Using Ground Based Sensors to Inform Thermal RPAS Methods for Detecting Crop Damage after Frost Events

Bonny Stutsel[1] and Nik. Callow[2]

[1] The University of Western Australia, 35 Stirling Highway, Crawley WA 6009, bonny.stutsel@research.uwa.edu.au
[2]The University of Western Australia, nik.callow@uwa.edu.au

Keywords: Thermal, Agriculture, Frost, Wheat, RPAS.

Abstract:
Frost costs cereal growers an average of $360 million dollars annually across the Australia Wheatbelt. While there is much research into frost resistant cereal varieties and there are options for better planning to manage frost risk, growers still need tools to rapidly and accurately assess the damage after frost occurs. This project aims to investigate the potential of Thermal Infrared (TIR) imagery (8-14 μm wavelength) and Remotely Piloted Aircraft Systems (RPAS) to map frost damage in cereal crops (wheat).

Ground-based temperature measurement has been used extensively to investigate plant health and stress in many crops. The temperature of a plant is a function of transpiration rate (stomatal aperture), metabolic reactions, and ambient weather conditions (Tanner 1963; Chaerle, Laury and Van Der Straeten 2000). Large (small) stomatal aperture leads to increased (decreased) transpiration and lower (higher) plant temperature (Grant et al. 2007). Changes in stomatal aperture is often an early physiological response to plant stress (Chaerle, Laury and Van Der Straeten 2000). Hence, we investigate the application of RPAS thermal imaging to investigation spatial patterns of crop health and condition, specifically the mapping of damage in winter cereal crops caused by frost events.

RPAS thermal cameras are increasingly affordable and available, but the accuracy and applicability of RPAS thermal imaging to crop stress detection is uncertain. Environmental factors during data collection (e.g. wind, cloud and temperature fluctuations) and degree of thermal response of plants to stress or damage relative to these other factors create challenges. Our project is investigating whether frost damage causes a change in transpiration that will lead to a detectable increase in plant temperature relative to other factors, allowing drone thermography crop damage assessment. We are investigating questions including: what time of day has the greatest difference in plant temperature (frosted/unfrosted), how many days after a frost event to detect and capture data; do plants recover from mild damage over time, and what pixel resolution (height) is optimal to detect change.

This project is using a network of thermal ground based sensor (ArduCrops, Australian Plant Phenomics Facility) to inform RPAS methods. These capture continuous plant canopy temperature measurement every second and report averages over one or five minutes (Figure 1). The preliminary data of diurnal plant canopy temperature profiles are being interrogated

to inform optimal RPAS operations in this field season and the potential success of the method. The project demonstrates how RPAS remote sensing operations can be optimised and informed by using ground based measurements. This is particularly important planning RPAS sampling methods for new applications such as frost mapping.

This work is supported by the Grains Research and Development Corporation's (GRDC) National Frost Initiative.

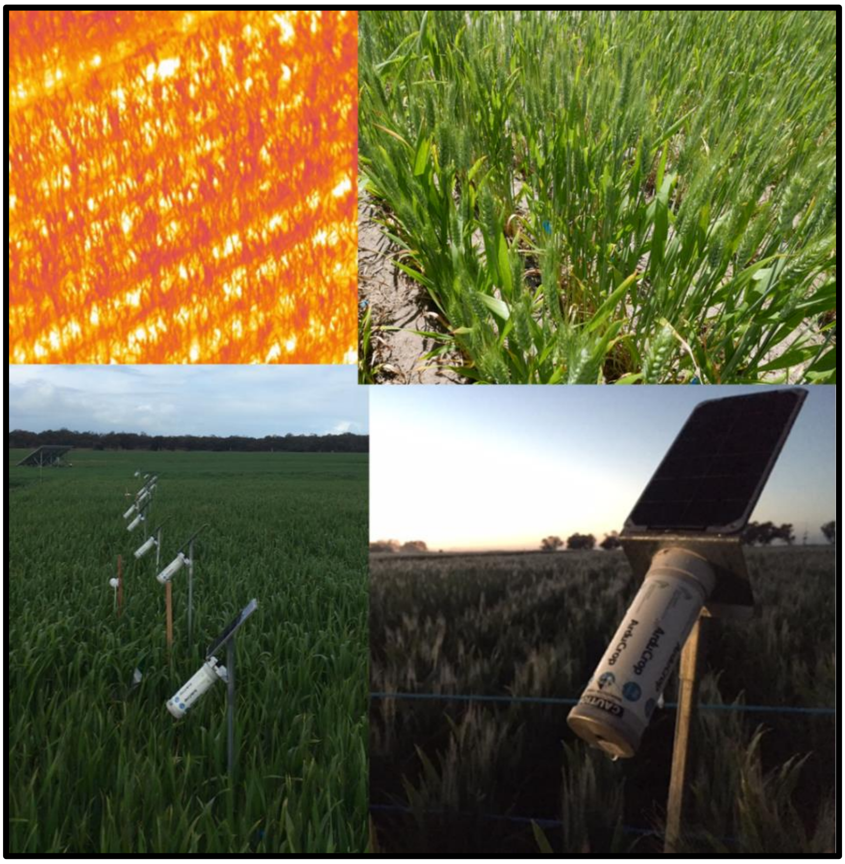

Figure 1. Left top: Thermal Imagery of wheat captured from a RPAS (FLIR TAU2 640 25mm). Right top: An example of the field of view of Arducrop V1 sensors. Left bottom: Network of Arducrop sensors deployed at the field site. Right bottom: Arducrop V1 thermal sensor.

References:

Chaerle, Laury and Van Der Straeten, D., 2000. Imaging techniques and the early detection of plant stress. *Trends in plant science, Elsevier Current Trends*, 5(11), pp.495–501.

Crimp, S., Bakar, K.S., Kokic, P., Jin, H., et al., 2014. Bayesian space-time model to analyse frost risk for agriculture in Southeast Australia. *International Journal of Climatology*, 35(8), pp.2092–2108.

Grains Research & Development Corporation, 2014. Frost. *Ground Cover Supplement- Issue 109*, pp.12–13.

Grant, O.M., Tronina, L., Jones, H.G. & Chaves, M.M., 2007. Exploring thermal imaging variables for the detection of stress responses in grapevine under different irrigation regimes. *Journal of Experimental Botany*, 58(4), pp.815–825.

Tanner, C.B., 1963. Plant Temperatures. *Agronomy journal*, 55(2), pp.210–211.