USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY20 Annual Performance Progress Report
Due date: July 29, 2021

Cover Page

Principle Investigator (PI):	Mark Sorrells
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Fiscal Year:	2020
USDA-ARS Agreement ID:	59-0206-0-119
USDA-ARS Agreement Title:	Development of FHB Resistant Wheat and Barley Varieties for the Northeastern U.S.
FY20 USDA-ARS Award Amount:	$ 154,958
Recipient Organization:	Cornell University 341 Pine Tree Road Ithaca NY 14850
DUNS Number:	872612445
EIN:	15-0532082
Recipient Identifying Number or Account Number:	1498135 (OSP135995)
Project/Grant Reporting Period:	5/3/20 - 5/2/21
Reporting Period End Date:	5/2/2021

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
BAR-CP	Breeding Spring and Winter 2-rowed Malting Barley for FHB Resistance and Reduced DON	$ 34,508
BAR-CP	Identification, Characterization, & Development of Widely-adapted FHB-resistant Germplasm	$ 4,620
BAR-CP	Genomics Selection for FHB Resistance and Malting Quality in Spring Malting Barley	$ 3,819
VDHR-NWW	Genetics and Breeding of FHB Resistant Soft White & Red Winter Wheat for the Northeastern U.S.	$ 108,563
VDHR-NWW	Coordinated Phenotypes of Soft Wheat Germplasm for the Midwest	$ 3,448
	FY20 Total ARS Award Amount	**$ 154,958**

Mark F. Sorrells

July 28, 2021

Principal Investigator Date

* MGMT – FHB Management
FST – Food Safety & Toxicology
R- Research
S – Service (DON Testing Labs)
GDER – Gene Discovery & Engineering Resistance
PBG – Pathogen Biology & Genetics
EC-HQ – Executive Committee-Headquarters
BAR-CP – Barley Coordinated Project
DUR-CP – Durum Coordinated Project
HWW-CP – Hard Winter Wheat Coordinated Project
VDHR – Variety Development & Uniform Nurseries – Sub categories are below:
SPR – Spring Wheat Region
NWW – Northern Soft Winter Wheat Region
SWW – Southern Soft Red Winter Wheat Region

Project 1: *Breeding Spring and Winter 2-rowed Malting Barley for FHB Resistance and Reduced DON*

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

Goal #1 - Increase and document the number of varieties with improved FHB resistance and high grain yield and grain quality, that are tested in statewide variety trials and available to farmers, to reduce DON in the US grain supply.

We are evaluating FHB resistance in our misted inoculated FHB nursery for malting barley varieties that are tested in both New York State Regional Spring and Winter Malting Barley testing programs. We are testing the FHB resistance in winter malting barley germplasm from Idaho and Nebraska. We collaborate with Tom Baldwin on evaluating Idaho spring malting barley.

Goal #2: Increase efficiency of the CPs' funded projects to develop and release FHB resistant varieties and germplasm.

We are evaluating FHB resistance in our misted inoculated nursery for spring malting barley varieties in a cooperative Uniform Eastern Spring Malting Barley nursery coordinated by Richard Horsley (North Dakota State University) and a Winter 2-row Malting Barley Trial coordinated by Kevin Smith (University of Minnesota). We are sharing seed of the elite winter and facultative barley DH lines developed in collaboration with Pat Hayes at Oregon State University with the barley community. All of our data are published and distributed to the barley community and the public at large through print, web, field days and workshops.

Goal #3: Evaluate and implement new breeding technologies and develop germplasm to further enhance short term and long term improvement of FHB resistance, and to efficiently introgress effective resistance genes into breeding germplasm.

We are evaluating FHB resistance and agronomic traits in our NY spring 2-row elite line genomic selection training population and we used genomic selection to develop spring 2-row malting barley varieties with FHB resistance and adaptation to the northeastern U.S. The genomic predictions were used to select lines for harvest in the off-season nursery in New Zealand. We have completed 2 cycles of genomic selection using an index that includes FHB resistance. The second season of evaluation for gain from selection was completed this past summer.

