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:	59-0206-0-175
USDA-ARS Agreement Title:	Integrated Management Tools to Reduce FHB Impact in the Intermountain West and the PNW
Principle Investigator (PI):	Juliet Marshall
Institution:	University of Idaho
Institution UEI:	QWYKRJH5NNJ3
Fiscal Year:	2021
FY21 USDA-ARS Award Amount:	$125,356
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Period of Performance:	6/1/21 - 5/31/23
Reporting Period End Date:	5/31/2023

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
BAR-CP	Determining FHB Susceptibility in Barley Cultivars in the Western US	$43,259
VDHR-SPR	Determining FHB Susceptibility in Wheat Cultivars in the Western US	$61,999
MGMT	Efficacy of a New Fungicide for FHB and DON Management in Idaho Integrated Management Studies	$20,098
	FY21 Total ARS Award Amount	$125,356

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.

Juliet M. Marshall — 7/26/2023

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: Determining FHB Susceptibility in Barley Cultivars in the Western US

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

FHB damage in spring grain continues to increase in southern and eastern Idaho. In 2015, fields of barley showed signs of the disease and many spring wheat fields tested at >5 ppm DON, even after appropriate treatments with fungicides. Large production areas north of Idaho Falls resulted in rejection of barley for malting due to high levels of DON. In 2018, 40,000 bu of barley was rejected from one producer alone near Rupert, Idaho. The majority of the barley varieties that are available to growers in the area are susceptible to FHB. Growers need information on FHB susceptibility of the varieties that currently are being grown and those newly released. Breeders need information on advanced lines and breeding material to release selections with reduced vulnerability to FHB damage and DON accumulation. Management practices need to be tested under the unique conditions in the irrigated production regions of the Intermountain West to develop appropriate management practices to reduce FHB and DON.
Project goals: Our specific objectives for this proposal were to: 1) determine the degree of susceptibility that exists in currently grown varieties and advanced lines to local *Fusarium graminearum* isolates; and 2) provide DON data to local breeders and growers to increase the ability to select the best varieties for breeding and production.

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?**

An assessment of released barley cultivars and advanced lines from entries in the University of Idaho Extension Variety trials was conducted in on-station FHB nurseries at the Aberdeen Research and Extension Center. A second location at the USDA-ARS research facility at Kimberly, Idaho was added to increase the number of environments and to include an environment more conducive to infection. Winter barley from the UI Extension Variety Trials were planted as well as awas planted at the Kimberly location Resistant and susceptible checks for the spring nursery were: Chevron and Quest were included as the six-row resistant checks; PI383933 and Stander as susceptible checks. ICB111809 was the two-rowed susceptible check, and Clho4196 was the 2-row resistant check. Experimental units consisted of two row plots with two replications using a randomized complete block design. Plots were 5-foot rows planted with a Hege 1000 headrow planter. Special irrigation systems were designed and installed to provide an environment conducive for FHB infection while simultaneously meeting the irrigation needs of the crop.

Autoclaved corn was inoculated with *F. graminearum* and allowed to grow for three weeks before drying. Corn spawn was spread in the field approximately three weeks prior to anthesis or head emergence of the earliest lines at 60 grams per plot. Barley plots were inoculated with a spore suspension of macroconidia of *F. graminearum* at head emergence. Barley symptom development has been more difficult to induce and disase development was greater after inoculation with both corn spawn and a spore suspension of 100,000 conidia per L. Plots were inoculated twice (100,000 conidia per L) with conidial suspension starting at head emergence (Feekes GS 10.1, June 9) using a CO_2 backpack sprayer with three 8003 VS nozzles at a ground speed of 1 sec/ft at 40 psi. A second inoculation of each barley plot occurred one week after the first. An irrigation system with sprinkler nozzles every 20 feet was used both for irrigation and increasing humidity in the plant canopy. After inoculation, plots were irrigated every other day

for two hours. A supplementary misting system with nozzles every 10 feet was also used for the barley screening nursery. The misters ran every 3 minutes every 2 hours between 9PM to 3AM and 9AM to 11AM.

b) What were the significant results?

