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QUEENSLAND
Centre for Agricultural Engineering

In-season yield prediction using VARIwise

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Overview



- Background of in-season yield prediction
- USQ-developed yield prediction software VARIwise
- Performance of VARIwise yield prediction with different data inputs
- Use of VARIwise at trial sites by CottonInfo extension officers in 2017/18 and 2018/19 seasons
- Further work

Existing yield prediction approaches



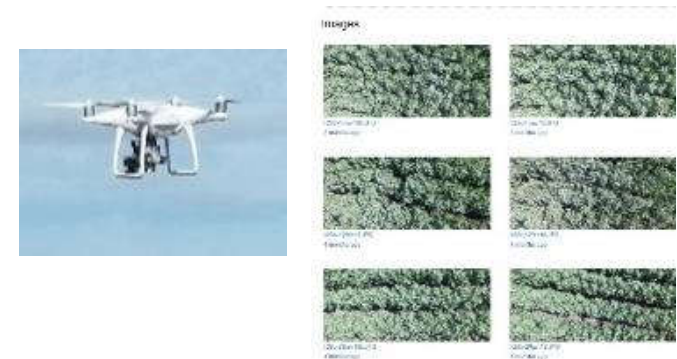
- Yield prediction improves contract planning and agronomic management (e.g. which field to irrigate)
- Existing approaches lack transferability and accuracy:
 - Machine learning models trained from satellite imagery and measured yield require intensive data collection for transferability
 - Biophysical models calibrated using satellite imagery have lower accuracy because of unreliable calibration data (e.g. Graincast has yield prediction errors of 33%)

USQ yield prediction 'VARIwise'

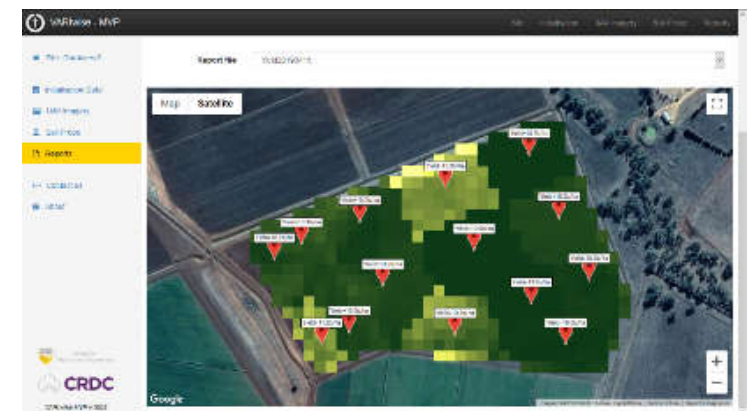
- Calibrates biophysical model using available weather, soil and management data and crop features extracted from UAV imagery
- Used in irrigation automation research
- Components of technology:
 - Crop monitoring sensors: UAV \$2000
 - Access to online weather and soil databases: free
 - Webpage for imagery upload and processing



1. Image collection



2. Image and model analysis



Evaluations of VARIwise yield prediction

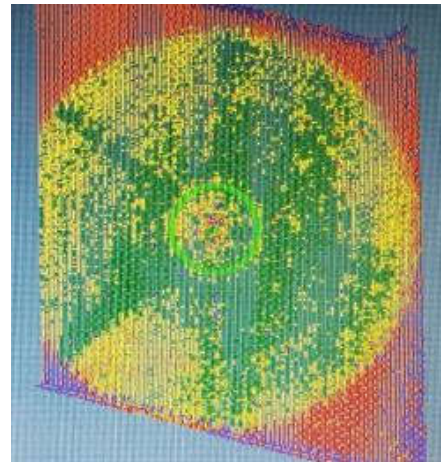


1. Identify impact on yield prediction accuracy from:
 - Source of weather and soil data (online vs in-field)
 - Frequency of UAV data collection
 - Evaluation of data requirements for yield prediction

2. Evaluate robustness of system at CottonInfo trial sites
 - Evaluation of VARIwise useability and robustness at broader scale

