USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY18 Performance Report
Due date: July 12, 2019

Cover Page

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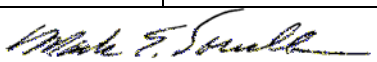
Fiscal Year:	2018
USDA-ARS Agreement ID:	59-0206-8-196
USDA-ARS Agreement Title:	Development of FHB Resistant Wheat and Barley Varieties for the Northeastern U.S.
FY18 USDA-ARS Award Amount:	$ 109,753
Recipient Organization:	Cornell University 341 Pine Tree Road Ithaca NY 14850
DUNS Number:	872612445
EIN:	15-0532082
Recipient Identifying Number or Account Number:	1498554
Project/Grant Reporting Period:	5/3/18 - 5/2/19
Reporting Period End Date:	05/02/19

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
BAR-CP	Interstate Spring 2-rowed Malting Barley Breeding for FHB Resistance and Reduced DON.	$ 23,910
VDHR-NWW	Genetics and Breeding of FHB Resistant Soft White & Red Winter Wheat for the Northeastern U.S.	$ 69,584
VDHR-NWW	Male Sterile Facilitated Recurrent Selection for FHB Resistance.	$ 1,264
VDHR-NWW	Coordinated Phenotyping of Uniform Nurseries and Official Variety Trials.	$ 3,388
VDHR-NWW	Use of Genomic Selection to Improve FHB Resistance and Yield in Northern SWW.	$ 11,607
	FY18 Total ARS Award Amount	$ 109,753



9 July 2019

Principal Investigator Date

* MGMT – FHB Management
FST – Food Safety & Toxicology
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

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

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

The overall goal of this project is to develop spring 2-row malting barley varieties with FHB resistance and adaptation to the northeastern U.S.

Specifically:
1) Evaluate FHB resistance in spring malting barley varieties in a Uniform Eastern Spring Malting Barley nursery coordinated by Richard Horsley at North Dakota State University,
2) Evaluate FHB resistance in malting barley varieties in the New York State Regional Spring and Winter Malting Barley testing program,
3) Evaluate FHB resistance and agronomic traits in our NY spring 2-row elite line training population, and
4) Use genomic selection to develop spring 2-row malting barley varieties with FHB resistance and adaptation to the northeastern U.S.

2. What was accomplished under these goals? *Address items 1-4) below for each goal or objective.*

1) major activities: Evaluation of all experimental lines, cooperative and regional trial entries for both winter and spring barley in our misted, irrigated FHB nursery.

2) specific objectives: In our misted, inoculated FHB nursery we evaluated all entries from the Winter Malting Barley Trial, Eastern Spring Malting Barley (ESBN) Trial, Cornell Regional Winter and Spring Malting Barley Trials, our advanced spring malting barley breeding program, and potential new sources of resistance for both spring and winter barley from the J. Innes Center.

3) significant results: We collected replicated incidence, severity and FHB damaged kernels data on 90 JIC spring barley lines, 25 ESBN lines, 22 Spring Malting Barley Regional entries, 391 diverse naked selections, 30 WMBT entries, 28 Winter Malting Barley Regional entries, and 25 lines in an elite naked barley trial. In our spring barley breeding program, we tested 100 elite lines in 5 locations. We also made 100 crosses in our spring barley breeding program where we are selecting for FHB resistance using genomic selection.

4) key outcomes or other achievements: Over the past 5 years, we have accumulated reliable FHB data for winter and spring malting barley varieties as well as some new sources of resistance for New York. Also, we have been able to determine optimum application times for fungicides. This is critical information because before 2013 there was no malting barley grown in NY. The NY Farm Brewery Legislation requires that they use New York-grown ingredients creating a new market for malting barley that is required by

craft maltsters and brewers. We have disseminated the cultural practice information to extension agents and farmers through field days, workshops and web sites.

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

Daniel Sweeney is a PhD candidate who is in charge of the spring malting barley breeding program. Together we have designed a high intensity breeding program using the latest technologies to generate high quality breeding lines that are candidates for variety release in the shortest possible time. We anticipate releasing a Cornell spring malting barley variety in 2020. Karl Kunze is in charge of my winter malting barley and organic naked barley breeding program. 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 both winter and spring FHB nurseries.

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

Describe how the results have been disseminated to communities of interest. Include any outreach activities that have been undertaken to reach members of communities who are not usually aware of these research activities, for the purpose of enhancing public understanding and increasing interest in learning and careers in science, technology, and the humanities.

Each year we publish the results of our state regional trials for both spring and winter malting barley including FHB and malting quality data in hard copy through mail or email and online.

