

USDA-ARS | U.S. Wheat and Barley Scab Initiative
FY21 FINAL Performance Progress Report

Due date: July 26, 2023

Cover Page

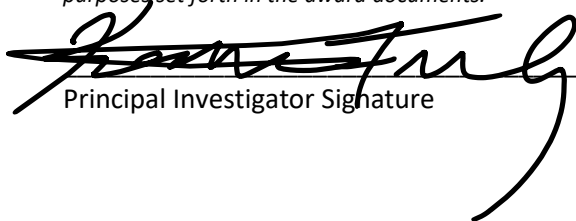
USDA-ARS Agreement ID:	59-0206-0-178
USDA-ARS Agreement Title:	Breeding Scab Resistant and Low DON Winter Wheat and Barley Varieties for the Great Plains
Principle Investigator (PI):	Katherine Frels
Institution:	University of Nebraska
Institution UEI:	HTQ6K6NJFHA6
Fiscal Year:	2021
FY21 USDA-ARS Award Amount:	\$142,019
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Period of Performance:	5/15/21 - 5/14/23
Reporting Period End Date:	5/14/2023

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
BAR-CP	Breed Scab Resistant and Low DON Winter Barley Varieties for the Great Plains.	\$33,000
HWW-CP	Breed Scab Resistant and Low DON Hard Winter Wheat Varieties for the Great Plains	\$102,036
HWW-CP	Innovated Selection Plan to Improve the FHB Resistance of Hard Winter Wheat	\$6,983
FY21 Total ARS Award Amount		\$142,019

I am submitting this report as a: FINAL 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.



Principal Investigator Signature

7/25/23 _____
 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: Breed Scab Resistant and Low DON Winter Barley Varieties for the Great Plains.

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

Our goal is to develop winter barley cultivars that are resistant to Fusarium head blight and accumulate reduced levels of DON following infection. Our barley program has traditionally developed feed barley cultivars for regions with low scab risk, however, we are seeing more interest in barley production in regions susceptible to scab, and we are also developing winter malting quality cultivars. Therefore, our objectives are to 1- Evaluate and implement new breeding methods to increase resistance to FHB and the accumulation of mycotoxins; 2- Develop new barley varieties with enhanced resistance to FHB and lower mycotoxins; 3- Evaluate chemical, biological and cultural management strategies that reduce FHB and/or mycotoxin accumulation in barley; and 4- Develop and promote best management strategies through integrated disease management that is robust to conditions experienced in barley production fields in diverse geographies.

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?

We continued our barley FHB inoculated nursery screening efforts in 2022 and included the UNL advanced and elite barley yield trials, the Winter Malting Barley trial, and the first year of the winter NABSEN. Due to hot and dry weather after flowering, disease pressure was lower than in 2021 even with irrigation.

We utilized the 2021 screening results to select parents for new crosses in the 2022-2023 greenhouse season (described in FY22 performance report).

The dry weather made it challenging to evaluate best management practices for winter barley, as FHB was not present in our barley trials outside of the inoculated nursery.

b) What were the significant results?

We evaluated 40 elite and 45 advanced lines from the UNL program in the inoculated nursery in 2022. The Nebraska lines averaged 19% for severity and 52% incidence compared to 36% for severity and 67% incidence in 2021. Like in 2021, the WMBT entries had lower disease severity on average, suggesting that we should continue to source FHB resistant parents from this nursery. The winter NABSEN entries averaged 15% for severity, 31% incidence, and 1.8 PPM DON (Table 1), suggesting that some of these entries could be good parents for Nebraska barley if they are winter hardy enough. The Nebraska entries in the winter NABSEN had low severity and high incidence compared to the other entries, but they had some of the lowest DON levels in the trials.

