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:	59-0206-0-127
USDA-ARS Agreement Title:	Fusarium Head Blight Resistance for Montana Barley
Principle Investigator (PI):	Frankie Crutcher
Institution:	Montana State University
Institution UEI:	EJ3UF7TK8RT5
Fiscal Year:	2021
FY21 USDA-ARS Award Amount:	$45,879
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Period of Performance:	5/6/21 - 5/5/23
Reporting Period End Date:	5/5/2023

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
BAR-CP	Fusarium Head Blight Resistance for Montana Barley	$45,879
	FY21 Total ARS Award Amount	$45,879

I am submitting this report as a: ☒ FINAL Report

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

Principal Investigator Signature — Date Report Submitted: 7/22/2023

ǂ 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: Fusarium Head Blight Resistance for Montana Barley

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

Objective 1: Continue crossing resistant material into Montana lines; field screen resulting progeny in three different environments.

Objective 2: Continue to pyramid resistant lines and screen for resistance in the field for future genotype mapping.

Objective 3: Collect and identify Fusarium isolates from FHB infected barley.

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?

Objective 1: We grew lines that have shown promise in previous screenings in four locations: Sidney, Langdon, Fargo, and Minnesota for disease. We also grew a subset of these lines and evaluated them for agronomic characteristics in Bozeman in 2021.

Objective 2: We screened over 500 lines per year produced from pyramiding different sources of resistance in small hill plots in our nursery and have included a subset of the 2-row nested association mapping (NAM) panel. We sent in seed for DON analysis for many of these lines.

Objective 3: We have identified 350 isolates collected in 2019 from two regions in Montana and have almost completed identifying the chemotype for the F. graminearum isolates. We are also evaluating F. sporotrichioides isolates collected from two malt barley fields in south central Montana for temperature effects on growth, fungicide sensitivity, and virulence on barley.

b) What were the significant results?

Objective 1: We have evaluated our results from 2021 and 2022 and believe that several of the lines tested show promise as either a new variety or a line that can be used for crosses to develop a new variety (Table 1 and 2).

The lines that showed the best agronomic characteristics (2017-42-3, 2017-47-6, 2019-21-12, 2019-26-24, and 2019-27-46) had above average DON amounts in Langdon but performed well in Sidney and Fargo where disease pressure was lower. The line 2017-59-2 had both good disease and agronomic characteristics at all locations. We have submitted these lines to Langdon and Fargo again this year for evaluations.

Table 1: 2021 Disease screening for MT barley breeding lines

Line	Sidney			Langdon		Fargo		Minnesota
	Severity	Incidence	DON	Severity	DON	Severity	DON	DON
2017-39-11	2.3	33.3	0.4	23.3	47.1	3.0	2.2	9.4
2017-39-13	3.1	41.1	0.9	30.0	23.4	5.3	4.1	
2017-39-7	5.0	15.0	0.2	16.7	49.4	2.0	1.6	4.3
2017-40-10	2.2	28.4	2.5	21.0	31.1	3.0	1.8	7.3
2017-40-17	2.7	36.7	0.2	16.7	35.5	5.3	1.4	12.8
2017-41-10	1.2	22.2	0.3	23.3	43.9	3.0	1.1	2.6
2017-41-16	2.3	30.0	1.3	30.0	62.7	3.0	1.3	2.7
2017-41-6	1.7	25.5	0.4	10.0	32.3	5.3	1.2	3.0
2017-42-12	2.7	33.4	0.4	14.3	27.7	5.3	2.2	1.7
2017-42-18	1.4	22.2	1.0	14.3	36.3	3.0	1.0	1.4
2017-42-2	1.0	16.7	0.8	36.7	50.4	7.7	3.7	0.8
2017-42-3	1.0	16.7	0.4	16.7	54.3	3.0	2.5	
2017-42-6	1.3	23.3	0.1	30.0	38.2	5.3	3.6	2.0
2017-43-11	2.1	30.0	0.3	10.0	38.2	5.3	1.2	4.9
2017-43-18	2.8	41.1	0.6	14.3	22.7	3.0	1.0	3.2
2017-43-19	2.2	36.7	0.1	30.0	56.0	7.7	0.7	2.3
2017-43-20	2.3	31.1	0.2	10.0	44.8	5.3	0.7	3.1
2017-43-22	1.3	18.9	0.4	23.3	37.7	3.0	1.4	0.9
2017-43-8	2.1	33.4	0.9	23.3	21.6	3.0	1.3	3.0
2017-44-15	2.4	44.4	0.8	30.0	64.5	2.0	1.0	2.2
2017-44-18	1.5	26.7	1.0	23.3	61.7	3.0	1.0	0.7
2017-44-2	2.8	40.0	0.7	30.0	43.8	3.0	2.8	0.7
2017-44-21	1.4	18.4	0.9	21.0	41.9	2.0	1.6	3.1
2017-44-23	1.1	16.7	0.3	43.3	49.4	3.0	0.7	3.9
2017-45-12	2.1	33.4	0.8	16.7	50.7	3.0	2.3	
2017-45-13	1.4	25.0	0.1	23.3	44.1	3.0	0.5	3.6
2017-45-16	1.0	20.0	0.2	7.7	34.7	6.5	0.3	5.0
2017-45-7	1.5	23.3	0.5	23.3	52.2	3.0	0.2	2.1
2017-46-10	0.9	16.7	0.2	7.7	33.4	3.0	1.7	3.2
2017-46-19	2.3	36.7	0.5	7.7	33.6	2.0	1.0	3.5
2017-46-5	2.0	26.7	0.8	23.3	44.1	3.0	1.4	2.8
2017-47-3	1.2	21.1	0.5	30.0	50.1	5.3	2.1	5.3
2017-47-6	1.2	16.7	0.6	23.3	40.5	5.3	2.1	2.2
2017-59-2	1.8	28.3	0.7	16.7	27.5	11.0	2.0	3.2
2017-60-6	1.9	25.6	0.4	27.7	30.2	6.5	1.1	2.0
2017-69-13	1.9	31.1	0.7	36.7	54.8	3.0	5.2	4.5
2017-69-15	1.6	24.4	0.2	30.0	70.2	3.0	2.1	2.3
2019-21-12	0.8	15.0	0.5	16.7	57.6	3.0	0.8	
2019-23-31				16.7	64.9	5.3	2.6	

