In-season yield prediction using VARIwise

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DR Alison McCarthy, a mechatronic engineer at the Centre for Agricultural Engineering, University of Southern Queensland (USQ) in Toowoomba, has developed a tool that combines in-season, UAV imagery with models to provide yield prediction throughout the season. This research is part of the project 'Smarter Irrigation for Profit' project coordinated by CRDC and supported by funding from the Australian Government Department of Agriculture as part of its Rural R&D for Profit program. The research project, led by USQ's Associate Professor Joseph Foley, is collaborating with the CRDC's CottonInfo team.

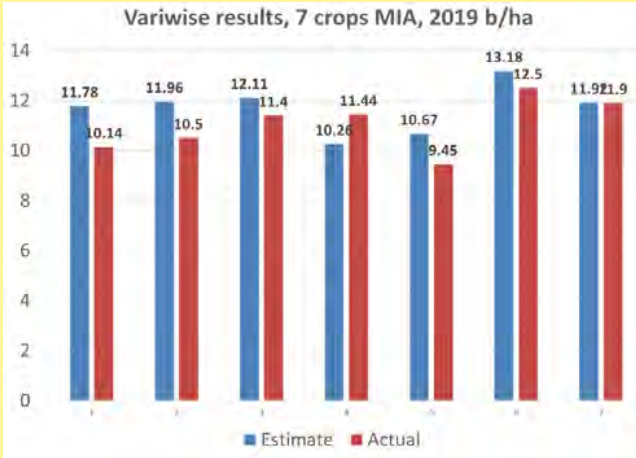
In-season yield prediction potentially enables improved agronomic management and planning for the sale of crops and insurance contracts. Yield is generally estimated using rules of thumb and manual boll counts. Data analytics approaches have been developed that link multi-spectral satellite images of the field with in-season weather conditions and yield measurements. But the relationship between spectral response and yield are site and season-specific and significant data collection and model development are required to identify relationships for each variety of cotton and soil type.

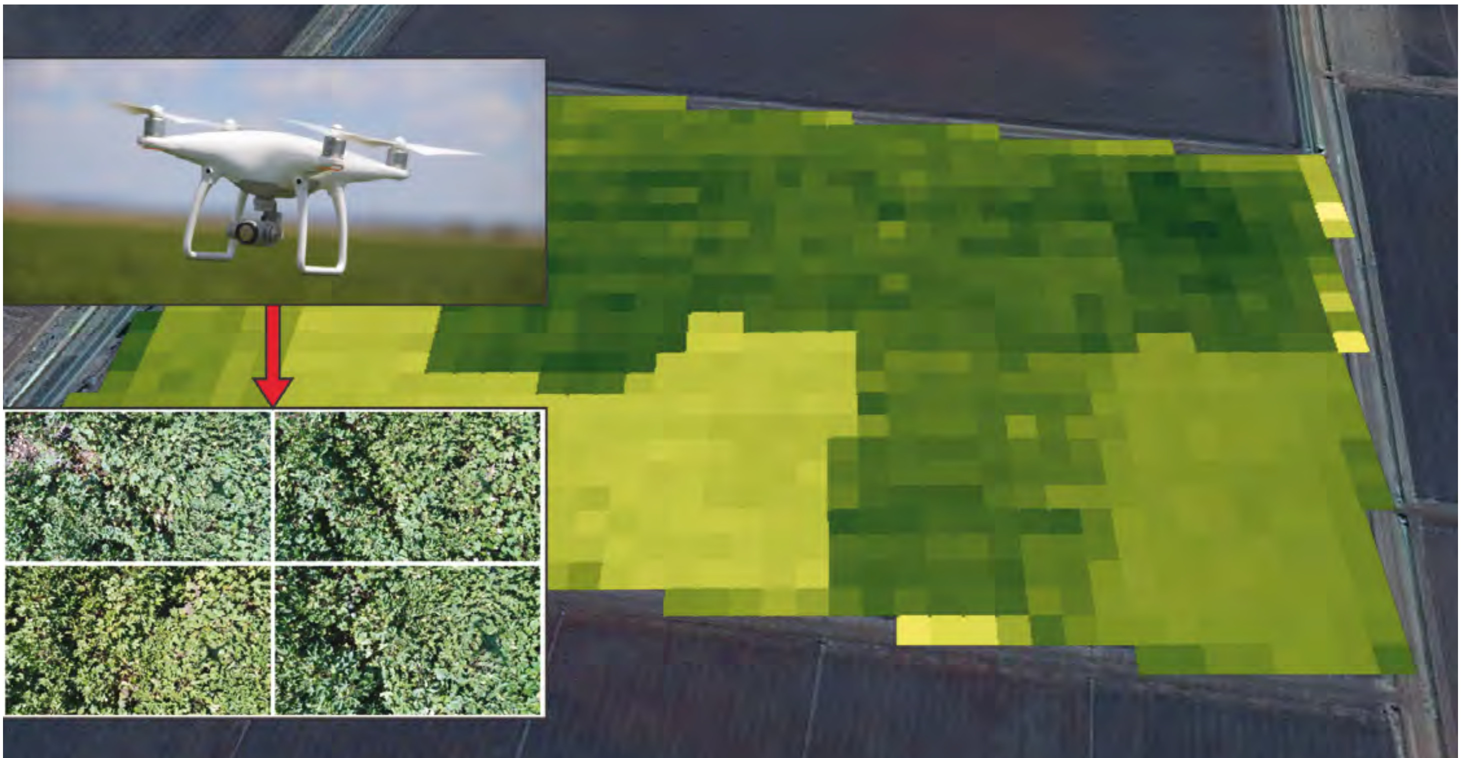
An alternative approach is to forecast yield using known soil-plant-atmosphere interactions in crop production models, calibrated using available field data. USQ has developed the software 'VARIwise' to predict yield throughout the season combining these models with:

