Beyond Hyperspectral

Linking multi-scale hyperspectral signals to wheat stress, yield formation and grain quality

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AAGI Analytics for the Australian Grains Industry

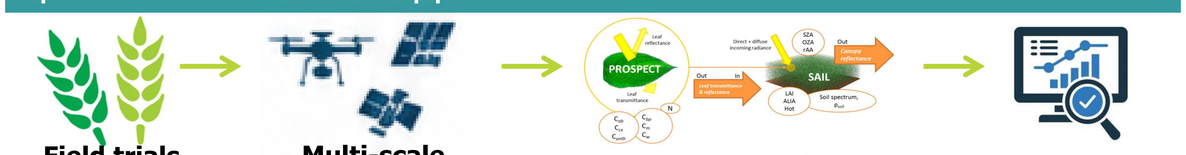
ABSTRACT

Hyperspectral remote sensing provides continuous spectral information sensitive to plant biochemical, structural and physiological traits, offering new opportunities to detect water and nutrient stress in wheat and to predict yield formation and grain protein. We established field rials in 2026 at Tosari (MCA Ag) and Gatton (UQ) with controlled water and nitrogen treatments and multi-scale observations (field measurements, UAV hyperspectral and thermal imaging, and commercial satellite data). By integrating radiative transfer modelling (PROSAIL/SCOPE) with data-driven approaches, we aim to identify key spectral features and develop scalable models linking hyperspectral signals to wheat growth, stress responses, yield and grain protein.

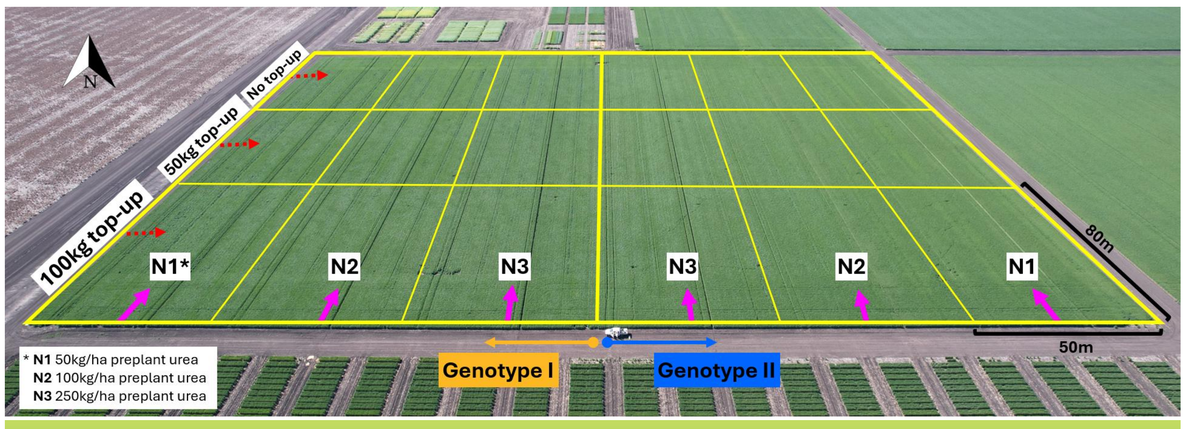
1 Project Objective and Approach

Objective

Identify hyperspectral signals sensitive to water and nitrogen stress in wheat, and develop models linking these signals to growth, yield formation and grain protein, with a pathway to an operational decision-support tool.