Good disease formed in the spring and winter nurseries, allowing us to confirm the level of genetic tolerance or susceptibility of currently produced varieties. DON levels were also obtained with the collaboration of Dr. Yanhong Dong, University of Minnesota. Disease development in 2021 as determined by the FHB Index in winter barley varieties ranged from "Resistant" of 0.1 (2WI14-7577) to Susceptible at 10.5 (Sunstar Pride). DON levels in harvested grain varied from a low of 2.9 ppm to 23.4 ppm.

FHB Index in spring barley in Kimberly ranged from "moderately resistant" to very susceptible. One 6-rowed feed barley (YU510-510) was identified as highly susceptible and the grain accumulated high levels of DON. Released varieties were identified with high FHB Indices and DON levels (Oreana and Diamondback feed barleys and malt barleys Moravian 164, Moravian 179, Moravian 180, LCS Opera, LCS Odyssey, and LCS Genie).

Winter barley was not planted in Aberdeen due to cooler conditions at heading that generally result in poor infection. Spring barley infection at Aberdeen was not as severe as in Kimberly, but ranking of disease severity (FHB Index) was similar. However, KWS Amadora was identified as being very susceptible, with an FHB Index of 35.9 and DON of 12.1 ppm.

c) List key outcomes or other achievements.

Two barley related abstracts were presented from the results of the FY21 testing. The 6-rowed feed barley (YU510-510) identified as highly susceptible was susbsequently utilized as a susceptible check in additional studies. Highland Specialty Grains eventually replaced FHB susceptible Oreana with another high-yielding feed barley (Carleton, released in 2023) that had reduced disease susceptibility and lower DON accumulation. Moravian 179 is still grown, but fungicide applicaitons are employed to reduce disease and DON in production.

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

I have a PhD student that has been working on this project (previously as a technician), whose responsibilities have been to develop inoculum, organize inoculations, analyze data and assist in preparing reports. The PhD project will incorporate weather data to assist in the development of predictive models that are specific to the intermountain West irrigated environment. I also had a postdoctoral fellow training to supervise the nursery following the graduation of the PhD student.

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

The results of all the trials are published in our Annual Small Grains Report, disseminated to collaborating breeders, presented at various grower seminar and field events, and reported annually at the Scab Forum.

Project 2: Determining FHB Susceptibility in Wheat Cultivars in the Western US

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

FHB damage in spring grain continues to increase in southern and eastern Idaho. Several years in a row, fields of spring wheat showed signs of the disease and many spring wheat fields tested at >5 ppm DON, even after appropriate treatments with fungicides. Growers now regularly incorporate fungicide treatments for FHB suppression as standard practices for susceptible varieties. The majority of the wheat varieties that are available to growers in the area are susceptible to FHB. Growers need information on FHB susceptibility of the varieties that currently are being grown and those newly released. Breeders need information on advanced lines and breeding material to release selections with reduced vulnerability to FHB damage and DON accumulation. Management practices need to be tested under the unique conditions in the irrigated production regions of the Intermountain West to develop appropriate management practices to reduce FHB and DON in susceptible cultivars.

Project goals: Our specific objectives for this proposal were to: 1) determine the degree of susceptibility that exists in currently grown varieties and advanced lines to local *Fusarium graminearum* isolates, 2) provide DON data to local breeders and growers to increase the ability to select the best varieties for breeding and production. Awareness of variety reaction to FHB determines need for potential fungicide applications. Specific objectives - The specific objectives were to screen currently grown varieties to determine degree of susceptibility and assess risk of DON under intermountain west irrigated production conditions, and to select for increased resistance in breeding lines of wheat and barley to improve FHB resistance and reduce DON in newly released varieties.

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?

