

USDA-ARS | U.S. Wheat and Barley Scab Initiative
FY21 FINAL Performance Progress Report

Due date: December 15, 2023

Cover Page

USDA-ARS Agreement ID:	59-0206-0-180
USDA-ARS Agreement Title:	Determinants of Aggressiveness in Fusarium graminearum
Principle Investigator (PI):	Santiago Mideros
Institution:	University of Illinois
Institution UEI:	Y8CWNJRCNN91
Fiscal Year:	2021
FY21 USDA-ARS Award Amount:	\$54,640
PI Mailing Address:	University of Illinois, Department of Crop Sciences 1102 S. Goodwin Ave., N533B Turner Hall Urbana, IL 60801
PI E-mail:	smideros@illinois.edu
PI Phone:	217-265-6340
Period of Performance:	5/15/22 - 9/30/23
Reporting Period End Date:	9/30/2023

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
PBG	Determinants of Aggressiveness in Fusarium graminearum	\$54,640
FY21 Total ARS Award Amount		\$54,640

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

13Dec2023

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: Determinants of Aggressiveness in *Fusarium graminearum*

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

The major goal of this project is to determine if the presence or absence of quantitative host resistance is selecting for more aggressive *F. graminearum* isolates and identify genes involved in pathogen fitness. To do so we will phenotype and genotype a population of 56 *F. graminearum* isolates.

The objectives are:

- 1) Aggressiveness characterization of 56 isolates in greenhouse assays.
- 2) Identify sequence variation among a population of isolates collected from wheat lines with different levels of resistance.
- 3) Identify regions of the *F. graminearum* genome that are under selection within the entire sample of 56 isolates and regions under divergent selection due to the different levels of host resistance.

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?

- Two large scale greenhouse assays were conducted to evaluate isolate aggressiveness. Phenotypic data (disease severity, fusarium damaged kernels, and DON contamination) was collected.
- Three large scale incubator assays were conducted to evaluate in vitro traits. We collected phenotypes for spore production and growth rate.
- The phenotypic data was analyzed.
- DNA was extracted from all of the *F. graminearum* isolates and sequenced.
- We established and executed a bioinformatics pipeline for SNP variant calling on the *F. graminearum* population.
- We established and executed a bioinformatics pipeline for two whole genome scans for selection. One scan identified selection in the entire population of *F. graminearum* isolates and the second scan identified divergent selection between the subsample of isolates from two different wheat resistance levels.
- Wrote a thesis that reports the results and conclusions of this research.

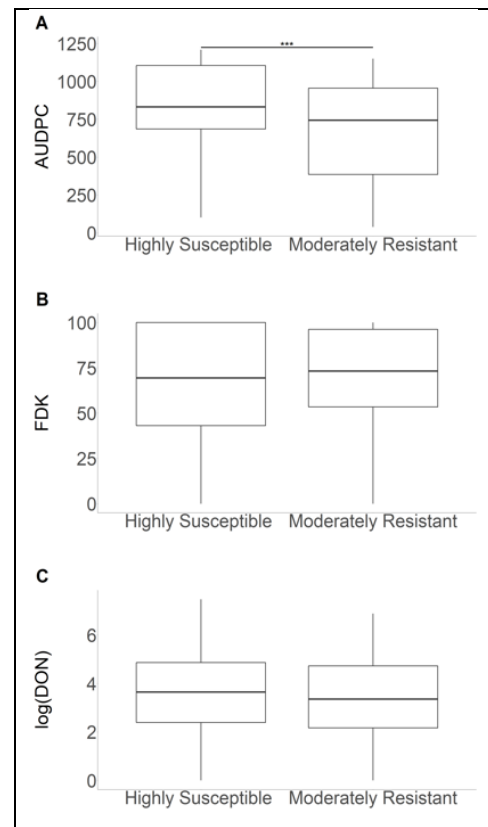


Fig 1. Boxplots of three phenotypes sorted by host resistance. The asterisks indicate significance between the wheat source's resistance levels, highly susceptible (N=31) and moderately resistant (N=25). **(A)** An AUDPC was calculated for each isolate from three disease ratings. **(B)** The percentage of damaged kernels was calculated for each wheat head to get FDK. **(C)** DON contamination was quantified as ppm from the kernels of each wheat head.

- Wrote and submitted a manuscript that reports the results and conclusions of this research to Phytopathology that is currently in the review process.
- b) What were the significant results?**
- Isolates from a susceptible wheat line (N=31) were more aggressive than those collected from a resistant wheat line (N=25; Figure 1).
 - In planta traits (disease severity, fusarium damaged kernels, and DON contamination) were significantly correlated to each other.
 - The diversity of the 56 isolates was analyzed in 10 Kb windows across the entire genome (Figure 2).
 - The overall scan for selection identified the trichothecene genes on two loci to be in windows under selection suggesting they are contributing to the fitness of *F. graminearum* isolates.
 - The scan for divergent selection identified 7 windows under selection containing 34 genes.