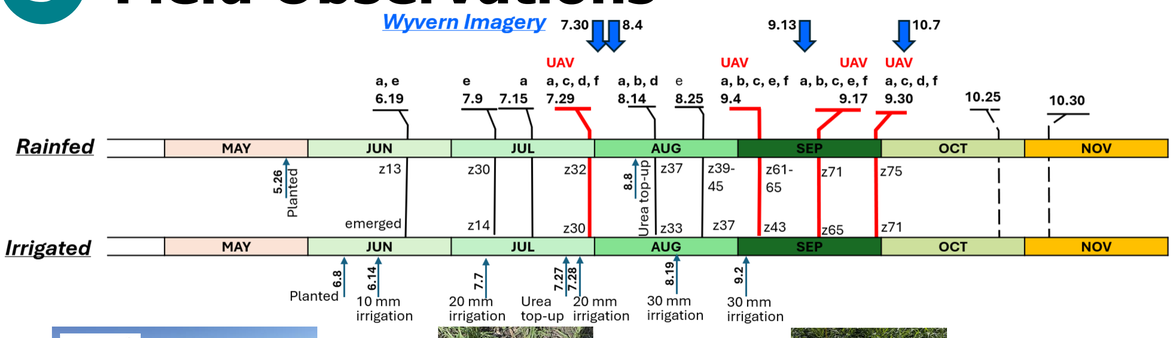


2 Field Trials and Experiment Design



- ❑ Large replicated plots to capture spectral signals from multiple sources (field spectroscopy, UAV, and satellite)
- ❑ Treatment settings generate controlled variation in canopy structure and biochemistry, enabling analysis of links to growth, yield formation and grain protein

