USDA-ARS | U.S. Wheat and Barley Scab Initiative

FY22 Performance Progress Report

Due date: July 26, 2023

Cover Page

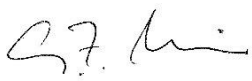
USDA-ARS Agreement ID:	59-0206-2-145
USDA-ARS Agreement Title:	Breeding Fusarium Head Blight (FHB) resistant Hard Winter Wheat for North Dakota
Principle Investigator (PI):	G. Francois Marais
Institution:	North Dakota State University
Institution UEI:	EZ4WPGRE1RD5
Fiscal Year:	2022
FY22 USDA-ARS Award Amount:	$57,655
PI Mailing Address:	North Dakota State University, Department of Plant Sciences Dept. 7670, PO Box 6050 Fargo, ND 58108-6050
PI E-mail:	gideon.marais@ndsu.edu
PI Phone:	701-231-8155
Period of Performance:	May 1, 2022 – April 30, 2026
Reporting Period End Date:	April 30, 2023

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
HWW-CP	Transfer of FHB Resistance to NDSU Hard Red Winter Wheat Breeding Material	$57,655
	FY22 Total ARS Award Amount	$57,655

I am submitting this report as an: ☒ Annual Report

I certify to the best of my knowledge and belief that this report is correct and complete for performance of activities for the purposes set forth in the award documents.



6/01/2023

Principal Investigator Signature — Date Report Submitted

‡ BAR-CP – Barley Coordinated Project
DUR-CP – Durum Coordinated Project
EC-HQ – Executive Committee-Headquarters
FST-R – Food Safety & Toxicology (Research)
FST-S – Food Safety & Toxicology (Service)
GDER – Gene Discovery & Engineering Resistance
HWW-CP – Hard Winter Wheat Coordinated Project
MGMT – FHB Management
MGMT-IM – FHB Management – Integrated Management Coordinated Project
PBG – Pathogen Biology & Genetics
TSCI – Transformational Science
VDHR – Variety Development & Uniform Nurseries
NWW –Northern Soft Winter Wheat Region
SPR – Spring Wheat Region
SWW – Southern Soft Red Winter Wheat Region

Project 1: Transfer of FHB Resistance to NDSU Hard Red Winter Wheat Breeding Material

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1. **What are the major goals and objectives of the research project?**
   Objective 1. Systematically raise the frequencies of specific, targeted FHB resistance genes in the HRWW breeding program by using planned convergent crosses, marker screening and agronomic evaluation.
   Objective 2. Select for genetic background (native) FHB resistance among advanced lines and utilize it in the breeding program.
   Objective 3. Develop 500-600 single seed descent (SSD) inbred lines in each project year. Derive F_4 seed from crosses that segregate for one or more FHB resistance QTL (plus resistance to the wheat rusts).
   Objective 4. Conduct an annual Winter Wheat x Fungicide performance trial (field) to evaluate the response of breeding lines and control varieties to fungicide application for the reduction of DON content.
2. **What was accomplished under these goals or objectives?** *(For each major goal/objective, address these three items below.)*
   a) What were the major activities?
   Objective 1. (a) The 2023 crossing block involved 50 parents which were crossed in 491 single cross combinations. Parents were chosen based on FHB resistance (15), wheat rust resistance (28), grain yield (41), height and plant phenotype (35) and winter-survival (26). (b) 576 new inbred lines were tested at the USDA Wheat Genotyping Laboratory, Fargo, ND using appropriate markers to predict *Fhb1*, *Qfhs.ifa-5A*, *Qfhb.rwg-5A.2*, and key rust resistance genes (*Sr2*, *Sr24*, *Lr34*, *Lr56*, etc). (c) Germplasm line XWC14-255-3-1 (spring habit) which has *Fhb7* (from *Thinopyrum elongatum*) was crossed to winter wheat (17Nord-96). This was followed by a first backcross to cultivar "Winner" as well as two more cycles of modified backcrosses (to 10 winter parents) employing marker-aided selection.
   Objective 2. A diallel study was done to detect background FHB resistance. Ten NDSU HRW wheat inbred lines and the cultivar, ND Noreen were crossed in all possible non-reciprocal cross combinations. The 11 parents and 55 F_1 were then evaluated (greenhouse) for FHB Type II resistance in a randomized block experiment with four replicates. Following statistical analyses, genotypes that appeared to have useful levels of background resistance were identified. (b) Line X Tester analysis of FHB resistance: In 2022, another 14 HRW genotypes were crossed with four tester lines to produce 56 F_1 hybrid combinations.
   Objective 3. SSD inbreeding was initiated from promising crosses (high yield with resistance to FHB and other diseases) to achieve generation acceleration. Chosen crosses had at least one FHB resistant parent. ± 96 F_2 seedlings/cross were screened with mixed leaf and stem rust inoculum. During inbreeding the plants were also selected for height and fertility. The F_4 was field planted in the fall of year 2 and single plants were selected in year 3. F_5 pure lines were established in year 4.
   Objective 4. A variety X fungicide evaluation trial with 22 entries was conducted at Casselton. The trial followed a split plot layout (three replicates) with half of the plots treated with Prosaro at 8.2 fl oz/acre at flowering (applied on three different dates to allow for variation in flowering dates among the varieties). Corn inoculum (FHB) was applied on two dates, the first application coincided with the onset of heading in the earliest varieties.

