Report on Michigan Wheat Checkoff Program Proposal

Enhancing Phenotypic Trait Data Collection and Analysis for Faster and Better Selections in Wheat Breeding Using High Resolution Drone Imagery

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Objectives

The main objective of this proposal is to enhance the breeding program of Dr. Eric Olson by providing high resolution plant reflectance imagery of the Mason Research Farm to increase the knowledge necessary for selection of wheat lines.

Specific research objectives:

- **Task 1.** Collect bare soil imagery of Mason Research Farm
- **Task 2.** Collect remotely sensed imagery in conjunction with ground truth measurements.
- **Task 3.** Relate remotely sensed vegetation indices to known varieties planted in replicated field trials.
- **Task 4.** Develop and apply a predictive model linked to the remotely sensed imagery understand the wheat growth and development that includes genetic information.

Methodology

Flights were made at the Mason Research Farm in 2017 and 2018 (Table 1). A flight map was created that covers all trials of the field flying at the minimum altitude of 262ft (80m). This allows the resolution of each image to be 2.2in (5.5cm) per pixel. At low wind speed and ideal conditions, flight time averaged 16-18 minutes. Each flight captured visible and multispectral imagery from 2 cameras mounted on the UAV. Multispectral imagery is captured in narrowband blue, green, red, red edge (RE), and near infrared (NIR) wavelengths. Simple vegetation indices like normalized difference vegetation index (NDVI), normalized difference red edge (NDRE), and green normalized difference vegetation index (GNDVI) quantifies the amount of light reflected by plants in the individual plots. The imagery is stitched together using Pix4Dmapper software (Pix4D, Switzerland) that creates an orthomosaic reflectance panel. Because each flight collects hundreds of images at a low altitude, the corresponding orthomosaic is a high-resolution picture of the entire flight encompassing all breeding trials (Figure 1). Ambient light is captured before and after each flight and used to calibrate the multispectral images. Images without calibration can't be compared temporally since light conditions, i.e. overcast, cloudy, clear, and shadows diffuse light differently.

An orthomosaic is created from hundreds of photos that each are georeferenced using the internal GPS mounted on the UAV. Accuracy is dependent on the error of the system installed on each

individual UAV (Table 2). Orthomosaic reflectance panels are georeferenced using stationary objects captured during flight (roads, structures, trees) in post-processing. For the research plots in Mason, polygons are drawn by hand from imagery captured during the first flight (Figure 2). The trials at the Mason Research Farm encompass multiple plot lengths and widths. Preliminary analysis of two varietal check (Pioneer 25R40 & Ambassador) plots that were located in each replicate of the performance yield trial (PYT) field.

Results

The mean yield of the pioneer check plot was compiled from 36 individual plots and graphed for each flight throughout the growing season. NDVI values captured immediately after wheat emergence were higher until early spring when the plant grew from the warmer temperatures. The plots reached saturation in May, with NDVI near 0.9 and smaller standard errors (Figure 3). Individual reflectance of NDVI from each plot were also graphed to further investigate the variability that exists from plot to plot. All plots are shown in Figure 4 that includes only flights made in the spring around the time of green-up. The variability within each flight gets smaller as the plots become more saturated later in the growing season. This particular check plot, Pioneer 25R40, is a common commercial variety grown in Michigan.

Conclusions

This procedure provides a snapshot of plant reflectance of a whole field with a quick turn-around. Reflectance from a variety of vegetation indices can be exported from individual plots and important notes associated to their growth and development over the course of the growing season can be detailed and related to additional notes collected by the breeding team.

