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 in the Southeast US and has significantly contributed to reduced acreage. Losses to FHB occur because of heavy rainfall during anthesis, incorporation of corn in crop rotations, and growers planting varieties without adequate 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 region (TX, LA, AR, MS, AL, and GA) and broader Southeastern U.S.

   Specific Project Objectives are to:

   (1)   Screen state performance trial entries, SunGrains regional nurseries, and advanced LSU breeding lines in inoculated misted nurseries to document the relative level of resistance to FHB, FDK, and mycotoxin accumulation in each entry.   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 a third inoculated misted nursery and select genotypes and populations with good FHB resistance as part of the variety development program.

   (3)   Apply methods that reduce breeding cycle time to more quickly 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?** *(For each major goal/objective, address these three items below.)*

What were the major activities?

Obj 1,2,3) A misted inoculated replicated nursery containing 500 two-row plots from Uniform Southern Scab Nursery, USDA Uniform Southern Soft Red Winter Wheat Nursery, Gulf-Atlantic Wheat Nursery, SunWheat Nursery, state variety trials, and advanced LSU breeding lines were planted at Alexandria 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 GWAS research project on sparse testing and within-family efficacy of multivariate genomic prediction models. The Baton Rouge location was lost due to poor stands as a result of heavy rain immediately after planting.

 All rows were rated for FHB severity (0-9), hand harvested and threshed using low air speed to retain damaged kernels. In the Winnsboro test, a planter glitch resulted in the rating and harvesting of single-row plots instead of two-row plots. FDK was determined on carefully cleaned samples, which were then ground to produce 30 grams of flour per sample for DON analysis.

1693 samples were shipped to the USDA DON under direction of Yanhong Dong in St. Paul in early July. These included 997 samples from cooperative tests, 544 from the graduate student project, and 152 fungicide trialing samples from cooperator Dr. Boyd Padgett. 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 database and utilized for advancement decisions and for genomic predictions.

 Obj 3) 303 new crosses made in winter 2025 included parents with diverse sources of FHB resistance in adapted, high-yielding backgrounds. A strong emphasis has been placed on *Fhb1* in making these crosses. Of the 303, 186 crosses had at least one *Fhb1* parent (61%), while 18 of those crosses had two *Fhb1* parents. An additional four crosses were made with *Fhb7* germplasm line WGC002, and *Fhb7* backcross lines obtained from the University of Maryland (Vijay Tiwari) will be used as parents in the next cycle. An off-season nursery of F_1 plants from FHB crosses was grown in Colorado in the summer of 2024 to save a year in the breeding cycle. A rapid generation advancement growth chamber was developed, and a protocol for generation advancement with a 3.5-month cycle time was optimized. All F1 populations that were not advanced to F2 through the Colorado headrow program were advanced in this growth chamber in the summer of 2024. All 2025 crosses will be similarly advanced, with 115 of the 2025 crosses going through both F_1 and F_2 generations in the RGA chamber, to be planted as space-planted F_3 populations in that same fall.

Obj 3, 4) Molecular markers for FHB QTL were run on 1,000 advanced breeding lines (610 Stage 1 $F_{3:5}$s, 390 Stage 2 $F_{4:6}$s) that were entered into the LSU preliminary trial (WPGS) tested in yield plots using a p-rep design at five locations. Genomic predictions for FHB traits and imputed *Fhb1* marker data on Stage 1 lines in those trials were used to augment selection of 334 associated seed-source $F_{4:5}$ headrows in Winnsboro prior to yield trial harvest. First year DHs were evaluated in short rows and selected rows were harvested for entry in the 2026 WPGS trial and also shared with DHR-SWW breeders.

Obj 5) Selections were made within new LSU DHs in the 2024 headrow nursery, and 47 lines were shared with VDHR-SWW members to plant in the 2025 season. A total of 758 new DH lines were generated by Heartland (450 lines) and the NC DH lab (308) from LSU crosses. These DH lines were trialed in both Baton Rouge and Winnsboro, along with 364 DH lines shared by the Virginia Tech, University of Georgia, Clemson University, and University of Maryland programs. Of the planted set, 114 new LSU DHs were harvested for sharing with VDHR-SWW members and advancement, along with 72 shared DHs for advancement.