Cornell Small Grains Performance Trials - 2017 Winter Malting Barley
https://plbrgen.cals.cornell.edu/sites/plbrgen.cals.cornell.edu/files/shared/WMB%20Reg17%20Table.pdf
Cornell Small Grains Performance Trials - 2017 Spring Malting Barley
https://plbrgen.cals.cornell.edu/sites/plbrgen.cals.cornell.edu/files/shared/SMB%20Reg17%20Table.pdf

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

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Project 2: *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 project?

The climate in the northeastern U.S requires that farmers grow FHB resistant wheat. FHB is the single greatest problem for successful production of soft white and red winter wheat in New York.

Our objectives are to:

1) Develop FHB resistant soft red and white 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 new sources of FHB resistance, both Asian and other sources.
3) Evaluate FHB resistant lines in New York regional 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.

2. What was accomplished under these goals? *Address items 1-4) below for each goal or objective.*

1) major activities: Breeding, FHB nursery evaluations, recurrent selection, genomic selection, marker assisted selection.

2) specific objectives; Breeding – 37 new crosses made with alien sources of FHB resistance, 48 new general FHB crosses made from FHB nursery selections; In our advanced trials, we have 7 new soft red FHB line and 2 second-year selections. In our soft white winter wheat advanced trial we have 13 new FHB lines and 9 second-year entries. In our Master nursery, we have 48 FHB selected entries. Eighty four lines that were selected using genomic selection were evaluated in two trials.

3) significant results: Our breeding program is the only public wheat breeding program in the northeastern U.S. that is releasing soft white and red winter wheat varieties that have been selected for FHB resistance. The wheat varieties grown in NY are nearly all from Cornell and Pioneer and all are moderately susceptible to moderately resistant to FHB. Branded varieties are often not tested because the companies do not want to enter their varieties in our testing program. Branded varieties are grown on a very small acreage in NY.

4) key outcomes or other achievements: We successfully commercialized Jensen and Medina soft white winter wheat varieties that have improved resistance to FHB. Because most of the DON is in the bran, FHB resistance in white wheat is a more important problem than it is for red wheat because white wheat bran is widely marketed to the food industry for use as an additive in high bran food products. We are also developing FHB resistant soft red winter

wheat varieties for this region and we have collaborated with Ohio State University to release Otsego and Erie. Over the past 8 years we have released 6 new soft winter wheat varieties with at least moderate FHB and preharvest sprouting resistance. Two of the varieties have fhb1 from marker assisted backcrossing and four have native resistance. Except for branded varieties, all varieties marketed in NY have at least some level of resistance to FHB. We strongly advise farmers not to grow susceptible varieties. We anticipate the release of a new soft white winter wheat variety this year that has excellent resistance to FHB.

3. 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 both winter and spring FHB nurseries. All students and postdocs participate in taking field notes and harvest.

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

Describe how the results have been disseminated to communities of interest. Include any outreach activities that have been undertaken to reach members of communities who are not usually aware of these research activities, for the purpose of enhancing public understanding and increasing interest in learning and careers in science, technology, and the humanities.

Each year we publish the results of our state regional trials for both spring and winter malting barley including FHB and malting quality data in hard copy through mail or email and online.

Cornell Small Grains Performance Trials (https://plbrgen.cals.cornell.edu/research-extension/small-grains/cultivar-testing/)

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

Project 3: *Male Sterile Facilitated Recurrent Selection for FHB Resistance.*

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

Objective 1: Increase and document acreage seeded to varieties with improved FHB resistance to increase grain yield and grain quality and reduce DON in the US grain supply.

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

Objective 3: 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.

Recurrent selection is not a new breeding technology but it is one that has a proven track record and has not been used for improving FHB in the past. Results from this past year are very encouraging.

2. What was accomplished under these goals? *Address items 1-4) below for each goal or objective.*

1) major activities: Intermating dominant male sterile lines with multiple sources of resistance, selection of resistant plants, evaluation of selections.

2) specific objectives: The specific objects are to develop soft winter wheat populations with multiple sources of FHB resistance and improve those populations by recurrent selection.

3) significant results: To initiate this project, the dominant male sterile population was allowed to intermate with entries in the NWWSN for two generations. The population was then intermated for a generation followed by half sib selection. Since then, the dominant male sterile population was planted as replicated half sib families in the misted, inoculated FHB nursery. Male sterile plants were tagged at anthesis and three weeks later each half sib family was scored for FHB incidence and severity. The most resistant 25% of the families were selected and within each family, male sterile plants that showed the fewest symptoms were selected and harvested. Those selected plants became the half sibs for the next generation. A bulk harvest of the selected half sibs was planted adjacent to the half sib families to serve as a pollen source for the male steriles. In addition, male fertile plants from the selected families were planted in a replicated trial to determine if there has been an increase in FHB resistance resulting from selection over the past 5 generations.

