AGRICULTURAL RESEARCH FOUNDATION
INTERIM REPORT
FUNDING CYCLE 2019 – 2021

TITLE: Foliar Disease Detection with Multispectral Imaging

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EXECUTIVE SUMMARY:

The Pacific Northwest is one of a few areas worldwide that has a climate suitable for producing high quality Brassicaceae seed. Pacific Northwest growers produce half of US *Brassica* seed and a quarter of world *Brassica* seed. Black leg (*Leptosphaeria maculans*), a fungal foliar disease, has become widespread in the Willamette Valley since 2014, and chlorotic leaf spot (*Pyrenopeziza brassicae*) is likewise becoming common. Seed contaminated with these diseases can be impossible to export or sell. Aerial surveillance using an unmanned aerial system (UAS) with a multispectral camera may be able to detect these foliar diseases in field and help growers determine appropriate timing of fungicide applications for control. Aerial surveillance is particularly suitable as these foliar diseases appear in winter, when wet and muddy conditions in fields make scouting on foot or using vehicles very difficult. Additionally, large acreage fields become troublesome to obtain accurate estimates of disease levels, where remote sensing may provide a quantitative measurement more representative of the population compared to ground sampling.

OBJECTIVES:

Determine if field monitoring using multi-spectral imaging can provide early detection of plant foliar diseases common to the Willamette Valley.

PROCEDURES:

The UAS used for surveying is a DJI Matrice 210 with a RedEdge M multispectral camera. In other sampling protocols (such as determining canopy coverage or overall plant health indices), we have determined good resolution within the trigger speed of the camera is achieved when the drone is flown at 2 meters per second at 20 m altitude. At these flight conditions, each pixel in the images representing 1.4 cm^2. After the flight, the images can be stitched together to create an orthomosaic of the entire field and further analysis can help create different visual representations for plant growth qualities through vegetative indices. In this project, we are testing if these flight conditions, with this camera, will also allow for detection of early stages of disease in the field. We hypothesize disease detection of black leg symptoms and signs on *Brassica* crops can be achieved through remote sensing and image analysis techniques.

Two *Brassica* seed fields that were found to be infected with black leg by in-person scouting and laboratory confirmation of infected plant samples were surveyed via drone in early 2019. Aerial photographs were taken in November and December to provide a baseline, and continued as flight conditions allowed during the growing season to track the development of foliar symptoms. Field scouting detected the presence of black leg and chlorotic leaf spot in the surveyed fields in January 2020.

The images gathered in the field were used to help inform a graduate student project. The student, in cooperation with Ocamb's and Buckland's labs, accomplished detailed analysis of field images in 2020 and determined a lack of resolution on the images sufficient to indicate disease within the field (Figure 1). In order to move forward, we were required to increase the resolution by conducting drone imaging at lower distances above ground level. Additional imaging of symptomatic turnip and canola plant material was imaged and analyzed with varied pre- and post-processing machine-learning techniques. While applied applications of these techniques were compromised through a lack of resolution, alternative crop-pathogen systems presented themselves as viable options for these aerial scouting techniques. Although the lack of resolution at field scale for detecting black leg disease was disappointing, we decided to move forward with two actions. First, we asked "what pixel size do we NEED within field scouting to be able to see black leg with our drone?" Second, we trialed the disease scouting system with a different disease/crop combination in the fall of 2020 with Botrytis bud blight (gray mold) in hemp.