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 evaluated FHB resistance in spring malting barley varieties in a Uniform Eastern Spring Malting Barley nursery coordinated by Richard Horsley at North Dakota State University and a Winter 2-row Malting Barley Trial coordinated by Kevin Smith at the University of Minnesota. We evaluated FHB resistance in malting barley varieties that are tested in both New York State Regional (state-wide) Spring and Winter Malting Barley testing programs. We tested and reported FHB resistance in winter malting barley germplasm from Idaho and Nebraska. We evaluated FHB resistance and agronomic traits in our NY spring 2-row elite line training population and used genomic selection to develop two new spring 2-row malting barley varieties with moderate FHB resistance and adaptation to the northeastern U.S.

b) What were the significant results?

Two spring malting barley lines showed moderate resistance to FHB. Data were summarized for the ID and NE winter barley populations and sent to collaborators. The NE barley lines were nearly all susceptible but the ID population was segregating for FHB resistance and excellent data were summarized and sent to ID. Genomic prediction identified spring malting barley breeding lines that had high genomic estimated breeding values. A severe spring drought limited the quality of the data from the spring malting barley evaluations.

c) List key outcomes or other achievements.

The two lines, designated CU-31 and CU-198 were approved for release and breeder seed of CU-198 and Foundation seed of CU-31 was produced this year. We completed the seed increase and initiated agronomic evaluation of over 500 DH lines developed in collaboration with Pat Hayes at Oregon State University. Seed of those lines have been sent back to the OSU program for evaluation and are available to the barley community. Genomic selection was effective for identifying lines with good FHB breeding values.

3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns and/or restrictions, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.

Yes – we were not allowed to hire summer students to help with field work. Consequently, my grad students, technicians and I spent long days and weekends trying to prevent the loss of data and seed. We had to reduce the number and size of our

program by 30% and some of the breeding nurseries had to be moved to 2021. Greenhouse operations were severely curtailed.

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

All of our graduate and undergraduate students participate in the collection and analysis of data from our FHB nurseries.

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

Summary tables and reports (annual and cumulative) are prepared and distributed to more than 400 agents, farmers, scientists, and administrators by regular mail and email. All reports are made available online at two web sites. We also deposit our data in T3.

Project 2: *Identification, Characterization, & Development of Widely-adapted FHB-resistant Germplasm*

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

   1) Identify resistant lines in elite winter germplasm;
   2) Cross resistant spring lines to a) create mapping populations and b) broaden the adaptability of Aberdeen FHB-resistant malting germplasm by introducing broad-spectrum disease resistance.
   3) Investigate fungal biomass estimated qPCR as a screening tool for selection of low-DON lines.

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?

   For the past 2 years we have evaluated breeding lines in two different nurseries from Univ of Nebraska and both winter and spring mapping populations from the Univ of ID. This project was expanded from the original collaboration with ID to include NE.

   b) What were the significant results?

   Excellent data were collected and analyzed for all three winter nurseries from both years. Data for the spring population from ID were of sufficient quality from one year. It was noted that there was very little evidence of resistance in the NE materials. The ID winter population was especially useful for mapping FHB resistance.

   c) List key outcomes or other achievements.

   Collaborators were able to obtain useful data from our location.

3. **Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns and/or restrictions, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.**

   Yes – we were not allowed to hire summer students to help with the field research. Consequently, my grad students, technicians and I spent long days and weekends trying to prevent the loss of data and seed.

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

   All of our graduate and undergraduate students participate in the collection and analysis of data from our FHB nurseries.

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

All data were collected analyzed and sent to our collaborators in ID and NE.

