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

FY22 Performance Progress Report

Due date: July 26, 2023

Cover Page

USDA-ARS Agreement ID:	59-0206-2-142
USDA-ARS Agreement Title:	Integrated Management of Fusarium Head Blight (FHB) in the Intermountain West
Principle Investigator (PI):	Juliet Marshall
Institution:	University of Idaho
Institution UEI:	QWYKRJH5NNJ3
Fiscal Year:	2022
FY22 USDA-ARS Award Amount:	$74,084
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Period of Performance:	May 1, 2022 – April 30, 2026
Reporting Period End Date:	April 30, 2023

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
BAR-CP	Determining FHB Susceptibility in Barley Cultivars in the Western US	$23,238
MGMT IM-CP	Fungicide Combinations and Genetic Resistance for FHB and DON Management	$29,258
VDHR-SPR	Determining FHB Susceptibility in Wheat Cultivars in the Western US	$21,588
	FY22 Total ARS Award Amount	$74,084

I am submitting this report as an: ☒ Annual Report

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

Juliet M. Marshall

Principal Investigator Signature

7/26/2023

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. In the 2022 experiments, Kimberly winter barley DON levels varied from 1.1 ppm to 27.4 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). In 2022, the spring barley DON levels varied from 1.6 ppm to 100.4 ppm.

Winter barley was not planted in Aberdeen due to cooler conditions at heading that generally results in poor infection. Spring barley infection at Aberdeen was not as severe as in Kimberly, but ranking of disease severity (FHB Index) was similar. In 2021, KWS Amadora was identified as being very susceptible, with an FHB Index of 35.9 and DON of 12.1 ppm. In 2022, Aberdeen spring barley infection in 2022 was effective as well, with DON levels varying from 0.16 ppm to 68.7 ppm.

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 2: Fungicide Combinations and Genetic Resistance for FHB and DON Management

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

In this funding cycle, the **goal** of this proposal is the continuance of integrated management (IM) and uniform fungicide (UFT) trials that would allow us to evaluate new combinations of AIs either as pre- or tank-mixtures or as sequentially applied treatments. For the wheat IM trial, we will conduct inoculated experiments consisting of two cultivars with different levels of resistance to FHB subjected to at least five fungicide treatments, all applied at Feekes 10.5.1, plus two untreated checks. The **objectives and expected outcomes** of this FHB Management Coordinated Project (MGMT_CP) are to:

1) Evaluate the integrated effects of fungicide treatment and genetic resistance on FHB and DON in wheat and barley, with emphasis on new combination fungicides, Prosaro Pro and Sphaerex.
2) Compare the efficacy of Prosaro Pro and Sphaerex to that of Prosaro, Caramba, and Miravis Ace.
3) Generate data to further quantify the economic benefit of FHB and DON management programs.
4) Generate data to validate and advance the development of FHB risk prediction models.

Two new fungicides, Prosaro Pro, a mixture of two DMIs (prothioconazole and tebuconazole) and an SDHI (Fluopyram, Pyridinyl-ethyl-benzamide), and Sphaerex, a mixture of two DMIs (metconazole and prothioxonazole) are being promoted for the control of FHB and other diseases of small grain crops. Both Sphaerex and Prosaro Pro were recently registered for use in wheat. As is commonly the case, these new products will likely be marketed at higher prices than Prosaro (tebuconazole + prothioconazole) and Caramba (metconazole), the current industry standards for FHB management, and are being developed as replacements for the latter two fungicides. Therefore, the obvious questions being asked by stakeholders and researchers are whether the efficacy of these new fungicides against FHB and its associated mycotoxins, particularly DON, will be high enough to justify the added cost, and whether they are just as or more effective than current industry standards. **Approach:** Designated fields for FHB screening and fungicide trials will be planted with wheat and barley trials at the Aberdeen R&E Center in a randomized complete block design in order to address the goals of both IM and UFT experiments. Appropriate fungicide treatments will be applied after inoculation with macroconidia of fungal isolates. Plots will be rated, harvested and assessed for effectiveness of treatments. **Mutual Interest:** Stakeholders will benefit by having efficacy data of the standard available fungicides compared to new fungicides, combinations and timing of applications.

