USDA-ARS
U.S. Wheat and Barley Scab Initiative
FY19 Performance Report
Due date: September 30, 2020

Cover Page

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Fiscal Year:	2019
USDA-ARS Agreement ID:	58-5062-8-018
USDA-ARS Agreement Title:	Color and spectral imaging for High-Throughput Phenotyping to Assess FHB Severity
FY19 USDA-ARS Award Amount:	$ 79,361
Recipient Organization:	Regents of the University of Minnesota Suite 450 Sponsored FIN RPT-P100100001 Minneapolis, MN 55455-2003
DUNS Number:	555917996
EIN:	41 -6007513
Recipient Identifying Number or Account Number:	CON000000076065
Agency PI:	H. Corby Kistler
Project/Grant Reporting Period:	9/1/19 - 8/31/20
Reporting Period End Date:	8/31/2020

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
EC-HQ	Color and Spectral Imaging for High-Throughput Phenotyping to Assess FHB	$ 79,361
	FY19 Total ARS Award Amount	**$ 79,361**

09/30/2020
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

Project 1: *Color and Spectral Imaging for High-Throughput Phenotyping to Assess FHB*

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

Our goal is to increase the accuracy, efficiency, and cost-effectiveness of FHB phenotyping in the field. Our specific objectives for this FY19 technology proposal are to:

1) develop an efficient pipeline for assessing FHB severity on wheat and barley in the field based on image processing;
2) compare the efficiency and cost-effectiveness of this FHTP system to conventional visual assessment protocols in the field;
3) investigate the feasibility of hyperspectral imaging for assessing DON content in wheat and barley grain under controlled laboratory conditions and
4) design and make a field pheno-cart platform for efficient data collection.

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

a) What were the major activities?

1) Conducted image preprocessing, annotation, deep learning model training and validation for the assessment of FHB severity for wheat in the field.
2) Recorded and compared the workload required for FHTP system and the conventional visual assessment.
3) Collected lab DON hyperspectral reflectance images (HSI) and fluorescence hyperspectral images and processed the HSI image set for DON detection using more than 800 barley seed samples.
4) Redesigned the field pheno-cart platform and used it in both St Paul and Crookston experimental fields.

b) What were the significant results?

1) Obtained reliable deep learning algorithms for field FHB detection and published the result. One more paper was submitted to a journal and is now under review.
2) From the observation, a large scale field trial will for sure benefit from the FHTP system.
3) Built a robust correlation between hyperspectral imaging detection and the DON GC-MS measurement and conducted feature selection so that the image processing efficiency was improved. One paper was submitted to a journal and is now under review.
4) The pheno-cart has a more sophisticated and advanced design to meet the requirements of field data collection.

c) List key outcomes or other achievements.

The scope is now broadened to other collaborative projects focusing on phenotyping more wheat/barley disease types based on the achievement and experiences from this project.

3. Was this research impacted by the COVID-19 pandemic (i.e. university shutdowns, reduced or lack of support personnel, etc.)? If yes, please explain how this research was impacted or is continuing to be impacted.

The postdoc working on this project Dr. Wenhao Su had to leave for another position which is more secure for him. However, he will keep working on the project in his spare time until we have enough finding from the fluorescence hyperspectral imaging for seed DON detection. A journal paper is planned to be published by the end 2020.

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

An undergraduate student intern from Lewis Stokes North Star STEM Alliance was advised by the postdoc Dr. Wenhao Su to conduct deep learning model training and validation. He gained a lot of experience with Python programming and deep learning modeling. He presented his work in the annual Lewis Stokes North Star STEM Alliance Symposium in September, 2020.

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

Findings and achievements have been presented in the 2019 FHB annual forum to the audience by both poster and oral presentations. Multiple presentations have been given to the phenotyping communities in the International Conference of American Society of Agricultural and Biological Engineering and Open Drone Meeting by North American Plant Phenotyping Network. An invited talk has been delivered in the 2019 Minneanalytics AgTech Conference hosted by Cargill Data Science.

Training of Next Generation Scientists

Instructions: Please answer the following questions as it pertains to the FY19 award period (9/1/19 - 8/31/20). 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 FY19 award period?**
   N/A

   If yes, how many?

2. **Did any graduate students in your research program supported by funding from your USWBSI grant earn their Ph.D. degree during the FY19 award period?**
   N/A

   If yes, how many?