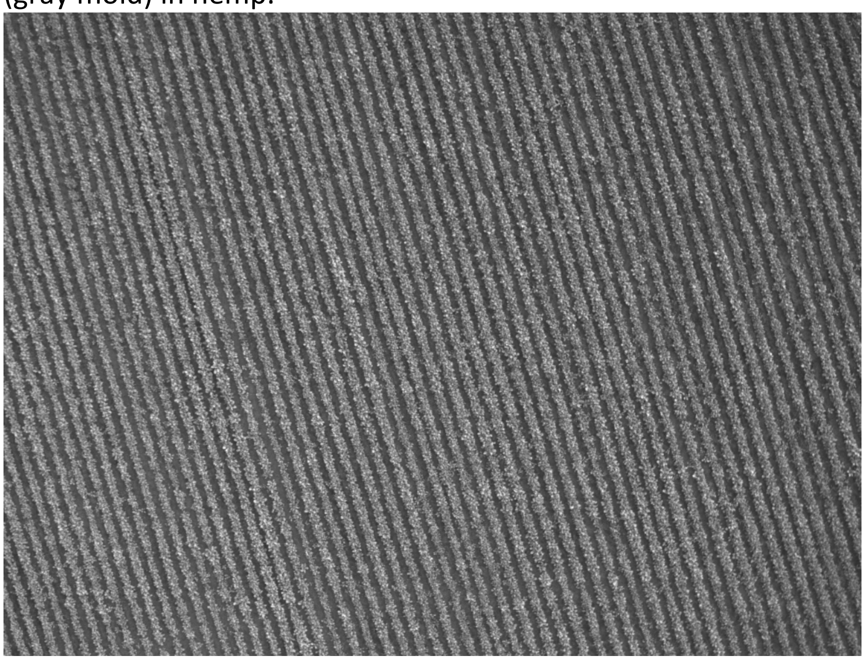

Figure 1. Image of turnip field captured by UAS at 20 meters altitude.

To determine the pixel size required for black leg detection in the field, greenhouse work was completed to model the appearance of black leg (funded separately). Black leg-infected and healthy leaves were collected from turnip fields near Salem, OR in early 2019 and photographed using a fixed RedEdge-M multispectral camera. A multispectral camera collects light at bands of varied wavelengths, some not visible to the human eye, but important to photosynthesis and plant health. A supervised machine-learning model was developed and tested to categorize imaged leaves as infected or uninfected based on this set of images. This support vector machine model can identify areas on photographed leaves that are infected and assessed accuracy with a confusion matrix on test data. This model will be adapted as we use images captured at various altitudes to develop an effective field detection strategy for black leg.

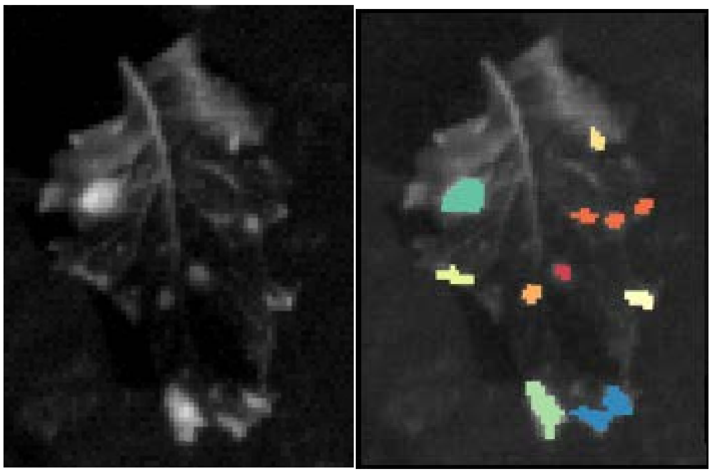

Figure 2. Example of a gray-scale image from the Rededge camera at 2 meters AGL, and the same image with infected areas highlighted based on model predictions.

Not all plant pathogen symptom and signs are observed in similar patterns on foliage. Therefore, we wanted to see if we could use a similar method to identify botrytis in hemp fields with the Rededge camera resolution capabilities. Because *Botrytis* is often found in the upper canopy where inflorescent maturity is greatest and often encompasses the whole flower, aerial detection should be easier to achieve. Flights at 10-m AGL over hemp yards with larger disease representation than found in *Brassica* fields suggested this approach would be feasible.

SIGNIFICANT ACCOMPLISHMENTS TO DATE:

A computer model has been produced to identify black leg using multispectral images, and aerial surveillance has been conducted to provide images to develop this model for field use. Additionally, we have determined that successful field scouting for black leg would need to involve a significant decrease in pixel size, possibly as much as a ten-fold reduction in pixel size, in order to be effective using the flight methods we currently employ. This is not to say field-scale disease detection is unachievable; however, with the camera resolution of our equipment and desire to fly at altitudes for 10-20 m above ground for both safety and ensuring the prop-wash does not disturb the plant canopy, this disease is not readily detectable. Conversely, other plant pathogens such as *Botrytis* may be more aligned with widespread field scouting as observed in hemp fields in 2020.

ADDITIONAL FUNDING RECEIVED DURING PROJECT TERM:

None.

FUTURE FUNDING POSSIBILITIES:

This project has demonstrated the potential uses of UAS imagery for early detection of foliar diseases which will enable us to present preliminary data for outside funding opportunities in the near future. We hope to partner with local agronomy industry opportunities to refine the equipment and procedures for regionally significant pathogens.