4) key outcomes or other achievements: This past year I evaluated 72 lines from this project and all but 5 of them had a higher level of resistance than Truman. For 2019, I have added 60 more and these 142 will be grown in 2 replicates. We have released four soft white and two soft red winter wheat varieties with moderate resistance to FHB. Results from the evaluation of fertile segregates from selected half sib families this year indicate that we have developed a population of adapted soft wheat with a very high level of FHB resistance. Although these lines have potential for variety release, they are more likely to be used as a multi-genic source of FHB resistance. These populations will be beneficial to regional and local breeding programs because they are an adapted population with multiple sources of FHB resistance in a soft winter wheat genetic background. This project will provide breeding programs in the eastern region with germplasm from which to extract breeding lines that have the potential to have unique combinations of FHB resistance genes. We will characterize this population and publish a germplasm release. We submit our data to the T3 database each year.

3. 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 both winter and spring FHB nurseries. All students and postdocs participate in taking field notes and harvest. In addition, for this nursery, I teach my students how to carry out modified half-sib selection.

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

Describe how the results have been disseminated to communities of interest. Include any outreach activities that have been undertaken to reach members of communities who are not usually aware of these research activities, for the purpose of enhancing public understanding and increasing interest in learning and careers in science, technology, and the humanities.

We have reported the results of this project to other members of the Northern Winter Wheat FHB community. Once we have completed the evaluation of the fertile selections, we will prepare a germplasm release publication.

Project 4: *Coordinated Phenotyping of Uniform Nurseries and Official Variety Trials.*

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

Objectives:

1) Increase and document acreage seeded to varieties with improved FHB resistance to increase grain yield and grain quality and reduce DON in the US grain supply.

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

3) 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.

2. What was accomplished under these goals? *Address items 1-4) below for each goal or objective.*

1) major activities: major activities – Each year we have collected incidence, severity, FDK, and DON data on the NUWWSN by evaluating it in a misted inoculated FHB nursery. We normally enter four of our own experimental lines in the NUWWSN each year and enter the data from our NUWWSN location in a coordinated database.

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

3) significant results – Advanced lines that perform well in this nursery are entered into our state regional trials to determine if they are suitable for variety release. This project has been important for helping in the identification of two new soft white and three new soft red winter wheat lines that are in the final stages of regional testing as candidates for release within the next year. Previously we released four soft white and two soft red winter wheat varieties with moderate resistance to FHB. Our soft white variety Medina is the only white variety grown in NY. In the red wheat market we compete with Pioneer and a couple of branded varieties.

4) key outcomes or other achievements: The results are included in our regional trial summaries that are distributed to extension personnel, farmers, and seed companies and published on the Internet. We also contribute to the T3 public database. The NUWWSN is our primary source of new FHB resistance and each year we introduce new lines from the NUWWSN into our crossing block. We routinely use MAS for Fhb1, 5A and 2D resistance loci.

3. 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 both winter and spring FHB nurseries. All students and postdocs participate in evaluating lines in our FHB nursery, taking field notes on agronomic traits and harvest.

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

Describe how the results have been disseminated to communities of interest. Include any outreach activities that have been undertaken to reach members of communities who are not usually aware of these research activities, for the purpose of enhancing public understanding and increasing interest in learning and careers in science, technology, and the humanities.

Each year we publish the results of our state regional trials for both spring and winter malting barley including FHB and malting quality data in hard copy through mail or email and online.

Cornell Small Grains Performance Trials (http://smallgrains.cals.cornell.edu)

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

Project 5: *Use of Genomic Selection to Improve FHB Resistance and Yield in Northern Soft Winter Wheat.*

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

   Objectives:

   1) Increase and document acreage seeded to varieties with improved FHB resistance to increase grain yield and grain quality and reduce DON in the US grain supply.

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

   3) 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.

2. **What was accomplished under these goals?** *Address items 1-4) below for each goal or objective.*

   1) major activities: Genotyping advanced lines and phenotyping them for model training, line selection and crossing

   2) specific objectives:
      - To implement GS for FHB resistance in soft winter wheat by completing two cycles of GS.
      - Initiate evaluation of the effectiveness of GS for FHB resistance in soft winter wheat lines.

   3) significant results: The results of the cycles 1 through 4 of genomic selection are currently being analyzed and will be reported this winter and in a publication. We increased the capacity of our misted inoculated nursery to accommodate this project. We submit our data to the T3 database each year.