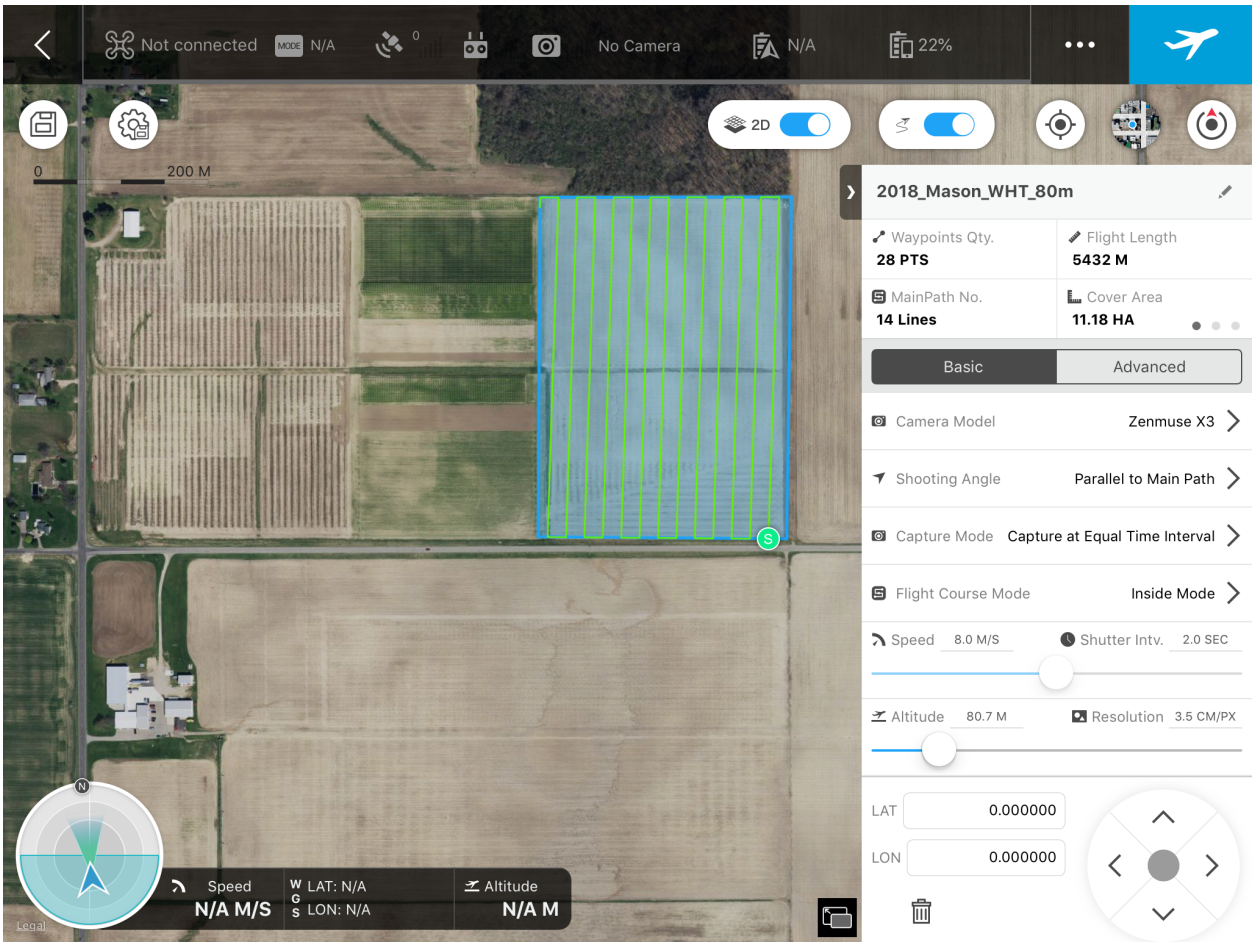

Figure 1. Flight plan for Mason Research Farm related to the plots planted in 2018. The flight covers 27.6 acres in a serpentine motion capturing 300-400 photos.

Table 1. Number of flights and dates for all imagery captured in 2017-2018 growing season.

Flight Number	Date	Location	Sensor
1	11/20/2017	Mason Research Farm	Multispectral/Visible
2	11/29/2017	Mason Research Farm	Multispectral/Visible
3	01/26/2018	Mason Research Farm	Multispectral/Visible
4	02/22/2018	Mason Research Farm	Multispectral/Visible
5	02/28/2018	Mason Research Farm	Multispectral/Visible
6	03/23/2018	Mason Research Farm	Multispectral/Visible
7	03/30/2018	Mason Research Farm	Multispectral/Visible
8	04/13/2018	Mason Research Farm	Multispectral/Visible
9	04/20/2018	Mason Research Farm	Multispectral/Visible
10	05/02/2018	Mason Research Farm	Multispectral/Visible
11	05/07/2018	Mason Research Farm	Multispectral/Visible
12	05/14/2018	Mason Research Farm	Multispectral/Visible
13	05/22/2018	Mason Research Farm	Multispectral/Visible
14	06/11/2018	Mason Research Farm	Multispectral/Visible
15	06/29/2018	Mason Research Farm	Multispectral/Visible

Table 2. Basso lab UAV, payload, and accuracy of internal GPS.