b) What were the significant results?

Objective 1. Of the 491 routine program crosses made in 2023, 67 involved *Fhb1*; 32 involved *Fhb1* & *Qfhs.ifa-5A*; 30 involved *Qfhb.rwg-5A.1* & *Qfhb.rwg-5A.2*; and 55 involved known background FHB resistance. During selection, strong emphasis will be put on the development of cold-tolerant, high yielding lines with FHB plus multiple disease resistance that will be suitable for release or will have utility as a breeding parent. Modified backcrosses with *Fhb7* resulted in 35 B_3F_1 combinations. Marker-assisted SSD inbreeding will now be done to establish and evaluate pure lines for field testing and employment as breeding parents.

Objective 2. (a) In the diallel study, the parents differed significantly for FHB Type II resistance. Overall, additive genetic effects were predominant (narrow sense heritability = 0.71), indicating that pure line selection is likely to be effective when breeding to improve resistance. Three parents with the lowest disease severity and highest general combining ability (GCA) were 18Nord-107, ND Noreen, and 19Nord-129. It appeared that these parents possess useful and diverse background resistance that may involve various FHB resistance QTL. An attempt will be made to select for better background resistance within segregating progeny of the three best lines. The three best parents also constitute valuable genetic backgrounds for pyramiding with known, larger-effect resistance QTL to achieve higher levels of FHB resistance. (b) With regard to the testcross analysis that is being done to evaluate an additional 14 winter wheats for combining ability: Among the four tester lines, one tester has both *Fhb1* and *Qfhs.ifa-5A*; one tester has *Fhb1* but intermediate resistance; one has intermediate "native" resistance and one is susceptible. The testcross F_1 plus parents will now be evaluated for FHB Type II resistance in a replicated greenhouse trial.

Objective 3. Three sets of SSD selections that were in different stages of development were handled during the report period: Two sets of SSD material were planted at Casselton in September 2022, namely 1,530 F_5 head rows derived from 40 crosses made in 2020 and 503 F_4 rows that derive from 44 crosses made in 2021. The two populations will continue to be evaluated during the summer of 2023. In addition, 504 F_3 lineages from 31 crosses made in 2022 were greenhouse planted in March 2023.

Objective 4. Owing to very dry growing conditions throughout the state, no significant incidences of foliar diseases occurred. In the fungicide trial, no significant FHB infection occurred, and no DON analyses were done. Fungicide treatment did not cause significant differential responses of varieties either. A new (2023) Winter Wheat Variety trial with 22 entries and the same statistical design was planted at Casselton in the fall of 2021.

c) List key outcomes or other achievements.

Objective 1. Promising new inbred lines are being derived annually of which a significant proportion possesses known resistance QTL. Agronomic, marker and disease resistance evaluation of the material is ongoing. Transfer of *Fhb7* resulted in the recovery of approximately 94% winter wheat genetic background. Resistant plants (greenhouse) showed no obvious phenotypic defects due to undesirable linkage drag and resistant heterozygotes were already utilized as parents in the 2023 routine breeding crossing block. *Objective 2*. (a) Statistical analyses of a diallel revealed that ND Noreen, 18Nord-107, and 19Nord-129 have significant levels of native FHB resistance. 18Nord-107 and ND Noreen had mostly dominant resistance QTL, whereas 19Nord-129 had mostly recessive resistance QTL. Coupled with their diverse origin, the lines appear to involve different resistance loci. Their F_2 progenies will be tested in a second greenhouse trial to confirm the results; identify segregating plants showing possible transgressive resistance; and initiate SSD inbreeding.

(b) In the second study to identify lines with native FHB resistance in a Line X Tester analysis, the 18 parents and their 56 F_1 hybrids are being evaluated for FHB type II resistance in a completely randomized greenhouse trial. Following statistical analysis of the F_1 data, F_2 from superior hybrids will be retested for FHB resistance in order to initiate single seed descent inbreeding and pure line development.