3. **Have any post docs who worked for you during the FY19 award period and were supported by funding from your USWBSI grant taken faculty positions with universities?**
   Yes

   If yes, how many? 1

4. **Have any post docs who worked for you during the FY19 award period and were supported by funding from your USWBSI grant gone on to take positions with private ag-related companies or federal agencies?**
   No.

   If yes, how many?

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 FY19 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**

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 FY19-FPR_Instructions for detailed more instructions for listing publications/presentations about your work that resulted from all of the projects included in the FY19 grant award. Only citations for publications published (submitted or accepted) or presentations presented during the **award period (9/1/19 - 8/31/20**) should be included. If you did not publish/submit or present anything, state 'Nothing to Report' directly above the Journal publications section.

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

> De Wolf, E., D. Shah, P. Paul, L. Madden, S. Crawford, D. Hane, S. Canty, R. Dill-Macky, D. Van Sanford, K. Imhoff and D. Miller. 2019. "Impact of Prediction Tools for Fusarium Head Blight in the US, 2009-2019." In: S. Canty, A. Hoffstetter, H. Campbell and R. Dill-Macky (Eds.), *Proceedings of the 2019 National Fusarium Head Blight Forum* (p. 12), Milwaukee, WI; December 8-10. University of Kentucky, Lexington, KY.
> Status: Abstract Published and Poster Presented
> Acknowledgement of Federal Support: YES (Abstract and Poster)

Journal publications.

Qiu, R., *Yang, C.*, Moghimi, A., Zhang, M., Steffenson, B.J. and Hirsch, C.D., 2019. Detection of Fusarium Head Blight in Wheat Using a Deep Neural Network and Color Imaging. Remote Sensing, 11(22), p.2658.
Status: Journal paper published.
Acknowledgement of Federal Support: YES

Wen-Hao Su, Ce Yang, Yanhong Dong, Ryan Johnson, Rae Page, Tamas Szinyei, Cory D. Hirsch, Brian J. Steffenson. 2020. Hyperspectral imaging and improved feature variable selection for automated determination of deoxynivalenol in various genetic lines of barley kernels for resistance screening. Food Chemistry.
Status: Journal paper under review.
Acknowledgement of Federal Support: YES

Wen-Hao Su, Jiajing Zhang, Ce Yang, Rae Page, Tamas Szinyei, Cory D. Hirsch, Brian J. Steffenson. 2020. Mask-RCNN based dual deep learning frameworks for automatic determination of disease severity of wheat Fusarium head blight. Computers and Electronics in Agriculture.
Status: Journal paper under review.
Acknowledgement of Federal Support: YES

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

Chapter 5 Title: Hyperspectral imaging and machine learning for rapid assessment of deoxynivalenol of barley kernels from Book Advanced Imaging Techniques and Applications in Agricultural Products Quality and Safety Evaluation 2020
Status: Revision finished.
Acknowledgement of Federal Support: NO

Other publications, conference papers and presentations.

Wen-Hao Su, Jiajing Zhang, Ce Yang, Rae Page, Tamas Szinyei, Cory D. Hirsch, Brian J. Steffenson. Evaluation of Mask RCNN for Learning to Detect Fusarium Head Blight in Wheat Images. 2020 International Conference of American Association of Agricultural and Biological Engineering.
Status: Poster Presented.
Acknowledgement of Federal Support: YES

Ce Yang. Color and Spectral Imaging for High-throughput Field FHB Detection and Lab DON Assessment. 2019 National Fusarium Head Blight Forum. Milwaukee, WI; December 8-10. *Invited talk.*
Status: Oral Presented.
Acknowledgement of Federal Support: YES

Qui, Ruicheng Qiu, Ce Yang, Ali Moghimi, Man Zhang, Brian J. Steffenson, and Cory D. Hirsch. 2019. "Detection of FHB in Wheat Using a Deep Neural Network and Color Imaging." In: S. Canty, A. Hoffstetter, H. Campbell and R. Dill-Macky (Eds.), *Proceedings of the 2019 National Fusarium Head Blight Forum* (p. 76), Milwaukee, WI; December 8-10. University of Kentucky, Lexington, KY.
Status: Poster Presented.
Acknowledgement of Federal Support: YES

Wenhao Su, Ce Yang. Modeling of Mask RCNN for the Detection of Fusarium Head Blight in Wheat. 2019 Minneanalytics AgTech Conference. *Invited talk.*
Status: Oral Presented.
Acknowledgement of Federal Support: YES