UAV Model	**Primary Payload**	**Horizontal Error (ft)**	**Vertical Error (ft)**
Matrice 600 Pro	LIDAR, thermal, multispectral, visible	4.92	1.64
Matrice 100	Thermal, multispectral, visible	6.56	1.64
Mavic Pro	Visible	4.92	1.64

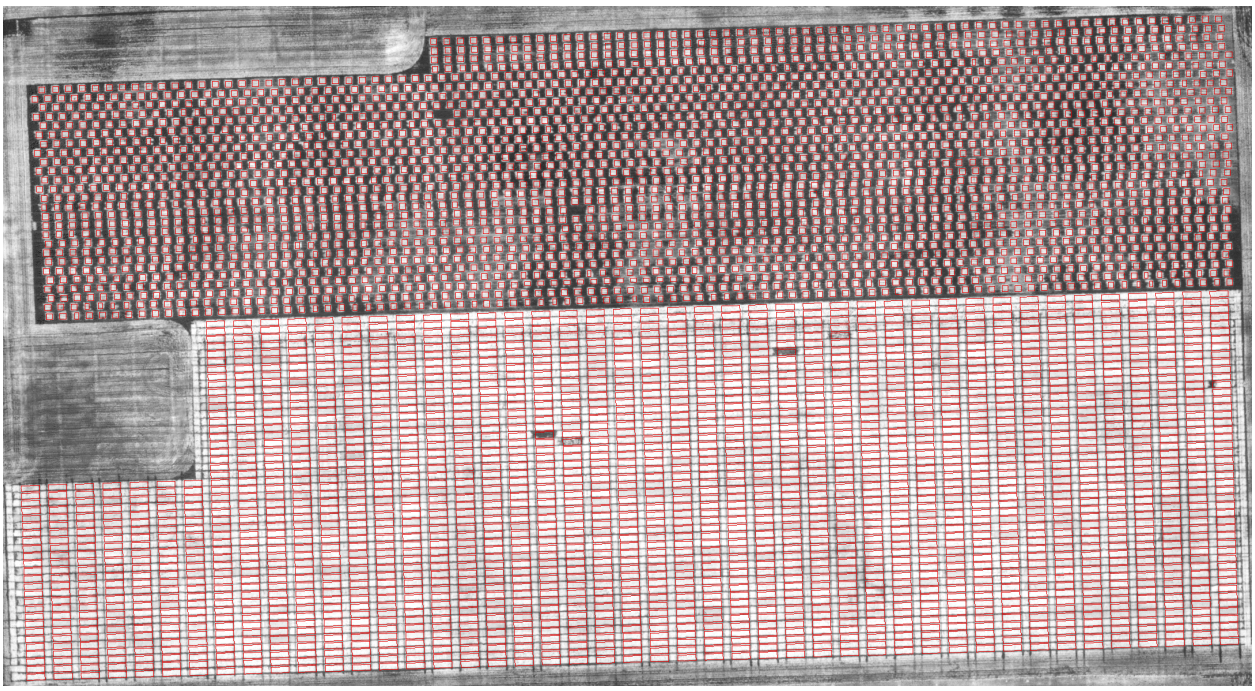

Figure 2. Hand drawn polygons (red) that outline each individual plot located at the Mason Research Farm.