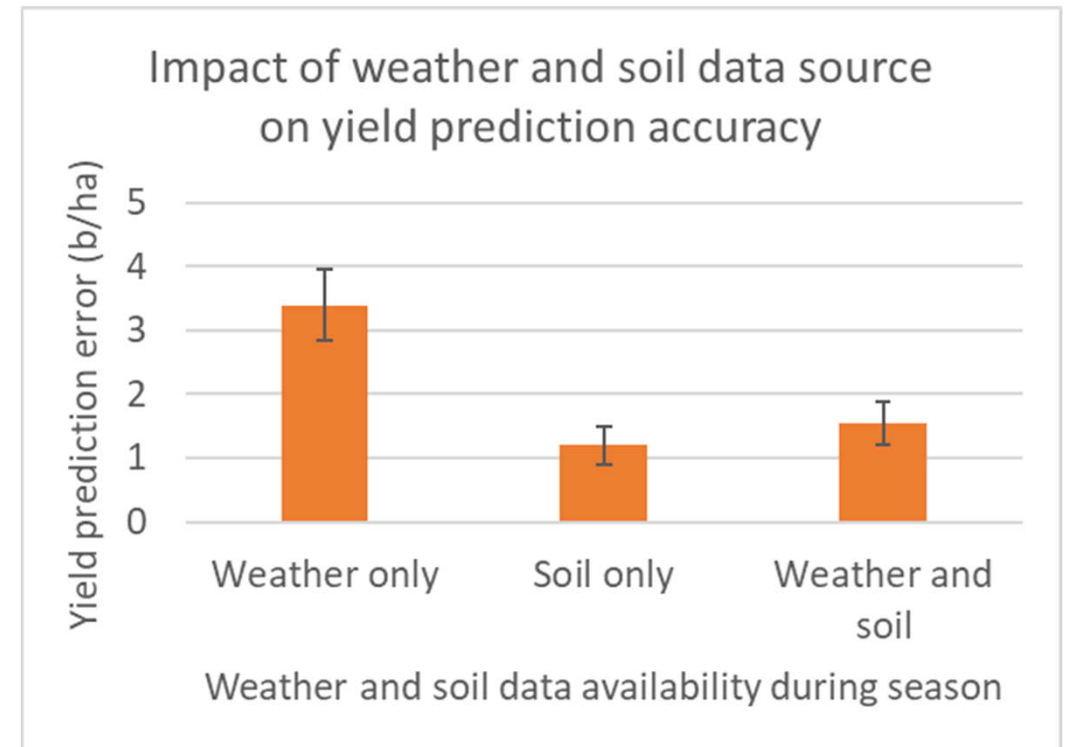
Methodology for VARIwise yield prediction evaluation in 2017/18 and 2018/19

1. Evaluation of data requirements for yield prediction:
 - Darling Downs centre pivot irrigated field
 - Onsite automatic weather station, electrical conductivity map, soil sampling, soil moisture sensors, weekly UAV and crop assessments
 - VARIwise yield prediction accuracy comparing weather and soil property data sources and frequency and timing of UAV data collection



