Applications of Unmanned Aircraft System for Improving Water Use Efficiency in Wheat

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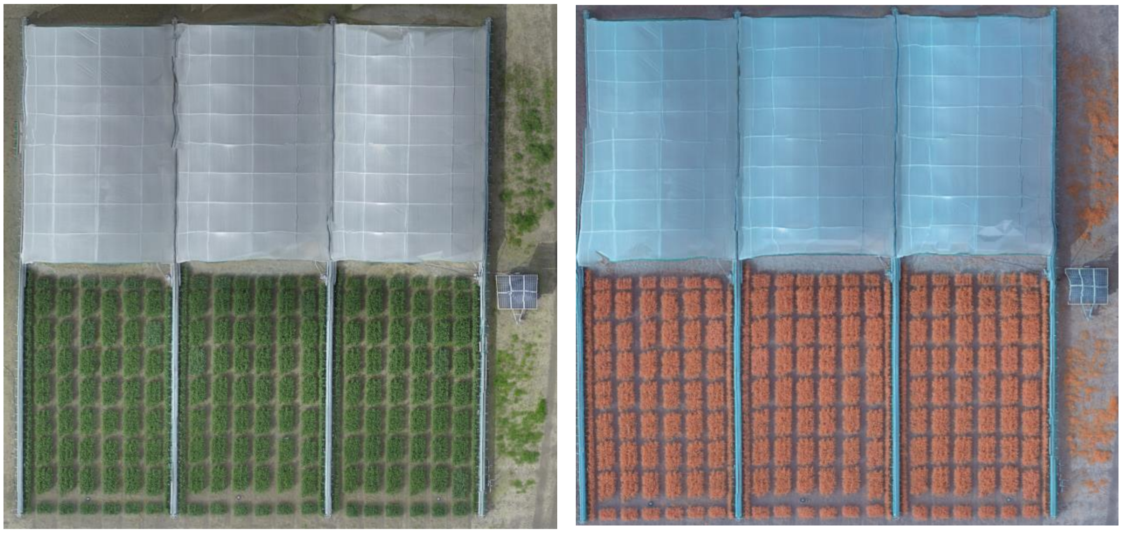
Keywords: Agriculture, plant phenotyping, phenomics, field trial, crop production

Precise and rapid phenotyping is critical for breeding of improved varieties in field crops. Non-destructive phenotyping techniques are preferred over destructive methods as repeat measurements can be obtained for the same genotype during the course of the growing period. Sensor and camera based equipment can provide non-destructive, precise and high-throughput measurements of crop growth. Aerial imaging is becoming an increasingly popular tool for field phenotyping. For aerial imaging cameras and multiband sensors are used to extract morphological as well as spectral signatures that enable the study of plant growth and development, and response to biotic and abiotic stresses. Thermal and multiband sensors are being effectively used to detect plant type, stress level and assess crop health in a high-throughput manner.

Crop growth and yield are significantly affected due to variable water inputs in many crop growing regions worldwide, including Australia, particularly in the context of climate change. There is a need to develop crop varieties with improved water use efficiency that use less water to produce sustained yield. A field experiment was conducted to study several wheat genotypes for their response to water use efficiency distributed across over 400 plots. The genotypes were each grown in four replicated, randomized plots with watering treatments of well watered and rainout shelter treatments. Three rainout shelters were developed to conduct precise water use efficiency experiments by excluding untimely rainfall. These automated rainout shelters are 20 x 10 m each, fully moveable and portable, solar powered and rain sensor activated.

The 3DR solo (3DR, Berkeley, USA) a multirotor unmanned aircraft system (UAS) was deployed for aerial observations. The UAS was mounted with GoPro Hero 4 (GoPro, California, USA) modified for near infra-red (NIR) and Sequoia (Parrot, USA) multispectral cameras. These cameras can estimate Normalized Difference Vegetation Index (NDVI) which correlates with canopy greenness, as an indicator of plant health. Canopy temperature is planned to be captured in future experiments using an IR thermal imaging camera (FLIR Vue Pro R, Oregon, USA) mounted on the UAS. The images obtained from the thermal imaging camera will be analysed using ResearchIR (FLIR, Oregon, USA) thermal image analysis software. Georeferenced orthomosaic RGB (Figure 1a) and NIR (Figure 1b) images were generated from multiple images taken over the experimental wheat plots grown in rainout shelters, and data is being extracted from the image, and analysed. The mean NDVI values obtained from aerial imaging will be correlated with biomass accumulation, grain yield and water use efficiency of the wheat genotypes. Aerial imaging thus is invaluable in phenotyping large field experiments with precise, informative, high-throughput, high-resolution, multi-time-point observations, throughout the entire crop growth cycle.



A B

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