**Project Title: Intra-Canopy Imaging for Crop Stress Diagnosis in Soybeans**

**Project Report from October 1, 2018 to December 31, 2018**

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**I. Statement of Project Objectives**

**Objective 1:** Soybean Intra-Canopy Imaging Stringer Suspended Crop Health Sensing (SSCHS) - Preliminary work has been completed on the SSCHS and image acquisition system. Several stock cameras are linked and controlled from a single, synchronized “main” camera. When the main camera is triggered, the other cameras are actuated with minimal delay. The cameras are controlled remotely through a mobile device app. After insertion into the soybean canopy, the cameras are lowered to multiple elevations within the plant canopy for image acquisition.

A second SSCHS will be developed for specifically for soybean crop canopies. This model will include cameras organized in a circle so imagery with a combined 360⁰ view of the lower portion of the canopy can be acquired, to give a single panoramic view of the area. We believe the panoramic view of the lower portion of the soybean canopy will account for many physical manifestations of a crop health problem. The final goal of stinger re-development will be the inclusion of structured LED lighting. LED illumination strips will mitigate the effects of soybean canopy self-shading.

**Objective 2:** Reference Library Development for Soybean Crop Health Assessment - To build the Reference Library, a network of crop scouts, growers, and state extensions specialists will be contacted. As crop health problems appear during the growing season, the above network will contact the project personnel. In turn, project personnel will travel to the location to take photographs and document crop health using the Precision Layered Sensing and Data Analytics

(PLSDA) Field Lab. The library will initially be limited only to crop health problems of importance to Ohio soybean producers. The general framework developed through the construction of the Reference Library for this project will allow for it to be expanded in a manner that enables its use in multiple settings, crops and applications.

**Objective 3:** Computational Process/Algorithm Development for Soybean Crop Health Classification – Post image acquisition data are transferred from the camera to the image processing, feature extraction and classification software environment. The advantage of doing this is the ability to extract more information about the plant than basic light reflectance and to able to create a robust sensing and model system that can work across different. Texture matching and color analysis techniques will be used to compare intra-canopy panoramas to those in the reference library for crop health diagnosis.

**Objective 4:** Commercial Scale Field Testing - In examining past research in the field, another notable weakness is that the test plots/fields are usually limited to one or two locations. Using a network of growers and state extension specialists, multiple locations across Ohio will be included. This will aid in assessing how well the sensors/algorithm are able to diagnose crop stresses. It will also provide a variety of test conditions to improve the functionality of the classification algorithms and validate the potential for use by soybean growers and crop scouts.

The Precision Layered Sensing and Data Analytics Field Lab (PLSDA), will be transported to a location upon notification from the network collaborators where there may be a crop stress. The research team has existing working relationship with numerous soybean producers as it is crucial for this sampling approach to be deployed in many locations.

**II. Statement of Quantifiable Progress Toward Project Objective(s) Achieved During the Reporting Period.**

**Objective 1:** Given the field-testing results from Objective 4 in the previous testing period, it was noted that there was an issue with the ability of the imaging sensors to compensate for intense direct sunlight, as shown in Figs. 1 and 2. Various algorithm approaches have been tested to adjust the functioning of the cameras to account for this. However, given the time of year, there has yet to be an opportunity to test these programming changes. Further, as a secondary plan we have looked at using neutral density filters, shown in Fig. 3 to help control the amount of light entering the camera and prevent over-saturation.

**Objective 2:** There is no additional progress to report for this objective.

**Objective 3:** From the 2018 cropping season testing, we have designed a Graphical User Interface [GUI] (refer to Fig. 4) to enable intuitive control of the cameras as well as viewing of the results. We will continue to develop and test this GUI with relevant stakeholders during the second year of the project (2019). We have also continued with Convolutional Neural Net

(CNN) training. As the group learns more about artificial intelligence, we continue to improve the functioning of these algorithms. Refer to Figs. 4, 5, and 6 for results & confusion matrices, a discussion about the results, and implications for 2019.

**Objective 4:** There is no additional progress to report for this objective.

**III. Problems and/or Obstacles that may Impact Completion Date, Cost or Scope of Project.**

The only new problem, in addition to those reported previously, is an inability to test new system modifications because of the time of year and lack of actively growing soybean crop to support both testing and evaluation. We look forward to continuing the development of SSCHS system in 2019.

**VI. Message, Questions, Comments or Requests**

None.

**Reporting Period**

October 1, 2018 to December 31, 2018

**Invoice File**

Invoice has already been submitted

**Additional File Attachments**

Please see attached figures file.