Entry	Year	Nursery	Loc	Name	SEV	INC	INDEX	FDK	PPM
1	2022	NABSEN	LNK, NE	DH141225	11	75	9	14	1.4
2	2022	NABSEN	LNK, NE	Buck	21	20	4	17	7.2
3	2022	NABSEN	LNK, NE	Streaker	11	20	2	25	6.6
4	2022	NABSEN	LNK, NE	DH180670	14	80	11	19	1.1
5	2022	NABSEN	LNK, NE	Thunder	9	25	3	20	4.6
6	2022	NABSEN	LNK, NE	Lightning	9	25	2	19	2.0
7	2022	NABSEN	LNK, NE	DH141222	21	73	18	21	0.2
8	2022	NABSEN	LNK, NE	13ARS777-2	13	37	8	23	0.8
9	2022	NABSEN	LNK, NE	13ARS537-19	22	30	7	22	0.6
10	2022	NABSEN	LNK, NE	10ARS839-2	.	.	.	24	2.7
11	2022	NABSEN	LNK, NE	13ARS537-25	22	30	7	14	4.6
12	2022	NABSEN	LNK, NE	11ARS652-7	22	30	7	17	4.5
13	2022	NABSEN	LNK, NE	12ARS578-3	.	.	.	20	3.8
14	2022	NABSEN	LNK, NE	NB20416	10	43	5	18	0.6
15	2022	NABSEN	LNK, NE	NB20428	20	77	16	19	0.2
16	2022	NABSEN	LNK, NE	NB19423	9	80	7	20	0.2
17	2022	NABSEN	LNK, NE	NB19420	14	63	11	18	0.4
18	2022	NABSEN	LNK, NE	NB17431	10	37	4	19	0.6
19	2022	NABSEN	LNK, NE	MT19WF5_05-01	11	45	5	23	0.2
20	2022	NABSEN	LNK, NE	MT19WF5_40-01	8	35	3	21	1.2
21	2022	NABSEN	LNK, NE	MT19WF5_67-01	.	.	.	18	2.7
22	2022	NABSEN	LNK, NE	PatsPop2019_31-2	16	83	14	21	0.5
23	2022	NABSEN	LNK, NE	MT19WF5_50-3	8	15	1	15	3.3
24	2022	NABSEN	LNK, NE	MT19WF5_51-9	16	33	6	21	1.8
25	2022	NABSEN	LNK, NE	MT19WF6_132-2	19	55	9	17	M
26	2022	NABSEN	LNK, NE	2MW18_3372-008	24	70	20	19	0.5
27	2022	NABSEN	LNK, NE	2MW18_4462-008	9	20	2	20	0.2
28	2022	NABSEN	LNK, NE	2MW18_3375-018	10	80	8	21	3.0
29	2022	NABSEN	LNK, NE	2MW18_4462-011	12	30	4		0.7
30	2022	NABSEN	LNK, NE	MW12_4007-001	22	83	18	23	0.4
31	2022	NABSEN	LNK, NE	6MW18_3372-011	16	53	9	18	0.9
32	2022	NABSEN	LNK, NE	2011-725-02	11	30	3	32	2.5
33	2022	NABSEN	LNK, NE	DH0214-007	21	63	14	22	0.5
34	2022	NABSEN	LNK, NE	DH02FL-028	11	33	4	20	2.6
35	2022	NABSEN	LNK, NE	RIL02FL-029	5	10	1	22	0.5
36	2022	NABSEN	LNK, NE	RIL02SC-16-02	11	40	5	21	0.4
37	2022	NABSEN	LNK, NE	RIL02SP-014	16	57	9	20	0.4
38	2022	NABSEN	LNK, NE	Endeavor	43	50	22	22	3.5
39	2022	NABSEN	LNK, NE	VA15H-73	19	60	12	27	0.6
40	2022	NABSEN	LNK, NE	Calypso	8	30	3	15	1.4
41	2022	NABSEN	LNK, NE	Wintmalt	17	57	10	22	0.4
42	2022	NABSEN	LNK, NE	Thoroughbred	13	50	6	17	0.7
43	2022	NABSEN	LNK, NE	Hirondella	17	40	7	18	6.3
44	2022	NABSEN	LNK, NE	Atlantic	25	73	20	19	0.1
45	2022	NABSEN	LNK, NE	Secretariat	13	55	7	20	0.7

Table 1. Results of the 2022 Winter NABSEN FHB inoculated trial in Lincoln, NE

c) List key outcomes or other achievements.

We received DH lines sponsored by BAR-CP from Dr. Pat Hayes at Oregon State University for two F1 crosses (NB17411/2ND38517 and NB15415/2ND38517) in late spring 2023. We will likely plant them in our fall or winter greenhouse for initial screening of FHB tolerance and winter/spring growth habit. Once seed is increased in

the greenhouse, both populations will be evaluated for scab resistance and winter hardiness and made available to all interested breeding programs.