- Plant parameters extracted from UAV imagery using image analysis;
- Online soil and weather data; and,
- On-farm management information.

UAV imagery has the potential to improve accuracy of yield

FIGURE 1: VARIwise results in seven crops in the MIA





UAV and processing for VARIwise yield prediction.

Variable-rate centre pivot irrigation machine on the Darling Downs.

prediction over satellite imagery as detailed crop features can be extracted and the timing of plant information collection is controlled. The cost of the sensing system is $2500 for a consumer UAV.

Evaluations have been conducted near Jondaryan, Goondiwindi and Griffith to:

- Identify the impact of the weather or soil data (online or infield) and frequency of UAV data collection on yield prediction accuracy; and,
- Evaluate the robustness of VARIwise for yield prediction in multiple regions.

The evaluations aimed to identify impacts of weather and soil data source on yield prediction accuracy was conducted on a centre pivot irrigated field on the Darling Downs. Data was collected from an onsite automatic weather station, electrical conductivity map, soil sampling, soil moisture sensors, weekly UAV and crop assessments.

The VARIwise yield prediction accuracy was compared using different combinations of infield and online weather and soil property data sources and frequency and timing of UAV data collection for plant feature tracking. This indicated that infield soil data is more important than on-farm weather data, and that the accuracy improved as the UAV capture frequency increased and the season progressed.

The robustness of the VARIwise yield prediction was evaluated at one cotton site in Goondiwindi and 16 sites in Griffith in the 2017–18 and 2018–19 seasons. Management zones in the fields monitored using the UAV were identified from vegetation index surveys, yield maps or satellite images. Phantom 4 UAV imagery was collected monthly at each site between January and picking to calibrate the crop model. The sites had varying levels of fruit removal, hail damage and heat stress.

In the 2017–18 Griffith trial, yield prediction errors were 10.2 per cent in January, 6.0 per cent in February, 2.5 per cent in March, and 0.5 per cent at picking, and in the 2018–19 Griffith trial the errors were 18.8 per cent in January, 4.9 per cent in February, 9.5 per cent in March, and 10.1 per cent at picking.

In the 2018–19 Goondiwindi trial, yield prediction errors were 8.7 per cent in February, 5.9 per cent in March, 7.1 per cent in April and 2.6 per cent in May.

The prediction errors at Griffith were higher in the 2018–19 season than the 2017–18 season because the sites experienced hail and heat stress that are not currently represented within the VARIwise crop model.

In the future, it is expected that the approach would be used by growers or consultants using UAVs for routine field checks. Data would be transferred to an App or webpage to provide regular mid and late season yield estimates.

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