   4) key outcomes or other achievements: Over the past three years we have phenotyped a training population of 649 lines. This included 600 RILs consisting of 100 lines from each of six breeding programs, each phenotyped at the breeder's location and 49 checks that were phenotyped by all six breeders at all locations and years. The lines selected using GS are currently being evaluated to measure gain from selection. Collaborators on this project have released several soft wheat varieties that have impacted the proportion of resistant varieties grown in the eastern region. Germplasm from this project will be used in our crossing block to introduce new sources of resistance to FHB.

3. 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 both winter and spring FHB nurseries. All students and postdocs participate in taking field notes on agronomic traits and help with harvest.

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

Describe how the results have been disseminated to communities of interest. Include any outreach activities that have been undertaken to reach members of communities who are not usually aware of these research activities, for the purpose of enhancing public understanding and increasing interest in learning and careers in science, technology, and the humanities.

Each year we publish the results of our state regional trials for both spring and winter malting barley including FHB and malting quality data in hard copy through mail or email and online.

The results of this project are currently being analyzed and will be reported this winter at the Scab Forum and in a publication.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY18 award period. 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 FY18 award period?**

   If yes, how many? None

2. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY18 award period?**

   If yes, how many? None

3. **Have any post docs who worked for you during the FY18 award period and were supported by funding from your USWBSI grant taken faculty positions with universities?**

   If yes, how many? None

4. **Have any post docs who worked for you during the FY18 award period and were supported by funding from your USWBSI grant gone on to take positions with private ag-related companies or federal agencies?**

   If yes, how many? None

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 FY18 award period. 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** (S, MS, MR, R, where R represents your most resistant check)	**FHB Rating** (0-9)	**Year Released**
NY99056-161	SWW	MR	7	2019

Add rows if needed.

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

Abbreviations for Grain Classes

Barley - BAR
Durum - DUR
Hard Red Winter - HRW
Hard White Winter - HWW
Hard Red Spring - HRS
Soft Red Winter - SRW
Soft White Winter - SWW

Publications, Conference Papers, and Presentations

Instructions: Refer to the FY18-FPR_Instructions for detailed instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY18 grant. Only include citations for publications submitted or presentations given during your award period (5/3/18 - 5/2/19). If you did not have any publications or presentations, state 'Nothing to Report' directly above the Journal publications section.

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

> Conley, E.J., and J.A. Anderson. 2018. Accuracy of Genome-Wide Prediction for Fusarium Head Blight Associated Traits in a Spring Wheat Breeding Program. In: Proceedings of the XXIV International Plant & Animal Genome Conference, San Diego, CA.
> Status: Abstract Published and Poster Presented
> Acknowledgement of Federal Support: YES (poster), NO (abstract)

Journal publications.

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

Sweeney, D.W., J. Sun, E. Taagen, M.E. Sorrells. 2018. Genomic Selection in Wheat. In: Miedaner, T., V. Korzun., editors, Applications of Genetic and Genomic Research in Cereals. Woodhead Publishing,p.273-302.
Status: Published
Acknowledgement of Funding Support: No

Neyhart, J.L., D. Sweeney, M. Sorrells, C. Kapp, K.D. Kephart, J. Sherman, E.J. Stockinger, S. Fisk, P. Hayes, S. Daba, M. Mohammadi, N. Hughes, L. Lukens, P. González Barrios, L. Gutiérrez, and K.P. Smith. 2019. Registration of the S2MET Barley Mapping Population for Multi- Environment Genomewide Selection. Journal of Plant Registrations doi:10.3198/jpr2018.06.0037crmp
Status: Published
Acknowledgement of Funding Support: Yes

Other publications, conference papers and presentations.

Cornell Small Grains Performance Trials – Hard copy mailed and pdf emailed to about 250 people. https://plbrgen.cals.cornell.edu/research-extension/small-grains/cultivar-testing/
Status: Published
Acknowledgement of Funding Support: Yes

Small Grains Varieties for NY – Small Grains Management Field Day, Aurora, NY June 7
Status: Presented
Acknowledgement of Funding Support: Yes

Small Grains Varieties for NY –Seed Growers Field Day, Ithaca, NY - July 3
Status: Presented
Acknowledgement of Funding Support: Yes

Small Grains Varieties for NY – In Service Cooperative Extension Agent Training, Ithaca, NY, Invited November 14.
Status: Presented
Acknowledgement of Funding Support: Yes

Born Bred and Brewed in NY - Malting barley varieties for NY, Empire Barley and Malt Summit, Liverpool, NY, Invited December 14.
Status: Presented
Acknowledgement of Funding Support: Yes