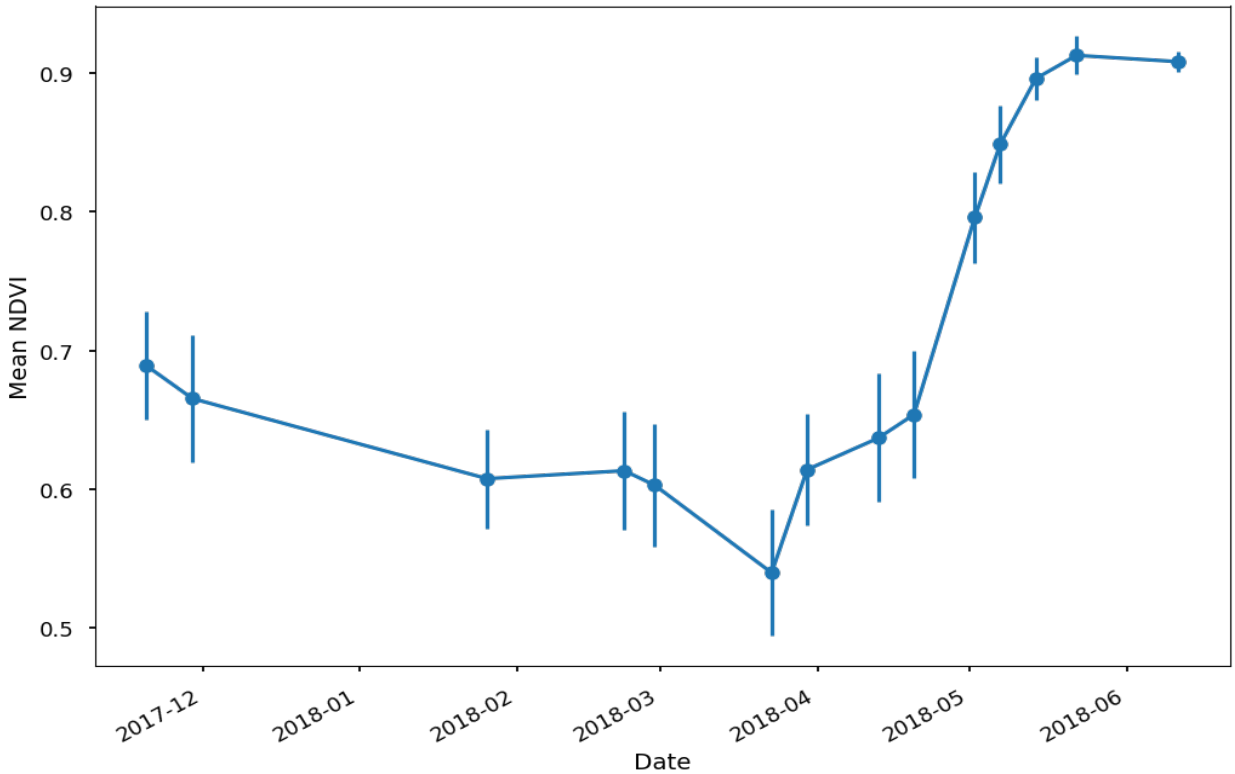

Figure 3. Mean NDVI of 36 individual check plots of Pioneer P25R40.

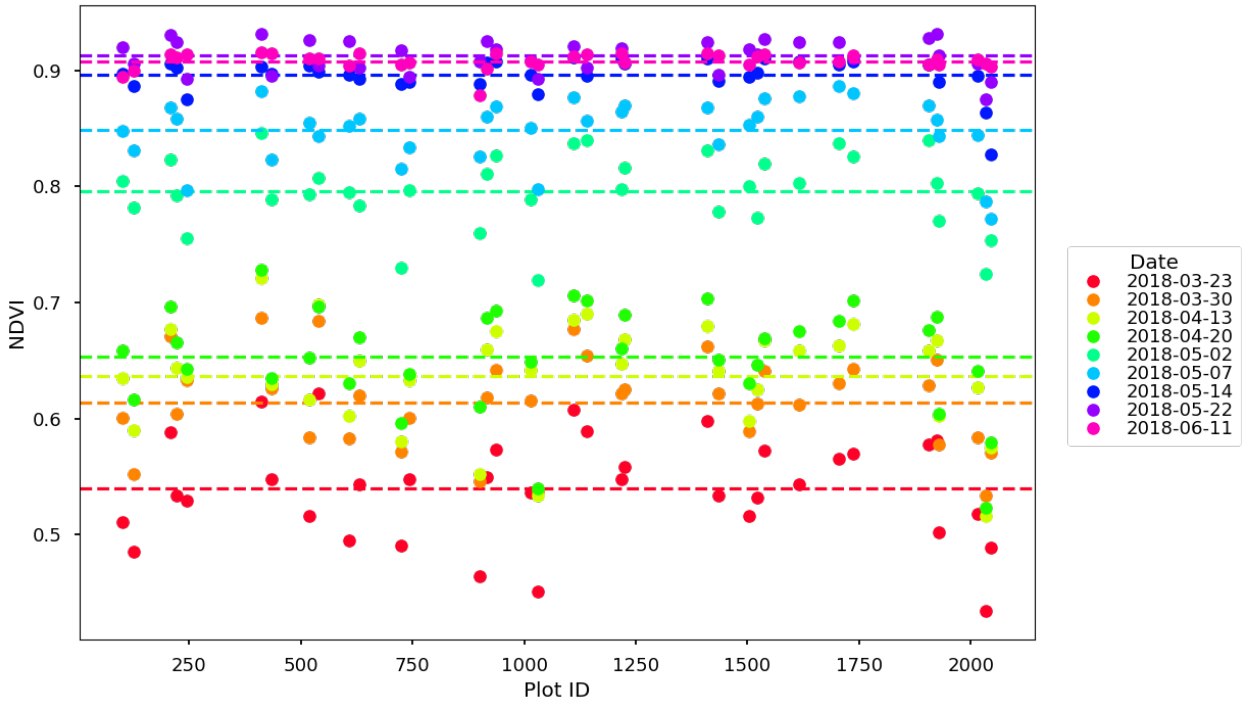

Figure 4. Dots represent reflectance of NDVI for each plot (n=36) and dashed lines represent the mean value for that particular date of flight.