What were the significant results?

Obj 1,2) Two of the four 1000-row misted nurseries (two cooperative screening, two LSU graduate student projects) were effective in delineating FHB resistance in regional nurseries and LSU breeding lines. The screening nurseries at Winnsboro, one for cooperative testing and one for the graduate student project, were successfully inoculated, rated, and harvested. The Baton Rouge nursery, one of the two locations for the graduate student project, was abandoned due to poor stands produced by heavy rainfall after planting. The cooperative screening nursery at Alexandria was successfully inoculated and harvested, but the misting system was not set up prior to heading. This produced a strong association of FHB severity with specific rainfall events. In Winnsboro, heading date was correlated with FHB severity (-.34), but not with FDK (-.06). Grain samples from both locations were ground and submitted to the University of Minnesota DON Testing Lab. Data on FHB, FDK, and DON and FHB reaction classification is included in the annual Wheat Research Summary published for growers, consultants, and seedsmen and includes a summary table of FHB reaction type and FHB index across environments (https://www.lsuagcenter.com/topics/crops/wheatoats/variety_trials_recommendations) FHB data from two nurseries was included in USDA regional and SunGrains nursery reports to assist collaborating breeders in developing FHB resistant varieties.

Obj 3) The majority of crosses made contained FHB resistance in both parents, and 61% had at least one *Fhb1* parent. Work was initiated to begin introgressing *Fhb7* into LSU and SunGrains germplasm. The Rapid Generation Advancement chamber was utilized for the first time in the summer of the 2024-25 breeding cycle and successfully produced F2 seed of numerous crosses that was planted in the field using a vacuum planter to facilitate individual F2 plant selection.

Obj 4) Early-stage material advanced to the Wheat Genomic Selection Prelim (WPGS) included 1000 breeding lines, of which 146 had imputed Fhb1 marker calls. Advancement decisions in those nurseries were based in part on marker calls for FHB QTL and genomic predictions for FDK and DON.

Genomic selection models, QTL marker information, and field data were used to advance first-year F3:4 lines and F4:5 lines in WPGS. ~85 breeding lines from WPGS are advanced to replicated yield testing each year. 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 (SunPre nursery) 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 5) DH headrows from crosses with high-yielding adapted parents containing multiple FHB QTL/genes 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, shaving a couple of years off traditional the breeding cycle. Shared DHs were evaluated in headrows and yield plots as part of WPGS. A DH line carrying *Fhb1*, LA18003-119, was released. An *Fhb1* DH line from the VDHR-SWW exchange program, LAVT19VDH-FHB-MAS11-10 from Virginia Tech, performed well in the 2025 GAWN and will be advanced to the Uniform Southern and entered in state variety trials as a variety release candidate.

List key outcomes or other achievements.

The LSU 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 Southeastern United States. AGS 3022 (LA16020-LDH22) had excellent performance in the 2023 - 2025 seasons. It is the highest yielding variety across south Louisiana for three years and has high test weight, excellent resistance to leaf and stripe rust, and very good resistance to FHB. It has performed well across the Southeastern US and was planted on substantial acreage in the 2024-2025 season.

The LSU wheat breeding program released LA18003-119 to JoMar seeds for sub-licensing in the Delta region of LA, MS, and AR. LA18003-119 is a product of the USWBSI-funded double haploid program. LA18003-119 carries *Fhb1* and has very strong FHB resistance along with strong resistance to leaf and stripe rust, powdery mildew, and Hessian fly. LA18003-119 was the top-yielding *Fhb1* line in the 2024 Uniform Southern nursery and has broad adaptation across the Southeast 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. His dissertation research project is on FHB resistance.

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 22, 2025 highlighted variety resistance, FHB screening, the breeding program, and fungicide control of FHB. Data from the 2024 statewide wheat variety trials was published online in LAES Research Summary No. 229 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/articles/page1725905907706).

5. **What do you plan to do during the next reporting period to accomplish the goals and objectives?**

The breeding program expends significant resources on the 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.