2019-24-13	7.7	40.0	0.1	23.3	52.6	5.3	0.8	
2019-25-100	1.5	27.8	0.1	30.0	46.8	5.3	0.8	
2019-25-29	2.1	33.3	0.3	16.7	38.7	6.5	3.1	
2019-25-75	1.5	26.7	0.1	30.0	68.7	7.7	1.7	
2019-26-24	2.2	30.0	0.2	23.3	55.4	5.3	1.1	
2019-26-26	1.0	20.0	0.0	23.3	58.0	3.0	2.6	
2019-26-73	1.1	21.7	0.2	30.0	36.5	3.0	1.9	
2019-26-76	1.5	25.0	0.1	23.3	52.6	5.3	0.9	
2019-26-8	1.8	28.3	0.1	30.0	47.5	6.5	2.5	
2019-27-16	1.9	35.5	1.0	43.3	64.6	7.7	1.3	
2019-27-25	1.6	23.3	1.2	23.3	59.5	3.0	1.0	
2019-27-46	2.3	35.0	0.7	30.0	44.3	5.3	2.1	
2019-27-71	1.0	18.3	0.3	10.0	52.6	3.0	1.1	
2019-27-74	1.4	23.3	0.2	21.0	51.3	5.3	1.3	
2019-28-36	4.4	50.0	1.8	7.7	39.4	7.7	3.2	
2019-28-48	1.6	25.0	0.7	23.3	33.4	5.3	2.0	
2019-28-60	2.7	33.3	1.6	30.0	59.8	7.7	4.1	
Bearpaw	2.7	43.3	0.3	16.7	31.3	3.0	2.3	
Buzz	1.7	18.4	0.5					
Chevron	3.2	32.2	0.1	36.7	53.2	5.3	0.4	
Haybet	1.3	23.4	0.1					
Hockett	1.8	26.7	0.2	23.3	42.2	10.0	0.9	
Lavina	4.5	58.4	0.4					
Stander	3.4	30.0	0.8	55.0	62.0	16.7	8.9	13.1
Pinnacle	1.9	23.4	0.0	10.0	36.2	3.0	2.0	1.9

*Due to planting/harvesting errors data from Sidney and Minnesota may represent less than three replicates.