2. What was accomplished under these goals or objectives?

Evaluate the integrated effects of fungicide treatment and genetic resistance on FHB and DON in wheat and barley, with emphasis on new combination fungicides, Prosaro Pro and Sphaerex.

a) What were the major activities?

Following standard protocol developed for the MGMT CP, we planted the wheat and barley trials and applied fungicides according to six different treatments to evaluate the efficacy of integrated effects of fungicide treatment and genetic resistance on FHB and DON in wheat and barley, with emphasis on new combination fungicides, Prosaro Pro and Sphaerex 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?

All fungicide treatments except MiravisAce applied at half heading significantly reduced FHB incidence and Index compared to untreated check. However, FHB severity was significantly reduced only by application of MiravisAce at fullheading, Prosaro and ProsaroPro. Among fungicide treatments, Sphaerex and Prosaro applied at full heading resulted in the lowest FHB incidence and index.

All fungicide treatments produced significantly lower DON content compared to the untreated check. DON content was lowest (0.005 ppm) on plots treated with Prosaro and ProsaroPro. Sphaerex had the next lowest (0.07 ppm) DON content. Untreated checks produced DON level higher than the threshold.

None of the fungicides had significant effect on yield, test weight and protein content compared to the untreated check.

c) List key outcomes or other achievements.

New fungicides have been added to the list of effective fungicides to reduce the impact of FHB and accumulation of DON . While MiravisAce does reduce disease and DON when applied earlier than Feekes 10.1.5, the most effective timing to reduce FHB and DON continues to be at flowering or shortly thereafter.

Compare the efficacy of Prosaro Pro and Sphaerex to that of Prosaro, Caramba, and Miravis Ace.

a) What were the major activities?

The Uniform Fungicide Trial followed standard protocol developed for the MGMT CP, designed to compare the efficacy of fungicides when applied at early heading or at anthesis. Trial establishment and general management including irrigation and misting treatments were reported previously. Fungicides were applied at early anthesis with three treatments 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. Plots of a single susceptible cultivar was planted in a randomized complete block, with 4 replicate blocks, and subjected to eleven fungicide treatments (two more than what was in the MGMT CP proposal). 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?

Low disease pressure in the spring nursery resulted in lower than optimal FHB Index and DON level, 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. 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.

Generate data to further quantify the economic benefit of FHB and DON management programs. Generate data to validate and advance the development of FHB risk prediction models.

a) What were the major activities?

Data generated from these trials will be combined with similar treatments throughout the cooperating programs to generate economic benefit analyses from these management programs.

b) What were the significant results?

Awaiting combined analyses from combined data analyses.

c) List key outcomes or other achievements.

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 National Fusarium Head Blight Forum.

Project 3: Determining FHB Susceptibility in Wheat 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. 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 white 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.

In 2021, 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). In 2022, DON levels in winter wheat varied from 1.0 ppm to 31.9 ppm. Disease pressure in 2021was very high and FHB Index in spring wheat in Kimberly ranged from “susceptible” to very susceptible. In spring wheat 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. Successful infection occurred with the spring wheat nursery in Kimberly in 2022 as well, with DON levels varying from 4.9 ppm to 95.2 ppm.

Winter wheat was not planted in Aberdeen due to cooler conditions at heading that generally result in poor infection. Spring wheat infection in 2021 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. In 2022, DON levels varied from 0.69 ppm to 25 ppm.

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.

Publications, Conference Papers, and Presentations

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

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

X Yes, I've included the citation reference in listing(s) below.

☐ No, I have nothing to report.

Journal publications as a result of FY22 award

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

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

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

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

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

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

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

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.*

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 National Fusarium Head blight Forum; Tampa, FL. December 4-6, 2022. Retrieved from: https://scabusa.org/forum/2022/2022NFHBForumProceedings.pdf

Marshall, J.M. and B. Yimer. 2023. University of Idaho and LCS Cereals Field Day. Aberdeen R&E Center. FHB Nursery Screening and Fungicide Trials Tour. July 20, 2023.

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.

Presentations: Marshall, J.M. and B. Yimer. 2023. University of Idaho and LCS Cereals Field Day. Aberdeen R&E Center. FHB Nursery Screening and Fungicide Trials Tour. July 20, 2023.