An assessment of released wheat cultivars and advanced lines from entries in the University of Idaho Extension Variety trials was conducted in on-station FHB nurseries at the Aberdeen Research and Extension Center. A second location at the USDA-ARS research facility at Kimberly, Idaho was added to add winter wheat testing, increase the number of environments and to include an environment more conducive to infection. Additional breeder material from Montana State University and a private breeding company (a division of Nutrien Ag) were included for testing. Winter wheat classes of soft whoite winter, hard white winter, and hard red winter where tested in Kimberly in conjunction with the USDA-ARS sites in Aberdeen and Kimberly. Spring wheat classes of soft white, hard white and hard red spring wheat were tested of existing varieties and advanced cultivars. Resistant and susceptible checks were: (for wheat) Jefferson hard red spring (susceptible check), and Rollag hard red spring (resistant check). Experimental units consisted of two-row plots with two replications using a randomized complete block design. Plots were 5-foot-long rows planted with a Hege 1000 headrow planter. Special irrigation systems were designed and installed to provide an environment conducive for FHB infection while simultaneously meeting the irrigation needs of the crop.

Autoclaved corn was inoculated with *F. graminearum* and allowed to grow for three weeks before drying. Corn spawn was spread in the field approximately three weeks prior to anthesis of

the earliest lines at 60 grams per plot. During and after anthesis, plots were irrigated every other day for two hours. An irrigation system with sprinkler nozzles every 20 feet is used both for irrigation and increasing humidity in the plant canopy. A misting system provided additional moisture to increase likelihood of infection every day Monday through Sunday (run intermittently for 5 hours in the evening 5pm-10pm and three hours in the morning 6am-9am).

FHB was assessed in each plot at about soft dough (Feekes 11.2). Scab readings were done 21 days after flowering (24 days post-heading). Thirty spikes per plot were rated for percent disease severity. Percent incidence was determined by calculating the proportion of infected and the total number of assessed heads. FHB index is calculated using the formula: FHB Index = (% severity x % incidence) /100. On-site weather stations were used to collect temperature and humidity data. Plots were harvested using Wintersteiger Classic small plot combine and weighed for yield and test weight. Harvested samples were assessed for VSK prior to testing for DON. Samples were ground and submitted to the USWBSI-funded DON testing laboratories in St. Paul, MN for DON analysis.

b) What were the significant results?

Good disease formed in the winter and spring nurseries in Kimberly, and the spring nurseries in Aberdeen, allowing us to confirm the level of genetic tolerance or susceptibility of currently produced varieties. DON levels were also obtained with the collaboration of Dr. Yanhong Dong, University of Minnesota. Consistent levels of disease have been achieved for several years.

Disease development as determined by the FHB Index in winter wheat varieties ranged from “Moderately susceptible” of 8.9 (WB4623CLP) to Very Susceptible at 52.2 (Yellowstone) and 60.2 (WB1783). DON levels in harvested grain varied from a low of 3.9 ppm (WB4623CLP) to 69 ppm (WB1783). Disease pressure was very high and FHB Index in spring wheat in Kimberly ranged from “susceptible” to very susceptible. Rollag had the lowest FHB Index at 25.5 and 11.8 ppm DON. DON levels ranged from a low of 17.2 ppm to 71 ppm in the durum wheat Alzada.

Winter wheat was not planted in Aberdeen due to cooler conditions at heading that generally result in poor infection. Spring wheat infection at Aberdeen was not as severe as in Kimberly, but even Rollag had high levels of infection, with an Index of 17.4 and DON at 1.5 ppm. One Montana State University line, DuClair, showed lower levels of disease and similar low levels of DON than Rollag.

c) List key outcomes or other achievements.

The results of the previous FHB experiments and this study was/will be presented numerous times at the local, national and international level. Consultants and breeding companies in the area have used this data to improve variety recommendations, and growers now regularly spray to reduce FHB and DON in susceptible and moderately susceptible spring wheat cultivars. Growers are now aware of the varieties that are less likely to get FHB and suffer high DON, and to spray those varieties they know are vulnerable, especially when following corn in their crop rotations.

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

We have trained two graduate students on these projects (one PhD candidate and one MS candidate) as well as additional training for a support scientist who have or will present the results at the USWBSI Forum.

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

The results of all the trials are published in our Annual Small Grains Report, disseminated to collaborating breeders, presented at various grower seminar and field events, and reported annually at the Scab Forum.