UNL did not release a barley cultivar in 2022.

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

Ph.D. students Sheryl Sierra and Sydney Graham are leading the UNL barley breeding efforts. They are gaining hand-on experience in designing and improving a breeding pipeline by integrating disease screening data such as FHB while maintaining germplasm necessary for meeting our goals of releasing 6-row feed barley cultivars and eventually 2-row malting cultivars adapted to the southern and central Great Plains. (Additional details in the 2022 Performance Report)

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

We continue to use Twitter and university outreach publications to reach our growers. In addition, our variety development and release committee is evaluating how to improve marketing of UNL barley varieties. Barley is discussed at UNL field days and seed days. Dr. Frels presented an update on the UNL barley breeding efforts at the 2022 USWBSI Scab Forum last December.

Project 2: Breed Scab Resistant and Low DON Hard Winter Wheat Varieties for the Great Plains

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

Our goal is to develop hard winter wheat cultivars that are resistant to Fusarium head blight and accumulate reduced levels of DON following infection. Our objectives are 1- Increase efficiency of coordinated project breeding programs to develop and release FHB resistant varieties by evaluating regional germplasm for FHB tolerance and DON levels; 2- Enhance selection efficiency through technologies such as genomic selection, marker-assisted selection, doubled haploid production and/or high throughput phenotyping leading to pyramiding of major and minor genes for FHB resistance; and 3- Enhance communication and coordination to increase the impact of our research beyond the region.

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

a) What were the major activities?

Obj 1- In FY 22, we tested the USWBSI HWW-CP regional trials, the UNL advanced and elite yield trials, as well as the UNL state variety trial for FHB and DON accumulation in an inoculated misted nursery. We participate in the P+NUWSSN nursery for the soft winter wheat region. We evaluate FHB infection and severity 21 days after flowering, and seed from these nurseries are also submitted for DON testing. Additionally, we test some breeding lines in greenhouse inoculation trials. Due to the frequent high temperature events and drought conditions in Lincoln, NE during flowering and grainfill, the greenhouse tests give us a back-up dataset for our phenotypic and genomic selection methods.

Obj 2- We continue to grow our preliminary, advanced and elite trials with and without fungicides at Lincoln to determine the effect of disease (primarily FHB and stripe rust) on our lines. In FY 22, the weather became hot and dry after flowering preventing the development of disease in the non-fungicide treated replications of our wheat yield trials. Therefore, fungicide x genotype interactions were not meaningful for the 2021-2022 growing season. We continue to develop a multi-year analysis of our fungicide treated and non-treated yield trials to determine the main effects of fungicide application. These efforts are primarily focused on the eastern NE growing regions as the main wheat production regions in west-central and Panhandle NE are too dry for FHB to occur.

We are advancing several segregating populations with *Fhb1* and native resistance developed in Dr. Fang Wang's Ph.D. research and are deriving homozygous *Fhb1* genotypes from these populations in addition to using them as parents in our crossing blocks. (Additional details in the FY 22 Performance Report)

Obj 3- Dr. Frels presented an update on the FHB breeding efforts at UNL at the 2022 USWBSI Scab Forum last December. We continue to share insights and recommendations on FHB risk and management via social and field days. Recently, we

have discussed FHB more in west central NE, an area that is traditionally lower risk for FHB but has recently seen greater infection.

b) What were the significant results?

Focusing on the results of the 2022 UNL Elite Yield Trial (EYT), we saw relatively low disease severity due to the hot, dry weather, but good incidence in the disease nursery. Of the 60 lines in the YET, 63% were at or below the trial average for severity (18%, Figure 1) and 47% were at or below the trial average (29%, Figure 2) for incidence. DON values averaged 3.4 ppm in the entire trial. This trial contains eight potential varieties targeted for release in the next 1-3 years. We were excited to see that many of our variety candidates have good FHB tolerance, and the majority of those that do not are targeted towards regions with minimal FHB risk (Table 2). The exception is NI17410 which is targeted as a statewide irrigated wheat variety. If this line is released to producers, we will need to highlight its greater susceptibility to FHB.