Project 3: *Genomics Selection for FHB Resistance and Malting Quality in Spring Malting Barley*

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

    1) Evaluate FHB resistance and malt quality of lines in a training population selected to represent the Aberdeen, ID spring malting barley breeding program.
    2) Develop and apply a genomic selection prediction model for FHB resistance in the Aberdeen spring malting barley germplasm, accounting for the need to maintain acceptable malt quality.

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?

    From a founder population of ~700 lines, 248 lines were selected as a training population (TP) representative of the Aberdeen spring breeding program and genotyped. Our collaborators at the Univ of ID have used our data as well as data from other locations for genomic prediction.

    b) What were the significant results?

    Excellent data were collected and analyzed for the ID spring barley training population from one of the two years. 2020 was lost to drought but it is being grown again in 2021.

    c) List key outcomes or other achievements.

    Data was collected and sent to our collaborators for genomic prediction.

3. **Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns and/or restrictions, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.**

    Yes – we were not allowed to hire summer students to help with field work. Consequently, my grad students, technicians and I spent long days and weekends trying to prevent the loss of data and seed. We had to reduce the number and size of our program by 30% and some of the breeding nurseries had to be moved to 2021. Greenhouse operations were severely curtailed.

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

    All of our graduate and undergraduate students participate in the collection and analysis of data from our FHB nurseries.

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

Data was collected and sent to our collaborators for genomic prediction.

Project 4: *Genetics and Breeding of FHB Resistant Soft White & Red Winter Wheat for the Northeastern U.S.*

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

1) Develop FHB resistant soft white and red winter wheat cultivars for the northeastern U.S. in collaboration with Gary Bergstrom, Department of Plant Pathology. Evaluate our elite lines in the Cornell University FHB Advanced Line nursery.
2) Pyramid FHB resistance genes by hybridizing elite lines with native FHB resistance to exotic sources of FHB resistance both Asian and other sources.
3) Evaluate FHB resistant lines in New York regional and state trials for release, farmer recommendations, and seed increase.
4) Participate in the coordinated sharing of information from the above activities to generate a comprehensive source of information that can be used in forward breeding strategies.
5) Implement recurrent mass selection in dominant male sterile populations in soft winter wheat backgrounds adapted to the eastern US.

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?

Breeding and selection of elite winter wheat lines and varieties with native and/or exotic sources of resistance to FHB, created elite populations segregating for FHB resistance that were used with marker assisted selection in variety development. Our FHB trials generated variety FHB resistance recommendations for farmers and other stakeholders, and distribution of information to collaborators and stakeholders.

b) What were the significant results?

We developed 393 early generation plots and half involved FHB parents in crosses. Our screening nursery had 154 plots and all were from FHB crosses. Our Preliminary Yield Trial had 214 FHB entries. Our state-wide trial had 12 soft red and 20 soft white winter FHB entries. We evaluated 591 new FHB selected lines in our misted, inoculated FHB nursery. We have evaluated 60 lines extracted from our Half-Sib Recurrent Selection population for 2 years and will prepare a germplasm release next year.

c) List key outcomes or other achievements.

We grew Breeder seed of a new soft white winter wheat that has excellent resistance to FHB and has been approved for release. Nearly all of the lines from the recurrent selection project have better FHB resistance than the most resistant check.

3. **Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns and/or restrictions, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.**

Yes – We were not allowed to hire summer temporary employees. This necessitated greatly reducing the workload for winter wheat fhb trials. Consequently, we were unable to harvest one of our regional trials because of lack of labor. We were able to collect data and harvest all of our winter FHB nurseries and the data quality was excellent. Greenhouse operations were greatly reduced thus limiting the number of FHB crosses we could make.

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

All of my grad students receive training in plant breeding methods and evaluation of FHB in our misted, inoculated nursery. Also, our undergraduate summer field assistants receive training and background information on our winter wheat FHB nurseries. We trained a new field assistant this year.

