be further narrowed to 240 for replicated testing based on thousand kernel weight.

Replicated Yield Testing. A set of 250 lines derived from the 2021 crossing program were evaluated in two replicates at two locations in MI. A set of 44 experimental lines and 4 checks were evaluated at 28 locations across IL, IN, KY, MO, OH, MI and Canada.

2. Evaluation of resistance levels of breeding yield trial entries and training population in a misted FHB nursery.

In 2024, 719 unique wheat genotypes were evaluated in replication in a misted and inoculated nursery. All regional, cooperative and commercial yield trials were evaluated for FHB resistance in three replicates. Nurseries tested included the F4 observation nursery (2 reps), Year 1-3 yield trials, MSU Preliminary Yield Trial, MSU Advanced Yield Trial, Michigan State Commercial Wheat Performance Trial (OVT), P+NUWWN, Big6 Core and Eastern Uniform Soft Red Winter Wheat Nurseries (all 3 reps).

Two research projects took place in the 2023 FHB nursery. The samples were imaged using a hyperspectral camera as part of a phenomics project to predict DON levels in intact (unground) grain samples. A second project was aimed at predicting visual FHB symptoms using thermal imaging.

The 2024 FHB nursery was delayed by 10 days relative to what is considered to be the normal date for rating FHB phenotypes. Data were collected on incidence, severity, FHB index. A total of 653 DON samples will be collected and processed. Reps will be bulked to minimize the number of samples for analysis.

The 2024 DON values were lower than average ranging from 0.15 ppm to 16.1 ppm in the most susceptible line and an average of 2.7 ppm. DON data was generated for a total of 222 unique genotypes across all trials. Data was shared with collaborators, used in research projects and reported to farmers and agribusiness.

Data from the breeding trial entries were used to train GS prediction models to select for FHB resistance. Correlation between genomic predictions and actual DON values in 2021 was 0.65. Visual FHB ratings will be published in the initial OVT report and DON data were published when received in June, 2022.

3. Enrichment of populations for Fhb1.

Crosses were made using a total of 39 *Fhb1* donor parents. Among 2024 crosses, 119 included *Fhb1* from at least one parent and 17 populations included *Fhb1* from more than one parent. Genotyping of advanced lines in the Big6 cooperative nursery confirmed the presence or absence of *Fhb1*.

4. Dissemination of resistant germplasm.

For regional FHB resistance evaluation nine entries were submitted to the Uniform FHB nurseries comprised of FHB resistant germplasm and lines tested in regional nurseries. FHB-resistant germplasm was also disseminated through the Big6 testing network.

5. Communication of FHB resistance in Michigan wheat varieties.
Wheat growers and agribusiness were educated on FHB-resistant varieties in presentations at field days and winter meetings. Eight talks were given to agribusiness and growers at four indoor meetings and four field days that included messages regarding the benefits of planting resistant varieties, especially the decreased FHB risk from the combination of a moderately resistant variety treated with a fungicide. Educational materials were distributed including a list of moderately resistant varieties, how resistance is determined visually and DON levels, and traits to look for in selecting varieties to mitigate the risk of FHB. Resistant varieties available to Michigan wheat growers were identified in the OVT report released in August, 2024.

What were the significant results?
Five years of predicted grain yield, visual FHB resistance and DON mycotoxin levels were used to guide selections in the field. Genomic model training data collected in the FHB nursery is of high value and has facilitated genomic selection for FHB resistance. A large SNP marker and DON data set was generated that will be made publicly available on T3 and other platforms that can be accessed by the USWBSI community.

List key outcomes or other achievements.

Progress was made in using hyperspectral imaging to predict DON content in FHB-infected grains. This work was done by Phd student, Jhon Concepcion who was awarded a PhD in April, 2025. The accuracy of training models in making forward predictions was found to be positive by low compared to cross validation studies evaluating model performance within observed years and environments.

The combination of accelerated generation advance with genomic selection prior to yield testing has shortened the timeline for variety release to eight years. The MSU wheat breeding program has successfully integrated speed breeding and genomic selection into the wheat variety development process. Continued use of these breeding strategies will accelerate the increase in FHB resistance in wheat varieties available to farmers across the Great Lakes region.

3. What opportunities for training and professional development has the project provided?

Assistant breeder, Amanda Noble continues to excel at management of staff and breeding nurseries. Amelia Orr, a technical staff member has gained technical proficiency in rating FHB and leads the generation of corn grain spawn inoculum that we rely on for success in establishing disease in the field. Amelia has also inoculated and rated thousands of individual heads in the greenhouse.

One PhD student, Jhon Concepcion, has been trained to work with the FHB system in the greenhouse and field. Jhon has led the development of image analysis tools to rate FHB in the greenhouse and field using thermal and hyperspectral imaging. Jhon defended his PhD in April, 2025

The entire team of MSU wheat FHB researchers took part in preparing the corn inoculum used in the 2025 nursery.

4. **How have the results been disseminated to communities of interest?**
   Data from FHB nurseries has been shared with collaborators. Growers and industry are continuously updated on our progress on breeding for FHB resistance at field days and industry events. Results of 2024 and ongoing work are shared at the USWBSI annual forum.

5. **What do you plan to do during the next reporting period to accomplish the goals and objectives?**
   All crossing, FHB phenotyping, yield testing activities and collaborations will continue through the next reporting period.