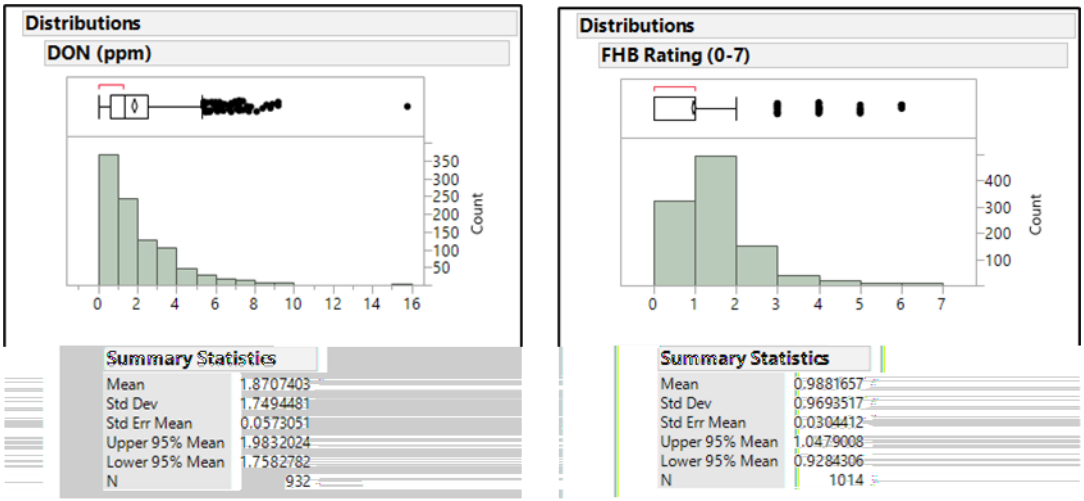
Table 2: Agronomic data for MT barley breeding lines

Line	Bozeman								
	Yield	Plump	Protein	Test Wt	Heading	Maturity	Height	Awns	Rachis
2017-39-11	75.6	93.2	12.6	51.8	165.0	203.0	68.7	Medium	
2017-39-13									
2017-39-7	76.2	85.1	13.7	50.1	174.0	200.3	78.7		
2017-40-10	89.4	92.0	11.1	51.3	170.3	207.0	65.7	Medium	
2017-40-17	87.9	96.2	11.6	51.0	170.0	199.7	69.3		
2017-41-10	83.9	96.0	14.8	53.7	174.0	200.3	77.3		
2017-41-16	77.5	87.3	16.1	52.0	166.7	197.0	70.3	Strong	
2017-41-6	77.3	90.4	15.3	51.2	171.0	198.7	72.3		
2017-42-12	76.8	88.9	13.3	51.3	178.0	208.7	69.3		Strong
2017-42-18	90.9	95.0	14.0	52.6	179.0	207.0	77.0	Strong	
2017-42-2	86.8	86.3	14.2	53.6	177.0	207.0	79.3		
2017-42-3	102.2	91.1	12.1	53.9	177.0	204.7	75.3	Medium	

2017-42-6	91.5	95.7	12.2	52.7	179.7	206.3	72.7		
2017-43-11	81.9	91.5	12.7	48.2	177.7	203.7	69.0	VS	VS
2017-43-18	84.3	92.4	12.2	51.6	178.0	203.7	65.3		
2017-43-19	91.9	88.9	12.6	51.1	179.0	206.3	75.7		Strong
2017-43-20	83.5	90.1	13.6	47.1	172.0	202.7	69.7		VS
2017-43-22	93.2	92.3	13.0	50.6	177.0	203.7	74.7	Medium	
2017-43-8	93.0	89.8	12.4	51.2	178.7	206.7	74.7		
2017-44-15	82.3	95.6	11.2	50.1	178.0	208.7	77.3		Strong
2017-44-18	91.1	92.1	12.7	52.2	179.0	207.3	74.3		
2017-44-2	85.1	93.4	12.6	51.7	179.0	206.3	68.7		
2017-44-21	83.5	94.6	11.6	52.2	175.7	209.3	72.0		
2017-44-23	83.1	96.9	13.4	51.7	177.0	205.3	80.7		
2017-45-12									
2017-45-13	87.4	90.9	13.7	52.4	178.0	206.3	70.3		Strong
2017-45-16	72.6	96.2	15.1	50.2	174.7	205.7	79.0	Medium	Strong
2017-45-7	92.3	97.2	13.9	53.5	178.0	206.3	77.0		
2017-46-10	88.8	96.6	12.7	52.5	179.0	207.0	68.3	Strong	
2017-46-19	86.8	96.9	13.9	53.1	178.0	206.0	80.3	Strong	
2017-46-5	85.5	94.5	14.4	52.9	178.0	207.0	83.3	Medium	
2017-47-3	85.2	87.4	13.0	50.6	172.0	204.7	73.0		
2017-47-6	95.8	93.0	12.5	51.7	177.3	207.0	73.7		
2017-59-2	99.9	97.2	12.8	54.0	173.3	205.0	71.7		
2017-60-6	86.9	92.1	13.0	53.4	176.7	207.3	68.3		
2017-69-13	90.8	88.5	13.1	52.1	175.3	203.7	68.7		
2017-69-15	84.5	93.9	13.0	52.9	179.7	207.3	69.7		
2019-21-12	96.2	97.4	13.1	53.7	172.7	204.3	71.0		
2019-23-31									
2019-24-13	68.8	46.8	14.9	50.1	179.7	207.7	72.3		
2019-26-24	97.3	94.3	12.4	52.0	179.0	204.7	70.3	Medium	
2019-26-26	92.5	95.7	13.6	52.9	178.0	201.0	66.0		
2019-26-73	89.3	91.0	13.6	51.7	178.0	203.0	64.0		
2019-27-46	98.8	85.6	13.4	53.0	176.0	201.7	66.3		
Buzz	97.3	95.9	10.6	51.7	174.0	207.0	66.7		
Hockett	106.7	94.5	11.8	53.2	177.0	206.3	70.7		