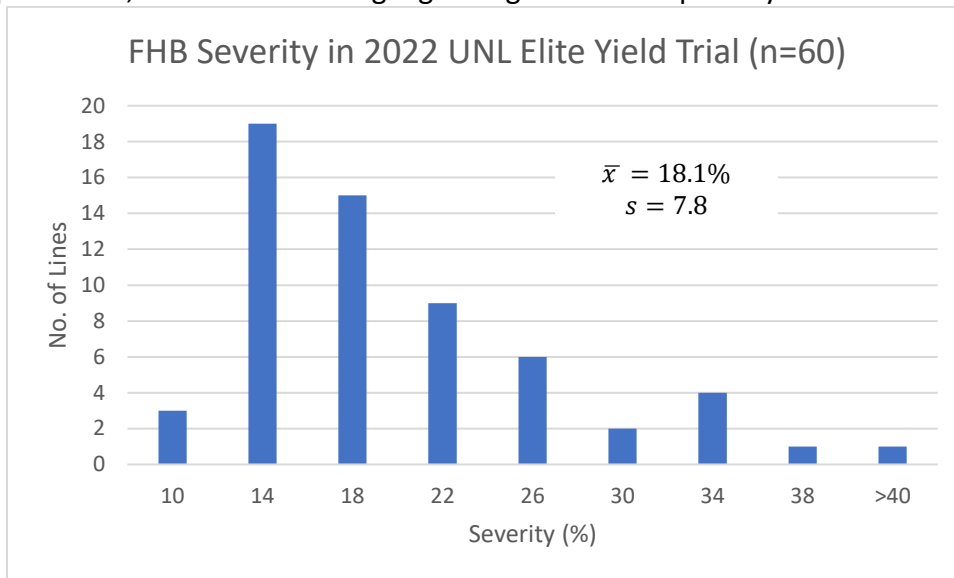


Figure 1: FHB severity in the 2022 Elite Yield Trial. These are the top performing breeding lines in the UNL Winter Wheat program.

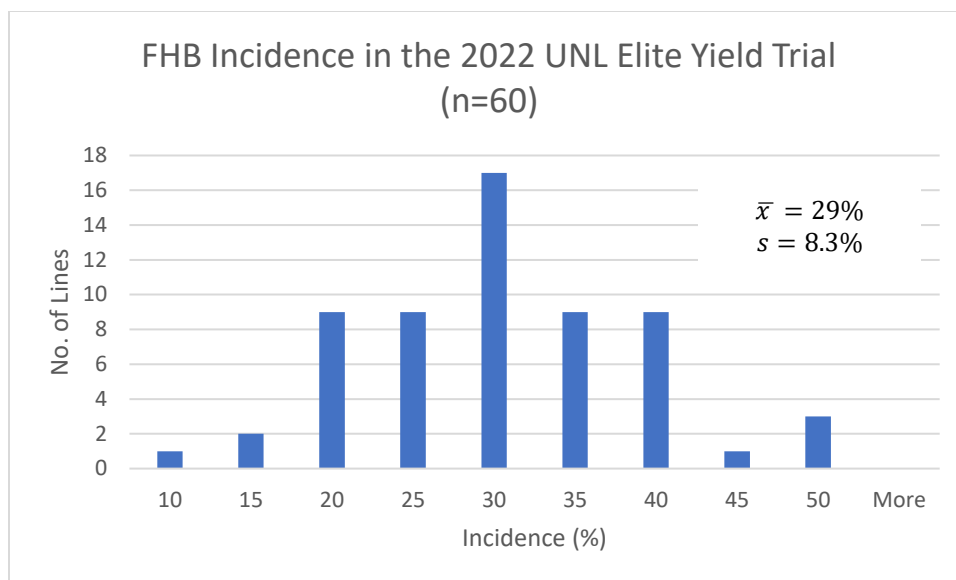


Figure 2: FHB incidence in the 2022 Elite Yield Trial. These are the top performing breeding lines in the UNL Winter Wheat program.