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

Each year we publish the results of our state regional trials for both sft red and soft white winter wheat including FHB and milling and baking quality hard copy through mail or email and online.
Cornell Small Grains Performance Trials:
Soft White Winter Wheat - https://cpb-us-e1.wpmucdn.com/blogs.cornell.edu/dist/5/8858/files/2020/10/SWWW-Reg20-table-SWWW-Table.pdf
Soft Red Winter Wheat - https://cpb-us-e1.wpmucdn.com/blogs.cornell.edu/dist/5/8858/files/2020/10/SRW-Reg20-Table-SRW-Table.pdf

We also present the results at three fields days and two workshops for extension agents.

Project 5: *Coordinated Phenotypes of Soft Wheat Germplasm for the Midwest*

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

   Specific objectives are:
   1) Phenotype advanced breeding lines that are candidates for release;
   2) Place FHB and other agronomic, disease resistance, and quality data in database and
   3) Report on purification and seed increase of the best lines.

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?**
   The coordinated testing of advanced lines in the various uniform and state-wide trials plus the data summaries for lines that are candidates for release was used to determine the FHB resistance of nearly all germplasm that is currently released, or likely to be released in the near future. Data were uploaded to T3.

   b) **What were the significant results?**
   Data and summaries were made available to collaborators, stakeholders and uploaded to the T3 database.

   c) **List key outcomes or other achievements.**
   The results were used to select parents for crossing and for advancement in our trials.

3. **Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns and/or restrictions, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.**

   Yes – We were not allowed to hire summer temporary employees. This necessitated reducing the workload for winter wheat FHB trials however, we were still able to collect data and harvest all of our winter FHB nurseries and the data quality was excellent.

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

   All of my grad students receive training in plant breeding methods and evaluation of FHB in our misted, inoculated nursery. Also, our undergraduate summer field assistants receive training and background information on our winter wheat FHB nurseries. We trained a new field assistant this year.

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

Each year we publish the results of our state regional trials for both soft red and soft white winter wheat including FHB and milling and baking quality hard copy through mail or email and online.
Cornell Small Grains Performance Trials:

Soft White Winter Wheat - https://cpb-us-e1.wpmucdn.com/blogs.cornell.edu/dist/5/8858/files/2020/10/SWWW-Reg20-table-SWWW-Table.pdf

Soft Red Winter Wheat - https://cpb-us-e1.wpmucdn.com/blogs.cornell.edu/dist/5/8858/files/2020/10/SRW-Reg20-Table-SRW-Table.pdf

We also present the results at three field days and two workshops for extension agents.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY20 award period (5/3/20 - 5/2/21). The term "support" below includes any level of benefit to the student, ranging from full stipend plus tuition to the situation where the student's stipend was paid from other funds, but who learned how to rate scab in a misted nursery paid for by the USWBSI, and anything in between.

1. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their MS degree during the FY20 award period?**
   ☐Yes ☒No
   If yes, how many? Click to enter number here.

2. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY20 award period?**
   ☒Yes ☐No
   If yes, how many? Click to enter number here.

3. **Have any post docs who worked for you during the FY20 award period and were supported by funding from your USWBSI grant taken faculty positions with universities?**
   ☒Yes ☐No
   If yes, how many? 1

4. **Have any post docs who worked for you during the FY20 award period and were supported by funding from your USWBSI grant gone on to take positions with private ag-related companies or federal agencies?**
   ☒Yes ☐No
   If yes, how many? 2

Release of Germplasm/Cultivars

Instructions: In the table below, list all germplasm and/or cultivars released with full or partial support through the USWBSI during the FY20 award period (5/3/20 - 5/2/21). All columns must be completed for each listed germplasm/cultivar. Use the key below the table for Grain Class abbreviations.

NOTE: Leave blank if you have nothing to report or if your grant did NOT include any VDHR-related projects.

