High-Throughput Aerial Phenotyping for Improving Nitrogen Use Efficiency in Wheat

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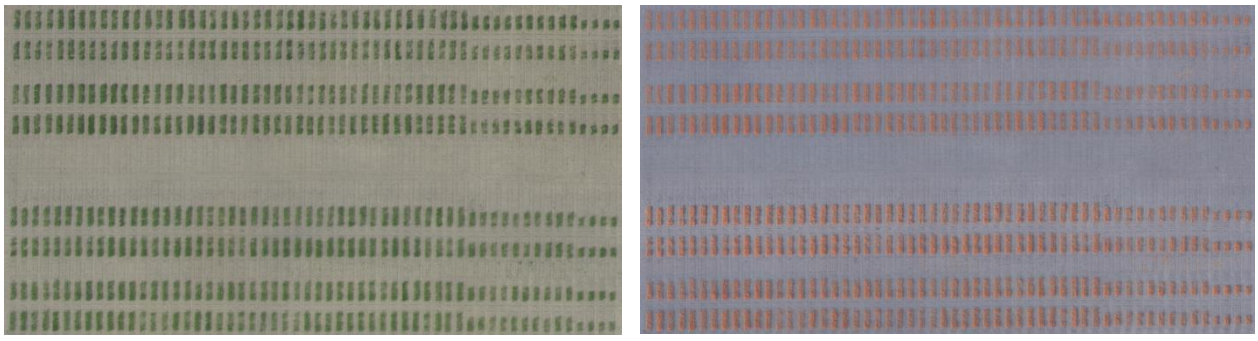
Phenotyping in agricultural research is essential in assessing plant traits such as growth, morphology, architecture, resistance to abiotic and biotic stresses, and yield under field conditions. The development and application of high-throughput phenotyping technologies is critical to reducing costs and improving efficiency. Images obtained through satellites are being used in agricultural applications but are low in resolution. Aerial imaging is becoming increasingly popular as a tool for high resolution and low cost plant phenotyping. Unmanned aircraft systems (UAS) are being equipped with multi band sensors which record reflectance signatures from crop canopies, and with cameras with modalities such as RGB/visible and near infra-red (NIR) to derive growth status and various indices of plant performance.

Nitrogen use efficiency is an important trait in wheat and other crops, and identifying genotypes which can efficiently utilize nitrogen for their growth, development and yield would ultimately reduce the usage of nitrogen fertilizers. This will reduce the cost of crop production, and the impact of pollution due to over application of nitrogen fertilizer. In an attempt to increase nitrogen use efficiency in wheat, several genotypes were tested in a field experiment for their response to low and optimum nitrogen fertilizer application. The experiment comprised 448 plots each of 1x4 m dimension. Sensor based hand held equipment such as Crop Circle (ACS 470, Holland scientific, Nebraska, USA) estimate Normalised Difference Vegetation Index (NDVI) that correlates well with crop canopy biomass. However measuring NDVI with Crop Circle that is either hand held or mounted on a ground based vehicle involves significant time and manual handling, and is restricted when the ground is wet.

Aerial imaging overcomes these limitations, is high-throughput, and allows time course observations during crop growth. Aerial imaging using the UAS 3DR Solo (3DR, Berkeley, USA) fitted with a GoPro Hero 4 black (GoPro, California, USA) modified for NIR, and Sequoia (Parrot, USA) multiband camera were used in the nitrogen use efficiency wheat experiment to capture RGB and NIR images. Multiple aerial images obtained in the experiment were stitched and a georeferenced orthomosaic image was generated using Pix4D mapper Pro (Pix4d SA, Lausanne, Switzerland) software. The shape file generated by the Pix4D mapper Pro, was imported into the geographic information system (GIS) software, QGIS to extract mean pixel and NDVI values from individual plots. Aerial images were recorded weekly and results are being analyzed. The orthomosaic images were generated from multiple images captured over the experimental wheat plots using RGB and NIR cameras and are shown in Figure 1a and 1b,

respectively. Preliminary results indicate a good correlation between aerial imagery data and manual observations and also with data collected using Crop Circle. Use of aerial phenotyping is efficient and would speed-up the research outcomes with significant cost savings in phenotyping experimental crop area.



A B

Figure 1. Georeferenced orthomosaic RGB (A) and NIR (B) images of experimental wheat plots.