Objective 2: Because of hill plot screening in 2019 and 2020, we were able to include lines in 2021 for screening in larger plots and at multiple locations (these are lines that begin with 2019-). Some of these lines show DON accumulation at levels similar to Bearpaw and Pinnacle and show promise for future screening. We have planted more than 1000 hill plots this year including new crosses.

Figure 1: Distributions of FHB ratings (0-7 scale) and DON concentration for 2021 barley hill plots



Objective 3: We have identified the isolates collected in 2019 down to species level (Figure 2). We found that *F. graminearum* is the predominant species in 2019 however there were two fields of malt barley that had high levels of *F. sporotrichioides*. Our graduate student has moved forward with these findings and is evaluating these isolates for growth temperature sensitivity, fungicide sensitivity, and virulence on Bearpaw and Hockett.

Additionally, we have identified the *F. graminearum* 3-ADON chemotype for the first time in Montana. These were found in large proportion in two durum fields in the far northeast corner of the state bordering Canada and North Dakota (Figure 3). These fields had a very high incidence of FHB in 2019 but DON records are unavailable because the field was not harvested due to very excessive rainfall amounts that year. We have included two of these isolates into our pathogen mix for the screening nursery in 2022.

Figure 2: Proportion of *Fusarium* species in Montana fields sampled in 2019