Name of Germplasm/Cultivar	Grain Class	FHB Resistance	FHB Rating (0-9)	Year Released
NY99056-161	SWW - Soft White Winter	MR - Moderately Resistant	5	2020
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year
Click here to enter text.	Select Grain Class	Select what represents your most resistant check	Enter as text 0-9 rating	Select Year

NOTE: List the associated release notice or publication under the appropriate sub-section in the 'Publications' section of the FPR.

Publications, Conference Papers, and Presentations

Instructions: Refer to the PR_Instructions for detailed more instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY20 grant award. Only citations for publications published (submitted or accepted) or presentations presented during the **award period (5/3/20 - 5/2/21**) should be included. If you did not publish/submit or present anything, state 'Nothing to Report' directly above the Journal publications section.

NOTE: Directly below each citation, you **must** indicate the Status (i.e. published, submitted, etc.) and whether acknowledgement of Federal support was indicated in the publication/ presentation. See example below for a poster presentation with an abstract:

Z.J. Winn, R. Acharya, J. Lyerly, G. Brown-Guedira, C. Cowger, C. Griffey, J. Fitzgerald, R.E. Mason and J.P. Murphy. 2020. "Mapping of Fusarium Head Blight Resistance in NC13-20076 Soft Red Winter Wheat." In: S. Canty, A. Hoffstetter, and R. Dill-Macky (Eds.), *Proceedings of the 2020 National Fusarium Head Blight Forum (*p. 12.), Virtual; December 7-11. Online: https://scabusa.org/pdfs/NFHBF20_Proceedings.pdf.
Status: Abstract Published and Poster Presented
Acknowledgement of Federal Support: YES (Abstract and Poster)

Journal publications.

Sweeney, D.W., J. Rutkoski, G.C. Bergstrom, M.E. Sorrells, 2020. A connected half-sib family training population for genomic prediction in barley. *Crop Science* 60: 262– 281. https://doi.org/10.1002/csc2.20104.
Status: Published
Acknowledgement of Federal Support: Yes

Veenstra, L.D., J. Poland, Jannink, and M.E. Sorrells. 2020. Recurrent genomic selection for wheat grain fructans. Crop Science 60:1499-1512. DOI: 10.1002/csc2.20130.
Status: Published
Acknowledgement of Federal Support: Yes

Fulcher, M.R., J.B. Winans, D., Benscher, M.E. Sorrells and G.C. Bergstrom. 2021. Triticum varieties grown as 'ancient grains' in New York differ in susceptibility to Fusarium head blight and harbor diverse Fusarium flora. European Journal of Plant Pathology, 1–7. https://doi.org/10.1007/s10658-020-02183-7.
Status: Published
Acknowledgement of Federal Support: Yes

Lugo-Torres, A., G.C. Bergstrom, D. Benscher, and M.E. Sorrells. 2021. Evaluation of Fusarium head blight and foliar diseases in spring malting barley varieties in New York, 2020. Plant Disease Management Reports 15: CF150.
Status: Published
Acknowledgement of Federal Support: Yes

Varshney, R.K., A. Bohra, J. Yu, A. Graner, Q. Zhang, M.E. Sorrells. 2021. Designing future crops: genomics-assisted breeding comes of age. Trends in Plant Sciences. 26:631-649. doi.org/10.1016/j.tplants.2021.03.010.
Status: Published
Acknowledgement of Federal Support: No

Books or other non-periodical, one-time publications.

Korzun, V., M. L. Ponomareva and M.E. Sorrells. 2021. Economic and academic importance of rye. In: The Rye Genome. N. Stein Ed., Springer
Status: Published
Acknowledgement of Federal Support: No

Other publications, conference papers and presentations.

2020 Small Grains Performance Trials for New York.
Status: Published
Acknowledgement of Federal Support: Yes

Description and Proposal for Release of NY99056-161 Soft White Winter Wheat – Cornell Cooperative Extension Publication.
Status: Published
Acknowledgement of Federal Support: Yes