Report for FY22-SP-010: Development of Elite Spring Wheat Germplasm with Fusarium Head Blight Resistance

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

The major goal and objective of this project is to develop adapted hard red spring wheat (HRSW) germplasm by transferring FHB resistance from unadapted sources into the HRSW cultivars.

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

What were the major activities?

- Completed manuscript and its publication about genome-wide association studies (GWAS) on the FHB resistance in the modified NAM population of 288 spring wheat genotypes, including 276 synthetic hexaploid wheat (SHW) derived HRSW lines and their 12 parents and checks.

- Continued evaluation of approximately 170 elite HRSW lines that are homozygous for 5AL QTL (*Fhb10*) and *Fhb1*, including six doubled haploid (DH) lines and 164 BC_1F_5 lines. These lines were previously selected by genotyping 700 BC_1F_2 plants (15FAR1157-1/2*ND Frohberg) and 15 DH lines (15FAR1157-1/ND Frohberg). There lines were previously evaluated using hill plots in the FHB nurseries in two locations (Prosper and Frago, ND) during the summer seasons (May – August) in 2024, 2025, and 2026. Therefore, these lines have been evaluated for FHB resistance in six environments. A set of 24 elite HRSW lines showing higher levels of FHB resistance were selected and further tested using shot-row plots for FHB resistance in the NDSU Spring Wheat Breeding Program, at both Fargo and Prosper, ND across three consecutive summers (2024-2026). Additionally, greenhouse evaluations for FHB resistance were conducted at the USDA-ARS Western Regional Research Center (WRRC) in Albany, CA, during the summer of 2026.

- Evaluated the 24 elite HRSW lines showing higher levels of FHB resistance above, along with HRSW varieties (Faller, ND Heron, ND Thresher, ND Stampede, and ND Frohberg) and checks, in the yield trials in Thompson, ND in the summer of 2025 and in Prosper and Thompson, ND in the summer of 2026.

- Produced BC_6F_1 hybrid seeds by backcrossing a wheat-*Th. elongatum* 7B/7E introgression line XWC14-255-13-1 (WGC002) carrying new *Fhb7* allele $Fhb7^{The2}$ to ND Frohberg.

- Developed BC_5F_1 seeds from backcrossing Wangshuibai lines with ND Frohberg to simultaneously transfer major FHB resistance QTL *Fhb1*, *Fhb2*, *Fhb4*, and *Fhb5*.

- Produced BC_2F_1 hybrids from backcrossing a wheat-*Th. ponticum* 7B/7el2 introgression line SN-26 carrying original *Fhb7* to ND Frohberg, ND Thresher, and ND Stampede.

- Produced F_1 hybrid seeds from the crosse between ND Stampede and Ji 5625 for introgression of *Fhb9* form Ji 5625 into HRSW varietis.

What were the significant results?

- A large number of elite HRSW breeding lines carrying individual or different combinations of multiple QTLs (*Fhb1*, *Fhb2*, *Fhb4*, *Fhb5, Fhb7*, and *Fhb10*) have been developed.
- Approximately 40 HRSW lines showed higher levels of FHB resistance than the current HRSW variety ND Frohberg. The yield trial 24 of the lines and varieties (Faller, ND Heron, ND Thresher, ND Stampede, and ND Frohberg) showed that these lines had the same or similar agronomic traits and performance as the HRSW varieties. Some of these lines such as 21AK006-36, 21AK008-29, 21AK006-26, 21AK003-04, 21AK005-14 and 21AK-DH-25-1 showed very high resistance to FHB.
- Based on our recent experiments, we found that our greenhouse conditions in Albany, CA has provided the most optimal environment for testing wheat plants for true reactions to *Fusarium graminearum*, making it unambiguous to distinguish resistant and susceptible genotypes. From greenhouse evaluation, we confirmed that five elite HRSW lines, including 21AK006-36 (Average FHB severity: 11.3%), 21AK008-29 (14.1%, 21AK006-26 (14.5%), 21AK003-04 (15.8%), 21AK005-14 (16.3%) from the backcross 15FAR1157-1/2*ND Frohberg, have high level of FHB resistance comparable to Sumai 3 and PI 277012. To make this resistance packed in the adapted HRSW background available to various breeding programs.

List key outcomes or other achievements.

- The elite HRSW breeding lines carrying *Fhb1* and *Fhb10* have been provided to the wheat breeding programs in North Dakota, South Dakota, Minnesota, and California.
- The BC_6F_2 population deverived from backcrossing wheat-*Th. elongatum* 7B/7E introgression line XWC14-255-13-1 (WGC002) carrying $Fhb7^{The2}$ to ND Frohberg have been provided to several wheat breeding programs.

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

This project provides training and professional development for two postdoctoral research associates.

4. How have the results been disseminated to communities of interest?

The results have been disseminated through publications and presentations at various workshops and seminars and communications with breeders and collaborators.

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

- Develop new BC_2F_1 populations for transferring and stacking *Fhb1*, *Fhb2*, *Fhb4*, *Fhb5, Fhb7*, *Fhb8*, *Fhb9* and *Fhb10* to new HRSW varieties in North Dakota, South Dakota, and Minnesota.
- Evaluate elite HRSW lines carrying pyramided multiple QTL *Fhb1*, *Fhb2*, *Fhb4*, *Fhb5*, *Fhb7*, *Fhb10* in the FHB nurseries in Fargo and Prosper, ND for the 1st year.
- Conduct yield trials for elite HRSW lines carrying pyramided *Fhb1* and *Fhb10* in the regional yield trial in multiple locations.
- Conduct a preliminary yield trial (single-row plots) of selected HRSW lines (BC_6F_5) carrying $Fhb7^{The2}$ from *Th. elongatum* and the lines (BC_6F_5) carrying *Fhb1*, *Fhb2*, *Fhb4*, and *Fhb5* from Wangshuibai in Langdon and Prosper, ND.
- Genotype ~150 U.S. HRSW varieties and breeding lines to determine the frequency and distribution of two *Fhb1* suppressors (*In1* and *In2*).
- Perform comparative genomics, fine mapping, and bulked segregant RNA-seq analysis to identify candidates for *Fhb10*.