3 Field Observations





a. Field spectroscopy



b. Canopy structure



c. Leaf Chlorophyll Content



d. Leaf Chlorophyll Fluorescence



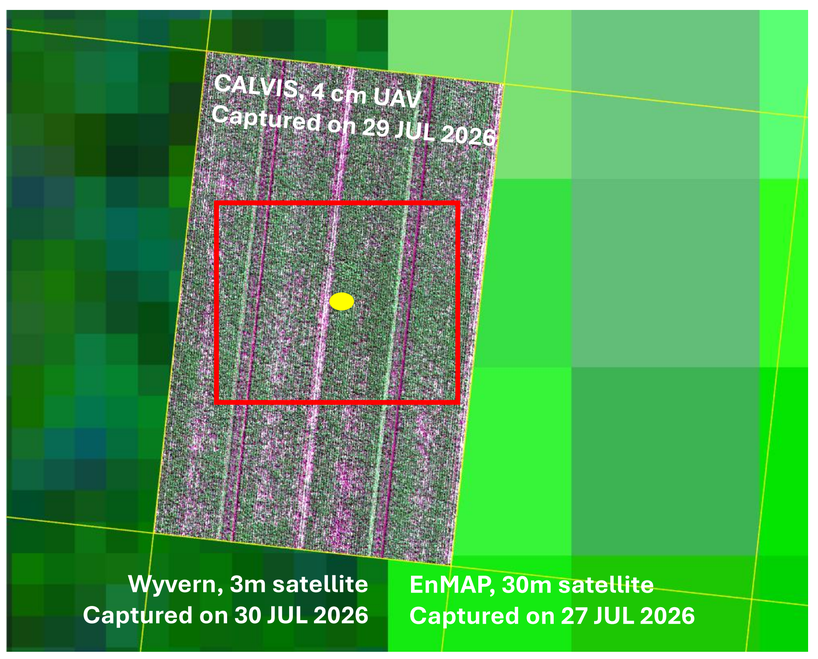
e. Biomass, leaf and grain sampling

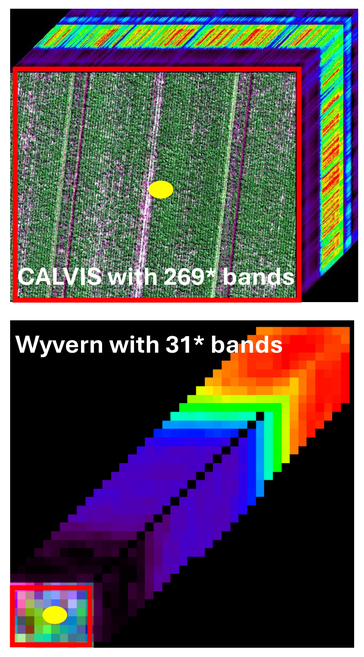


f. Growth measurement

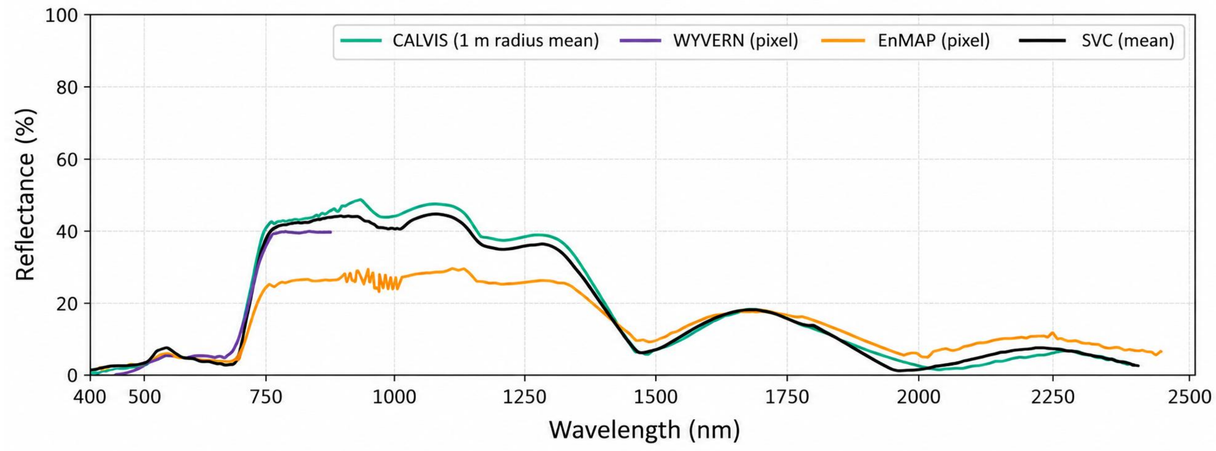
4 Hyperspectral Data across Scales

Sensor	Specifications	Pros vs. Cons
SVC HR-1024i	350–2500 nm; 1024 channels	High spectral detail; point-based canopy measurements
CALVIS / UAV	~4 cm pixels; 269 bands	Very high spatial detail; limited coverage and higher acquisition cost
Wyvern / satellite	~3–5 m pixels; 31 bands	Field-scale coverage; limited SWIR information
EnMAP / satellite	30 m pixels; 420–2450 nm; 224 bands	VNIR–SWIR coverage, freely available; coarser spatial resolution





Complementary spatial and spectral characteristics of field, UAV and satellite hyperspectral observations.



5 RTM Modelling

Bridging hyperspectral signal and crop physiology

Inputs	RTM simulation	Inverse modelling / trait retrieval	Hybrid modelling and analysis
Field measurements SVC, LAI, SPAD, fluorescence, biomass, leaf & grain traits **UAV hyperspectral& thermal** High spatial resolution canopy reflectance and temperature **Satellite hyperspectral** Wyvern, EnMAP	Simulate canopy reflectance and thermal response from biophysical parameters	Link spectra to biophysical traits (e.g., LAI, Cab, Cw, leaf N, etc) Retrieve trait maps and time series across scales	Combine RTM-derived traits with additional features (indices, thermal) using ML Predict crop growth, water and nitrogen stress, yield and protein

Model evaluation and refinement
(cross-validation with field data)

6 Research Priorities & Outcomes

- ❑ **Detect crop stress** – Identify spectral signatures of water and nitrogen stress for early detection.
- ❑ **Retrieve crop traits** – Integrate RTMs and hyperspectral data for accurate, interpretable crop monitoring.
- ❑ **Predict yield and quality** – Link crop traits and stress indicators to grain yield and protein.
- ❑ **Enable precision management** – Scale models from field to satellite for actionable decision support.

GRDC Grains Research & Development Corporation | Adelaide University | Curtin University | The University of Queensland Australia

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