Project FY22-SW-002: Development of FHB Resistant Wheat Cultivars Adapted to the Gulf Coast region.

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

Fusarium Head Blight (FHB) is an important disease of wheat along the Gulf Coast and has significantly contributed to reduced acreage. Losses to FHB occur because of heavy rainfall during anthesis, more corn acres, and a lack of adapted varieties with FHB resistance. Development of FHB resistant wheat varieties with high yield, regional adaptation, and broad disease resistance is the major goal of the LSU wheat breeding program. This proposal addresses all three VDHR research priorities and stives to encourage growers to plant high-yielding, FHB resistant varieties that lead to reduced DON content in the grain trade.

The objective of this project is to utilize conventional breeding, molecular markers, genomic prediction protocols and speed breeding to pyramid effective QTL in an adapted background to develop and commercialize FHB resistant cultivars that are highly productive and adapted to the Gulf Coast and Southeastern U.S. regions.

Specific Project Objectives are to:
(1) Screen state performance trial entries, SunGrains regional nurseries, and advanced LSUAC breeding lines in inoculated misted nurseries to document the relative level of resistance to FHB, FDK, and mycotoxins in each entry.
(2) Present data from the misted nursery trials to growers, seedsmen and breeders in reports and presentations to encourage the development and utilization of cultivars with improved FHB resistance.
(2) Screen segregating populations in FHB nurseries to select FHB resistant genotypes.
(3) Apply methods that reduce breeding cycle time to develop FHB resistant cultivars, including off-season nurseries, speed breeding, Double Haploids (DHs), and molecular markers.
(4) Utilize genomic prediction and sparse testing tools as a key factor in FHB resistant line advancement and parent selection.
(5) Develop and share DHs with important FHB resistance pyramids.

2. **What was accomplished under these goals or objectives?**

What were the major activities?
Obj 1,2,3) A misted inoculated replicated nursery containing 462 two-row plots from Uniform Southern Scab Nursery, Uniform Southern Soft Red Winter Wheat Nursery, Gulf-Atlantic Wheat Nursery, SunWheat Nursery, and state variety trials was planted at Alexandria, Baton Rouge (lost to poor stands) and Winnsboro. A misted inoculated nursery containing 1000 genotypes representing the early stages of the related LSU and Clemson breeding programs was grown at Baton Rouge and Winnsboro as a graduate student research project on sparse testing and within-family efficacy of multivariate genomic prediction models.

All rows were rated for FHB severity (0-9), hand harvested, and threshed with low wind speed to retain damaged kernels. FDK was determined on carefully cleaned samples, which were then ground to produce 30 grams of flour per sample.

1896 samples were shipped to the USDA DON under direction of Yanhong Dong in St. Paul in early July. FHB, FDK and DON were included in the annual Wheat Research Summary of variety trial performance results published each year and varieties were classified for FHB reaction type. FHB, FDK and DON data were included in the SunGrains regional performance trial data base and utilized for genomic predictions.

Obj 2) 381 new crosses were made in winter 2024 and included parents with diverse source of FHB resistance in adapted high-yielding backgrounds. Of those 381 crosses, 185 are segregating for Fhb1. Segregating populations were space-planted in a 7" x 15" grid of ~400 plants each for 132 F2 and F3 populations containing Fhb1 along with effective genes for resistance to Hessian Fly, stripe rust, and other diseases. Additional segregating populations were grown in bulk at two locations. The misted nurseries at three locations included selected segregating populations with unique combinations of FHB resistance genes and selected heads were harvested and advanced. About 4,000 yield plots were evaluated and harvested at the Baton Rouge and Winnsboro locations. Preliminary yield trials were also grown in Stoneville, MS and Marianna, AR to identify genotypes adapted to that region. Natural disease pressure at those locations allowed for some visual selection for resistance. Head selections were made from ~1200 segregating plots at two locations each year.

Obj 3, 4) Molecular markers for FHB QTL were run on 592 advanced breeding lines entered in the Genomic Selection Prelim project (WPGS) tested inn yield plots using a Sparse design at three locations. First year DHs were evaluated in short rows and selected rows were harvested and will be entered into WPGS, and also shared among VDHR-SWW breeders.

Obj 3) An off-season nursery of F1 plants from FHB crosses was grown in Idaho or Colorado each summer to speed up the breeding cycle of SunGrains programs. A Speed Breeding chamber was developed by equipping an insulated fruit shipping container with LED growth lights and air conditioning to facilitate generation advancement during the summer.

What were the significant results?