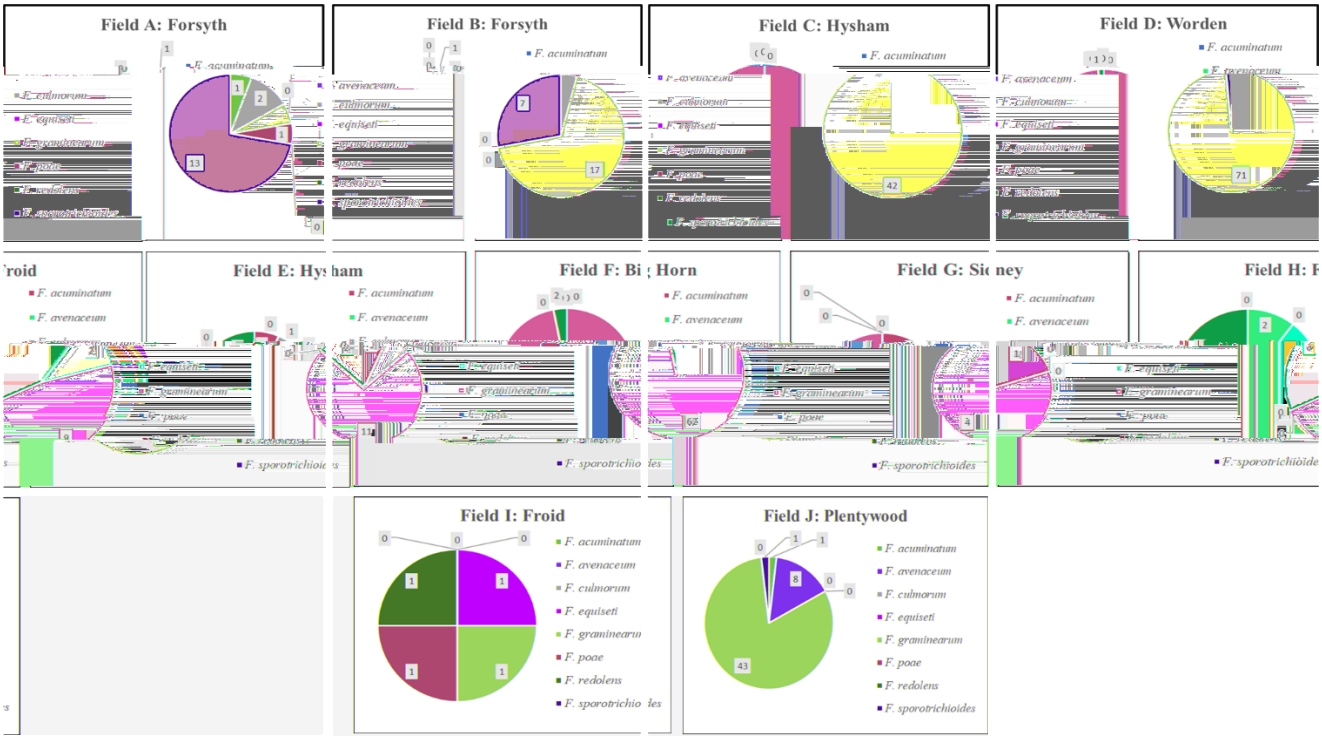
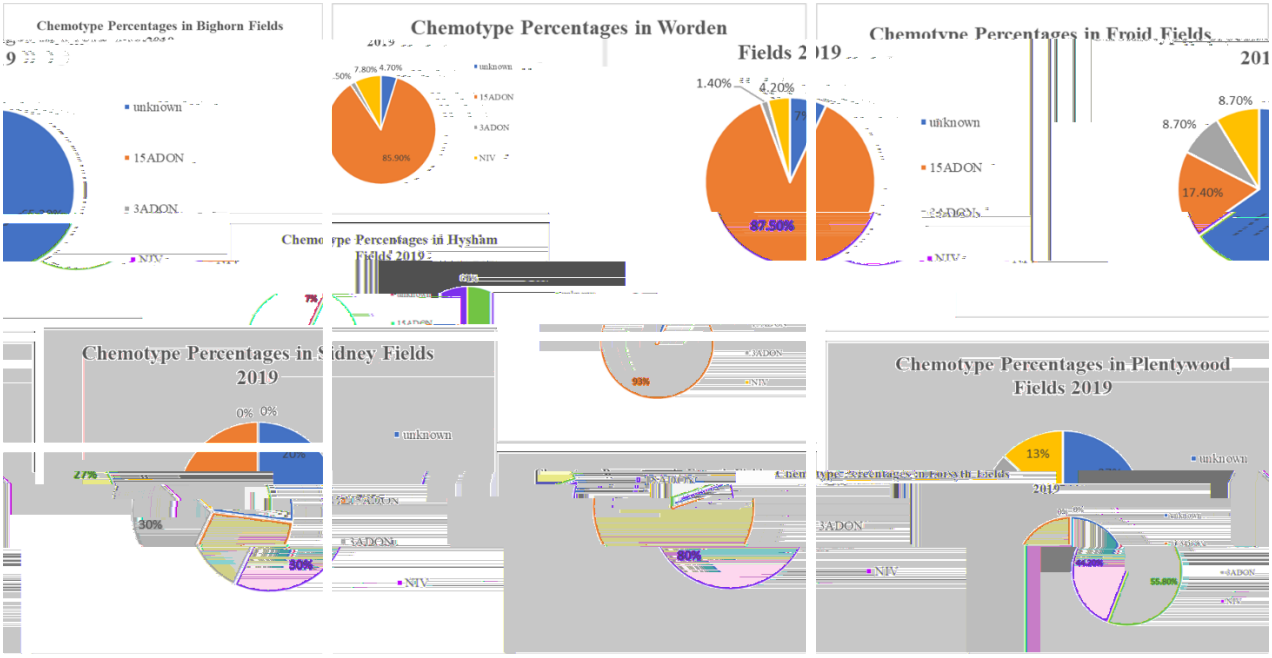


Figure 3: Proportion of different chemotypes of *F. graminearum* in Montana fields sampled in 2019



c) List key outcomes or other achievements.

Objective 1: We have identified potential candidates for the breeding program that we will continue to evaluate.

Objective 2: We have been moving potential lines forward and are still performing crosses in the greenhouse.

Objective 3: We have identified the F. graminearum 3-ADON chemotype for the first time in Montana. We will be using these isolates for varietal development.

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

The Fusarium species objective of the project is being led by a MS level graduate student.

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

Results of the screening have been presented at field days and included in the regional MonDak research report that reaches approximately 2500 people in Montana and North Dakota annually.

Publications, Conference Papers, and Presentations

Please include a listing of all your publications/presentations about your FHB work that were a result of funding from your FY21 grant award. Only citations for publications published (submitted or accepted) or presentations presented during the **award period** should be included.

Did you publish/submit or present anything during this award period?

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