Project 3: Efficacy of a New Fungicide for FHB and DON Management in Idaho Integrated Management Studies

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

FHB damage in spring grain continues to increase in southern and eastern Idaho. Fungicide management tools are being investigated in the irrigated western production region to reduce FHB pressure and DON contamination. Our goals are to participate in the MGMT CP to evaluate the integrated effects of fungicide treatment and genetic resistance on FHB and DON in hard red spring wheat grown in the Pacific Northwest and Intermountain West region, with emphasis on a new fungicide, Miravis Ace. We compared the efficacy of Miravis Ace when applied at heading or at anthesis to that of standard anthesis application of Prosaro or Caramba. The objective was to generate data to further quantify the economic benefit of FHB/DON management strategies and to develop more robust "*best-management practices*" for FHB and DON and generate data to validate and advance the development of FHB and DON risk prediction models**.** With the expansion of FHB into irrigated production areas of the PNW and intermountain West, and the limits of currently available fungicides, testing of the newly available fungicide Miravis Ace may provide increased choices for the producer.
Project goals: Our objectives for this proposal were to: 1) evaluate fungicide treatments of a new class of fungicides compared to standard applications and 2) test appropriate combinations of fungicides and host resistance for FHB and DON reduction.

Management Coordinated Project (MGMT_CP) goals are to:

1) Evaluate the integrated effects of fungicide treatment and genetic resistance on FHB and DON in all major grain classes, with emphasis on a new fungicide, Miravis Ace,
2) Compare the efficacy of Miravis Ace when applied at heading or at anthesis to that of standard anthesis application of Prosaro or Caramba,
3) Generate data to further quantify the economic benefit of FHB/DON management strategies;
4) Develop more robust "*best-management practices*" for FHB and DON; and generate data to validate and advance the development of FHB and DON risk prediction models.

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

Efficacy of a Miravis Ace for FHB and DON Management in Idaho Integrated Management Studies (FHB Management Coordinated Project)

a) What were the major activities?

Following standard protocol developed for the MGMT CP, we planted the and applied fungicides according to six different treatments to evaluate the efficacy of Miravis Ace in soft white spring wheat and hard red spring wheat of various resistance classes (susceptible, moderately susceptible and moderately resistant). Fungicides were applied at early anthesis with one treatment having an additional application 4-6 days after the first. There were two checks, one untreated and not inoculated and the other inoculated. Rating of disease occurred 21-24 days after inoculation, plots were harvested at maturity, and FDK and DON was determined from harvested grain samples.

b) What were the significant results?

Good disease formed in the spring nursery, with significant differences between varieties and fungicide treatments. The plots were rated in July and early August and harvested in early September. Greater disease suppression and significantly less DON was reported in moderately susceptible and moderately resistant varieties. Greater levels of DON were found in susceptible varieties even with appropriate timing and concentrations of fungicides. Fungicide efficacy of Miravis Ace was slightly better but not statistically different than Prosaro. Two fungicides provided better control than a single treatment, but not significantly enough to warrant two fungicide applications in practice.

c) List key outcomes or other achievements.

The results of this study have been and will be presented numerous times at the local, national and international level. Consultants and breeding companies in the area have used previous data to improve fungicide application recommendations, and growers now regularly spray to reduce FHB and DON in susceptible and moderately susceptible spring wheat cultivars. Growers are now aware of the varieties that are less likely to get FHB and suffer high DON.

Uniform Fungicide Trials

a) What were the major activities?

The Uniform Fungicide Trial followed standard protocol developed for the MGMT CP, designed to compare the efficacy of Miravis Ace when applied at early heading or at anthesis to that of standard anthesis application of Prosaro or Caramba. Trial establishment and general management including irrigation and misting treatments were reported previously in the proposal. Plots of a single susceptible cultivar was planted in a randomized complete block, with 4 replicate blocks, and subjected to at least ten fungicide treatments. Plots were harvested and DON levels in grain were measured in collaboration with Dr. Yanhong Dong and University of Minnesota.

b) What were the significant results?

