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:	59-0206-0-181
USDA-ARS Agreement Title:	Realtime Field Scab Assessment with Color and Spectral Imaging Systems on a Phenocart
Principle Investigator (PI):	Ce Yang
Institution:	University of Minnesota
Institution UEI:	KABJZBBJ4B54
Fiscal Year:	2021
FY20 USDA-ARS Award Amount:	$68,366
Recipient Organization:	University of Minnesota CFANS Bioproducts and Biosys Eng 207 BioAgEng, 1390 Eckles Ave. St. Paul, MN 55108-6005
E-mail:	ceyang@umn.edu
PI Phone:	612-626-6419
Period of Performance:	5/15/21 - 5/14/23
Reporting Period End Date:	5/14/2023

USWBSI Individual Project(s)

USWBSI Research Category*	Project Title	ARS Award Amount
EC-HQ	Realtime Field Scab Assessment with Color and Spectral Imaging Systems on a Phenocart	$68,366
	FY22 Total ARS Award Amount	$68,366

I am submitting this report as an: ☐Annual Report ☒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.

07/26/2023

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: Realtime Field Scab Assessment with Color and Spectral Imaging Systems on a Phenocart

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

   The **overall goal** of this project is to develop a real time high-throughput phenotyping method to be applied on a ground platform for field FHB assessment.

   a) hasten and streamline image processing procedures to increase phenotyping efficiency;
   b) enable real time field FHB assessments on the phenocart with on-board image computing;
   c) verify deep learning models for more robust performance with crop field trials;
   d) assess the feasibility of DON content detection in intact harvested wheat and barley seed by spectral imaging in comparison to GC-MS spectrometry.

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?

   1) Developed a new light weight deep learning algorithm for wheat spike detection that can be used for real time detection of wheat spikes from complicated background with boundary boxes, and masking individual spikes. The trained model is now applied to a ground based platform for high-throughput phenotyping to replace human disease scoring in the field.
   2) Yolact deep learning model was trained and achieved 92% MAP (Mean Average Precision), which was increased by 2% than the previously trained YoloV5-tiny model. The model has higher reliability in that it used a large image set for model training.
   3) Seed sample images are being preprocessed and combined to the previous image dataset for a more robust DON detection model by hyperspectral imaging.

   b) What were the significant results?

   The new algorithm to be integrated to a phenotyping platform reduced the processing time more than 10 times compared to previously developed deep learning models while achieving a higher disease detection accuracy than previously developed light deep learning model. It is ideal to be used for real-time wheat disease detection. It is now applied in a smartphone application.

   c) List key outcomes or other achievements.

   1) Developed a new light weight deep learning algorithm for wheat spike detection that can be used for real time detection of wheat spikes from complicated background with boundary boxes, and masking individual spikes. The trained model is now applied to a ground based platform for high-throughput phenotyping to replace human disease scoring in the field.
   2) Patent filing for the light-weight detection model and its application is undergoing.

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

1) My international collaboration opportunity to work on a similar project using data resources from China is a continuous effort. This collaborative work also resulted in a peer-reviewed journal paper with the report of a wheat spike detection models.
2) My MS student Fengyun Shi is actively working on the development of light weight deep learning models to be used for on-board FHB disease detection and achieved real time spike detection on a smartphone app. He will keep working on it for another year, with the goal of FHB disease detection model development and application on the smartphone app. The impact of this funded project will be increased tremendously by the user friendly platform that we are working on.
3) Two MS students from the Minnesota Robotics Institute under my supervision worked on the robot dog platform as a more efficient, remotely controlled phenotyping platform with cameras to replace the previously developed phenocart. The goal is to achieve motorized phenotyping platform specifically for the wheat trial field with on-board processing capability.

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

A poster presentation in the annual FHB forum 2022 has been made.

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?

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

☐ No, I have nothing to report.

Journal publications as a result of FY22 grant 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 grant 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).

C Yang, B Steffenson. Automatic evaluation of wheat resistance to fusarium head blight using dual mask. U.S. Patent App. 17/933,283

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

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

Fengyun Shi, Ce Yang. Development of An AI and Cloud Based Real-time Wheat FHB Detection Platform. Poster presentation, 2022 Annual FHB Forum. Tampa, FL.