Name	Target Region	SEV (%)	INC (%)	INDEX (%)	FDK (%)	DON (ppm)
NW15443	Statewide	11	10	1	.	.
NE19619	Panhandle, WC	11	20	2	17	4.3
NE16562	SC, WC	13	20	3	17	2.5
NI17410	Irrigated	15	43	7	16	1.9
NHH19668	Panhandle, WC	16	37	7	36	2.4
NHH17612	Panhandle, WC	18	27	6	18	5.3
NE17441	WC	21	40	6	18	5.0
NHH17450	Panhandle, WC	23	25	6	26	3.1
Variety Candidate Average		16.2	27.7	4.8	21.1	3.5
Trial Average		18.1	29.3	5.6	25.0	3.4

Table 2. Potential variety candidate breeding lines with FHB Tolerance data in the 2022 UNL Elite Yield Trial. Regions= Statewide, Panhandle, West Central (WC), South Central (SC), Irrigated. SEV= FHB severity (%), INC= Incidence (%), INDEX is a mathematical combination of SEV and INC, FDK= Fusarium damaged kernels (%), and DON= Deoxynivalenol content in parts per million.

c) List key outcomes or other achievements.

We participate in the HWWCP- DH production project led by Dr. Shuyu Liu. We have sent 3 F₁ populations that are segregating for *Fhb1* and *Fhb6* as well as segregating for native FHB resistance. We look forward to receiving these populations and testing for improved FHB tolerance.

We are continuing to advance Dr. Fang Wang's *Fhb1* backcross populations to derive homozygous lines and evaluate them in yield tests. These populations also make up the majority of our *Fhb1* donor parents in our crossing blocks.

Additional genomic selection outcomes are discussed in the FY22 report.

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

This project has provided partial funding to train several interns (3), visiting scholars (1), and graduate students (1) in plant production, disease inoculation and data collection and analysis. We encourage graduate students and post docs to attend the Scab Forum, but their schedules did not allow attendance in 2022.

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

We continue to use Twitter and university outreach publications to reach our growers. FHB and management methods for wheat are discussed at UNL field days and seed days. Dr. Frels presented an update on the effort to select FHB tolerant cultivars for Nebraska producers at the 2022 USWBSI Scab Forum last December.

Project 3: Innovated Selection Plan to Improve the FHB Resistance of Hard Winter Wheat

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

Our goal is to develop HWW cultivars that are resistant to FHB and accumulate reduced levels of DON following infection. This project is a collaborative work between University of Nebraska, South Dakota State University, and Ohio State University. We have the following objectives: 1- Increase efficiency of coordinated project breeding programs to develop and release FHB resistant varieties; 2- Enhance selection efficiency through technologies such as genomic selection, marker-assisted selection, doubled haploid production and/or high throughput phenotyping leading to pyramiding of major and minor genes for FHB resistance.

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?

Work for this effort was primarily completed in the 2020-2021 growing season.

b) What were the significant results?

All data was provided to Dr. Sneller for a graduate student to test genomic selection models for predicting FHB tolerance across breeding programs.

c) List key outcomes or other achievements.

Results expected at a later date.

3. What opportunities for training and professional development has the project provided? Research opportunities for GxE analysis of diverse germplasm and development of multi-trait GxE models for one graduate student.

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

Results expected at a later date.

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 FY21 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?

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

Journal publications as a result of FY21 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).

Books or other non-periodical, one-time publications as a result of FY21 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).

Other publications, conference papers and presentations as a result of FY21 award

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

Frels, K., F. Wang, S. Wegulo, X. Cai, V. Belamkar, and P.S. Baenziger. Selecting for Fusarium resistance in the Great Plains. In: USWBSI Networking & Facilitation Office (NFO) (Eds.), Proceedings of the 2022 National Fusarium Head Blight Forum (p. 93.), Tampa, FL; December 4-6. Online: <https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf>.
Status: Abstract Published and Presentation made
Acknowledgement of Federal Support: YES

Asif, M., S. Wegulo, J. Stevens, K. Frels, H. Hallen-Adams, and K. Eskridge. Effects of Fungicides and Cultivar Resistance on Fusarium Head Blight of Wheat. In: USWBSI Networking & Facilitation Office (NFO) (Eds.), Proceedings of the 2022 National Fusarium Head Blight Forum (p.16), Tampa, FL; December 4-6. Online: <https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf>.
Status: Abstract Published and Poster Presented
Acknowledgement of Federal Support: YES