Good disease formed in the spring nursery, with significant differences between fungicide treatments. The plots were rated in July and early August and harvested in early September. Performance of fungicides in reducing FHB and DON were comparable, including the newer fungicides Miravis Ace and Sphearex. The most effective application of Miravis Ace was at the standard application timing of all fungicides (early anthesis), however there was a reduction of disease and DON when applied at early heading in comparison to the treatment applied at anthesis. Two fungicide treatments were not significantly lower in DON and FHB incidence below the standard application timing.

c) List key outcomes or other achievements.

The results of this study have been and will be presented numerous times at the local, national and international level. Consultants and breeding companies in the area have used previous data to improve fungicide application recommendations, and growers now regularly spray to reduce FHB and DON in susceptible and moderately susceptible spring wheat cultivars. Growers are now aware of the varieties and fungicides needed to reduce FHB and suffer high DON.

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

We have trained two graduate students on these projects (one PhD candidate and one MS candidate) as well as additional training for a support scientist who have or will present the results at the USWBSI Forum.

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

The results of all the trials are published in our Annual Small Grains Report, disseminated to collaborating breeders, presented at various grower seminar and field events, and reported annually at the Scab Forum. Consultants from Bayer and Syngenta have utilized data to support their products at various grower meetings as well.

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?

X 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.

Baldwin, S.A., Yimer, B., Baldwin, T., Dong, Y., Marshall, J.M. (2021). Determining Fusarium Head Blight resistance of spring barley in Idaho. Proceedings of the 2021 National Fusarium Head Blight Forum; Virtual. December 6-7, 2021. Retrieved from: https://scabusa.org/forum/2021/2021NFHBForumProceedings.pdf

Marshall, J.M., Yimer, B., Shelman, T., Jones, L., Hatch, J., Moll, M., and Windes, S.M. (2022). 2021 Small Grains Report, Southcentral and Southeast Idaho Cereals Research and Extension Program. University of Idaho, Idaho Agricultural Experiment Station Bulletin. CIS BUL 205. 159 pp. *Published*

Yimer, B., Balfe, C, Marshall, J.M. (2022). Evaluation of Sphaerex for Control of Fusarium Head Blight and DON in Barley in Southeastern Idaho. Proceedings of the 2022 National Fusarium Head Blight Forum; Tampa, FL. December 5-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf

Yimer, B., Baldwin, S.A., Dong, Y., Marshall, J.M. (2022). Evaluation of Spring Wheat Varieties and Breeding Lines to Fusarium Head Blight Southeast Idaho. Abstract and Poster at the American Phytopathological Society Annual Meeting, Pittsburgh, PA. August 5-6, 2022. *Published.*

Yimer, B., Balfe, C, Marshall, J.M. (2022). Evaluation of Sphaerex for Control of Fusarium Head Blight and DON in Barley in Southeastern Idaho. Proceedings of the 2022 National Fusarium Head Blight Forum; Tampa, FL. December 5-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf

Marshall, J.M., Yimer, B., Shelman, T., Jones, L., Hatch, J., Moll, M., and Windes, S.M. (2023). 2022 Small Grains Report, Southcentral and Southeast Idaho Cereals Research and Extension Program. University of Idaho, Idaho Agricultural Experiment Station Bulletin. CIS BUL 206. 161 pp. *Published.*

Presentations:

Webinar: 2022 USWBSI Scabinar. Marshall, J.M., Friskop, Andrew (NDSU), Bradley, Carl (University of Kentucky). 2022. US Wheat and Barley Scab Initiative FHB "Scabinar". Organizing committee and Panel Member for 1) *Fusarium graminearum* Pathogen Perspective and 2) FHB Management. March 15, 2022. https://scabusa.org/scabinar

Marshall, J.M. Presentation to growers associated with Bingham Ag Services. Disease Control in Cereals, Seed treatments for disease control in wheat and barley. March 9, 2023. Invited.

Marshall, J.M. and B. Yimer. 2022. University of Idaho and LCS Cereals Field Day. Aberdeen R&E Center. FHB Nursery Screening and Fungicide Trials Tour. July 19, 2022.

Marshall, J.M., Yimer, B., Shelman, T., Jones, L., Hatch, J., Moll, M., and Windes, S.M. Cereal Disease Update and integrated approaches to common cereal diseases in Idaho. University of Idaho Cereal Schools, Online Feb 2, 2022.