Obj 1,2) Four of five 1000-row misted nurseries were effective in delineating FHB resistance in regional nurseries and LSUAC breeding lines. One nursery was abandoned at Baton Rouge due to poor stands. There was a strong correlation between heading date and FDK and DON at the misted nurseries in Winnsboro due to late onset of conditions conducive for FHB development. That data is used with appropriate maturity adjustment. Data were the misted nursery at Alexandria was excellent with highly significant genotypic variation and a correlation between FDK and DON of 0.85***. FDK ranged from 5% to 75% and DON from 2.5% to 23.1% in the misted nursery state variety trial. The misted nurseries were effective in identifying resistance to FHB, FDK and DON accumulation. FHB Index value is calculated as a weighted function of FHB, FDK and DON. The data on FHB, FDK, and DON was included in the annual Wheat Research Summary published for growers, consultants, and seedsmen in August each year. The data is included in tables for each location along with a summary table of FHB reaction type and FHB index across environments. The FHB index was

used to classify varieties and develop the list of resistant and moderately resistant varieties published on the USWBSI web site. FHB data from two nurseries was included in USDA regional and SunGrains nursery reports to assist collaborating breeders in developing FHB resistant varieties.

Obj 2) The majority of crosses made contained FHB resistance in both parents, and nearly half had at least one *Fhb1* parent. The Wheat Genomic Selection Prelim (WPGS) included 830 F3:4 and F4:5 breeding lines in first year yield trials, of which 146 had imputed *Fhb1* marker calls.

Obj 3) Genomic selection models, marker QTL information, and field data were used to advance first-year F3:4 lines and F4:5 lines in WPGS. Initial data from the graduate student testing project was incorporated into training population data sets for calculations of GEBVs for FDK and DON. Forty lines were advanced out of WPGS into multi-state regional testing based in part on marker calls for *Fhb1* and other mapped resistance QTL, genomic predictions for FDK and DON. Fourteen of the forty lines advanced out of WPGS carried *Fhb1*.

Obj 4) DH headrows from crosses with parents containing multiple FHB QTL/genes with high yield were selected and advanced to preliminary yield trials. Genomic predictions (including PopVar predictions for family variances and environment-specific predictions utilizing historic weather and soil data), marker data, and regional yield trial data were used to place promising lines from first year regional testing into the crossing plot, saving a couple of years in the breeding cycle. The genomic selection (GS) protocol included imputation of major QTL for FHB resistance and calculation of GEBVs for yield, FHB resistance and other important traits. The ability to accurately determine presence of major FHB QTL from GBS markers significantly increases the utility of genomic selection and reduces the resource limitations constraining running markers on large numbers of breeding lines. GS data was heavily weighted in advancement decisions of lines from the genomic selection prelim that will be in replicated yield trials. Shared DHs were evaluated in headrows and yield plots.

List key outcomes or other achievements.

The LSUAC wheat breeding program focuses on development of FHB resistant varieties that are high-yielding, well adapted and resistant to the many biotic and abiotic factors that limit yield in the humid Gulf Coast region. AGS 3022 (LA16020-LDH22) had excellent performance across the region in the 2023-24 season. It is the highest yielding variety across south Louisiana for two years and has high test weight, excellent resistance to leaf and stripe rust, and very good resistance to FHB. It performed well across the Southeastern US.

The LSUAC wheat breeding program is preparing breeding line LA18003-NDH119 for variety release. LA18003-NDH119 has very strong FHB resistance, along with being a carrier of *Fhb1*, as well as strong resistance to rust, powdery mildew, and Hessian Fly. LA18003-NDH119 was the top-yielding *Fhb1* line in the 2024 Uniform Southern Nursery and has broad adaptation across the Southeastern United States.

3. **What opportunities for training and professional development has the project provided?**
   Three graduate students were involved in setting up mist systems, inoculating nurseries, and rating field symptoms for FHB. One graduate student is in charge of the misted nurseries and rated all harvested samples for FDK and has a FHB related research project.

4. **How have the results been disseminated to communities of interest?**
   A Wheat Field Day held at the Macon Ridge Research Station in Winnsboro on April 23, 2024, that highlighted variety resistance, FHB screening, the breeding program, and fungicide control of FHB. The SunGrains breeders tour visited the LSUAC wheat breeding program on April 26, 2024. and spent substantial time discussing FHB resistance and germplasm evaluation. Data from the 2023 statewide wheat variety trials was published online in LAES Research Summary No. 226 and included tables and a discussion of data from the misted nurseries along with a classification of FHB reaction type for entries in the trials.
   https://www.lsuagcenter.com/~/media/system/0/2/8/b/028b05f5e365b3b6abf270fb03b3d0d0/rs228_smallgrainperftrials_rh823pdf.pdf

5. **What do you plan to do during the next reporting period to accomplish the goals and objectives?**
   The breeding program expends a significant amount of resources on development of superior wheat varieties with effective resistance to Fusarium Headblight. This is done in concert with SunGrains breeders in an efficient regional collaboration that also includes non-SunGrains members of the VDHR-SWW. The program will maintain the same focus and operate the same way in general. More emphasis will be placed on rapid generation advancement techniques given the funding cut that supported DH production.