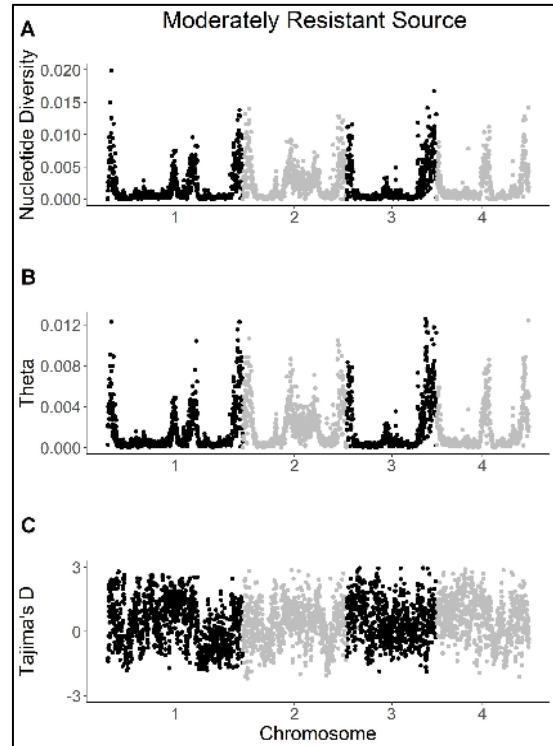


Fig 2. The diversity statistics of the entire sample (N = 56) plotted across the whole genome. Each point is a 10 Kb nonoverlapping window. (A) nucleotide diversity, (B) theta, and (C) Tajima's D.

c) List key outcomes or other achievements.

- The population of *F. graminearum* 56 isolates was phenotyped for in-vitro and in planta traits related to aggressiveness.
- The results suggest that resistant wheat varieties have not selected for a population with primarily aggressive isolates.
- Conversely, we found more aggressive isolates in in the more susceptible wheat line.
- Several genes associated with aggressiveness are also in windows under selection and possibly involved in fitness.
- Our results suggest that continued efforts to produce resistant wheat varieties will be durable and a long-term solution to FHB on wheat.

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

- A MS student (Mara Krone) has conducted all the research indicated above and graduated in August of 2022. The student was funded by this project. She took courses in plant genetics, genomics, and plant pathology. The student presented her results at three conferences and one joint PBG-GDER USWBSI meeting. The student was coached on conducting research on wheat and *Fusarium graminearum* by the PI.
- This project also funded Mara Krone to attend the Fusarium Laboratory Workshop in the Summer of 2022 where many laboratory skills on working with *Fusarium* spp. were gained.
- Two undergraduate students assisted with the preparation of experiments and data collection.

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

- Research posters were presented at three annual APS meetings:
 - Plant Health 2021 which was held online from Aug 2nd to Aug 6th;
 - Plant Health 2022 which was in person from Aug 6th to Aug 10th;
 - Plant Health 2023 which was in person from Aug 12th to Aug 16th.
- Research posters were presented at two annual NFHB Forums:
 - 2021 which was held virtually from Dec 6th to Dec 7th
 - 2022 which was in person from Dec 4th to Dec 6th.
- A talk was presented at an online joint USWBSI meeting between the PBG and GDER groups on April 27th, 2023.

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 5/15/22 – 9/30/23?

- 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).

Krone, M. J., Dong, Y., and Mideros, S. X. 2023. The effect of quantitative wheat resistance on the aggressiveness of *Fusarium graminearum*. *Phytopathology*. Under review (second round). Acknowledgment of federal support: Yes.

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.

None

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.

Krone, M. J., and Mideros, S. X. 2021. Identifying the determinants of aggressiveness in *Fusarium graminearum*. Poster presentation. (Abstr.) *Phytopathology* 111:S2.1. doi: 10.1094/PHYTO-111-10-S2.1. Federal support was acknowledged in the poster.

Krone, M. J., and Mideros, S. X. 2021. The effect of wheat resistance on the aggressiveness of *Fusarium graminearum*. Poster presentation. *Proceedings of the 2021 National Fusarium Head Blight Forum* (page)67. Federal support was acknowledged in the poster.

Krone, M. J., and Mideros, S. X. 2022. Genome signatures for selection due to host resistance in *Fusarium graminearum*. Poster presentation. (Abstr.) *Phytopathology* 112:S3.1. doi: 10.1094/PHYTO-112-11-S3.1. Federal support was acknowledged in the poster.

Krone, M. J., and Mideros, S. X. 2022. Selection due to host resistance in *Fusarium graminearum*. Poster presentation. *Proceedings of the 2022 National Fusarium Head Blight Forum* (page)67. Federal support was acknowledged in the poster.

Krone, M. J., and Mideros, S. X. 2023. The effect of quantitative wheat resistance on the aggressiveness of *Fusarium graminearum*. Oral presentation. Joint PBG-GDER meeting.

Krone, M. J., and Mideros, S. X. 2023. The effect of quantitative wheat resistance on the aggressiveness of *Fusarium graminearum*. Poster presentation. (Abstr.) *Phytopathology* PH2023. Federal support was acknowledged in the poster.

In addition to the required inclusion in this report, to increase the visibility of your work we encourage you to also submit your publications in the new [USWBSI ScabSource Publication Database](#), an open-access resource for all FHB researchers to reference.