Objective 3. In 2023, the first group of 503 promising F_5 pure lines will be selected for agrotype and advanced to preliminary (Junior) yield trials that will be planted in the fall. All preliminary yield trial entries will be screened for seedling resistance to wheat rust, tan spot and SNB. In addition, marker analyses will be done.

Objective 4. The results from the Variety X Fungicide trial were incorporated in the online publication: "North Dakota Hard Red Winter Wheat Trial Results for 2022 and Selection Guide" (A1196-22 September 2022).

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

Bipin Neupane graduated in the spring of 2023 with MS thesis title: Evaluation of winter wheat and tritipyrum germplasm to identify useful variation for biotic and abiotic stress tolerance.

Bhanu Dangi, MS thesis subject: Diversification of FHB resistance QTL in winter wheat germplasm. Is expected to graduate in the spring of 2024.

Kripa Rijal. Will join the project in August 2023. Her MS study will focus on pre-breeding to improve FHB resistance.

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

Advanced lines were entered in regional nurseries [NRPN (6); RGON (30); Northern Scab (15); USDA stem rust (100); USDA KS Stripe rust (160); USDA WSU stripe rust (100)] and statewide variety trials [ND (3); SD (1); MN (2)]. Data on the submitted material get listed in on-line reports of the respective nurseries. The results of the Variety X Fungicide trial of 2021/22 were incorporated in the NDSU annual publication "North Dakota Hard Red Winter Wheat Trial Results for 2022 and Selection Guide" (A1196-22 September 2022).

Publications, Conference Papers, and Presentations

Please include a listing of all your publications/presentations about your FHB work that were a result of funding from your FY22 grant award. Only citations for publications published (submitted or accepted) or presentations presented during the **award period** should be included.

Did you publish/submit or present anything during this award period May 1, 2022 – April 30, 2023?

☒ Yes, I've included the citation reference in listing(s) below.
☐ No, I have nothing to report.

Journal publications as a result of FY22 award

List peer-reviewed articles or papers appearing in scientific, technical, or professional journals. Include any peer-reviewed publication in the periodically published proceedings of a scientific society, a conference, or the like.

Identify for each publication: Author(s); title; journal; volume: year; page numbers; status of publication (published [include DOI#]; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).

None

Books or other non-periodical, one-time publications as a result of FY22 award

Report any book, monograph, dissertation, abstract, or the like published as or in a separate publication, rather than a periodical or series. Include any significant publication in the proceedings of a one-time conference or in the report of a one-time study, commission, or the like.

Identify for each one-time publication: Author(s); title; editor; title of collection, if applicable; bibliographic information; year; type of publication (book, thesis, or dissertation, other); status of publication (published; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).

Neupane, B. (2023). Evaluation of winter wheat and tritipyrum germplasm to identify useful variation for biotic and abiotic stress tolerance. MS Thesis (accepted April 2022, North Dakota State University). Federal support was acknowledged.

Other publications, conference papers and presentations as a result of FY22 award

Identify any other publications, conference papers and/or presentations not reported above. Specify the status of the publication.

Poster Presentations:

Bipin Neupane and Francois Marais. (2022). A Diallel Study to detect Variation in Genetic Background FHB Resistance in Winter Wheat. Proceedings of the 2022 National Fusarium Head Blight Forum; Tampa, FL. December 4-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf

Bipin Neupane and Francois Marais. (2023). A Diallel Study to detect Variation in Genetic Background FHB Resistance in Winter Wheat. Edgar McFadden Symposium, April 24-26, Grapevine, Texas.

Bhanu Dangi and Francois Marais. (2022). Expansion and diversification of FHB resistance QTL in Winter Wheat germplasm. Proceedings of the 2022 National Fusarium Head Blight Forum; Tampa, FL. December 4-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf

Bhanu Dangi and Francois Marais. (2023) Diversification of FHB Resistance QTL in Winter Wheat Germplasm. Edgar McFadden Symposium, April 24-26, Grapevine, Texas.

Information bulletin:

Clair Keene, Francois Marais, Andrew Friskop, Zhaohui Liu, and Shaobin Zhong (NDSU Main Station); Eric Eriksmoen (North Central Research Extension Center, Minot); Glen Martin (Dickinson Research Extension Center); John Rickertsen (Hettinger Research Extension Center); Mike Ostlie (Carrington Research Extension Center); Gautam Pradhan (Williston Research Extension Center); Bryan Hanson (Langdon Research Extension Center). North Dakota Hard Red Winter Wheat Trial Results for 2022 and Selection Guide (A1196-22 September 2022). https://www.ndsu.edu/agriculture/extension/publications/north-dakota- hard-red-winter-wheat-variety-trial-results-2022-and-selection