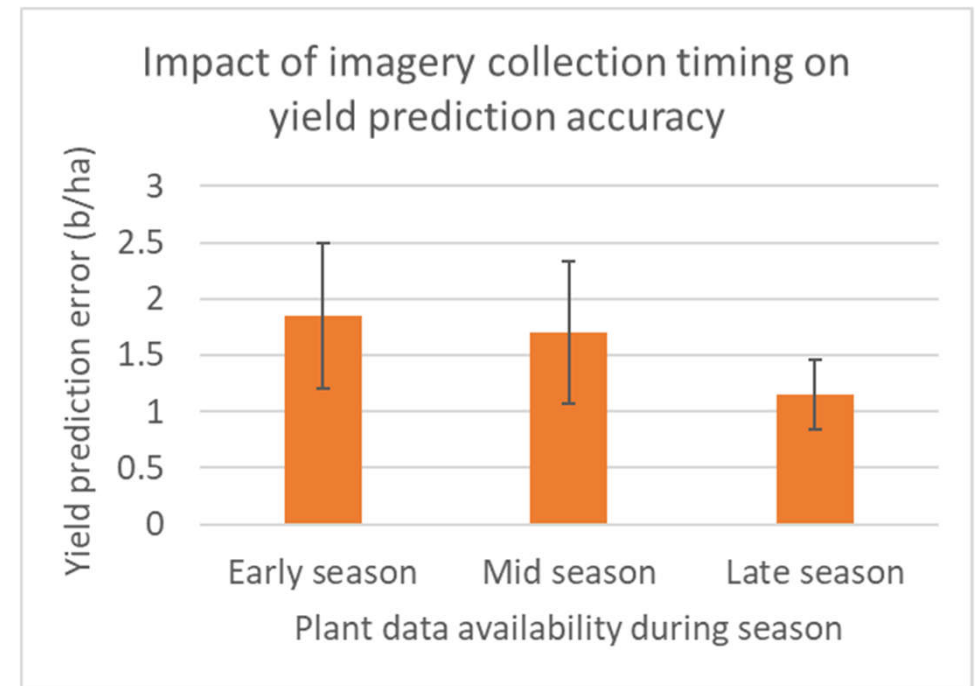
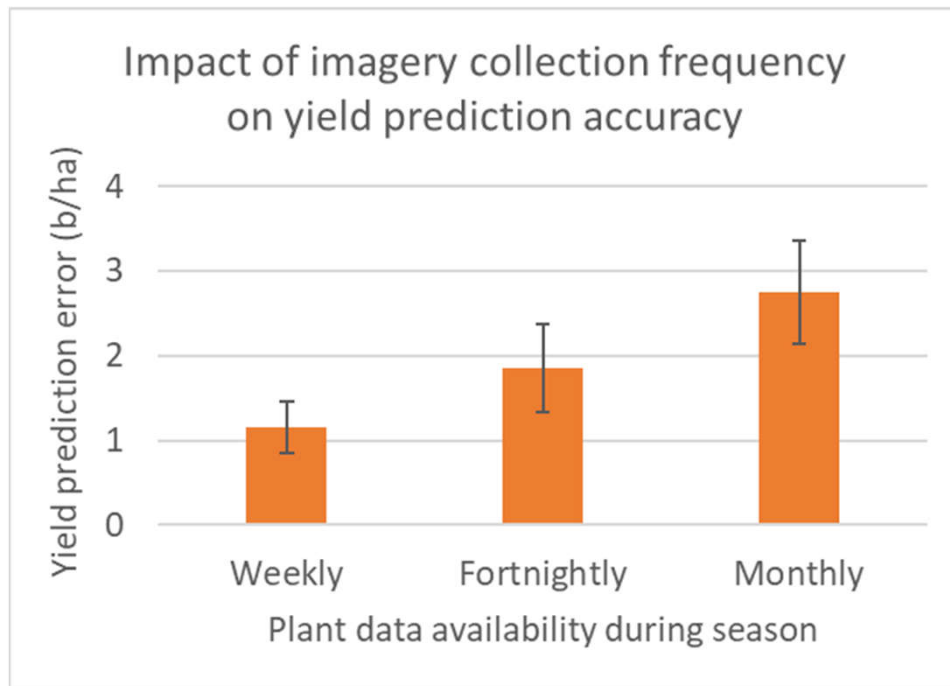
Impact of weather and soil property data source on yield prediction accuracy

- Yield prediction accuracy analysed with UAV imagery and different combinations of weather and data sources
- Infield soil data more important than on-farm weather data
- No significance difference between soil data and weather/soil data



Impact of UAV data collection frequency on yield prediction accuracy

- Yield prediction accuracy improves as:
 - UAV capture frequency increases
 - Season progressed

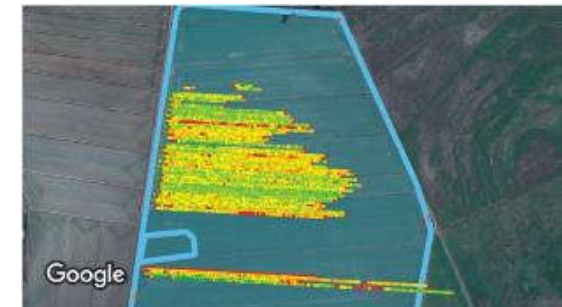


Methodology for VARIwise evaluation in 2017/18 and 2018/19



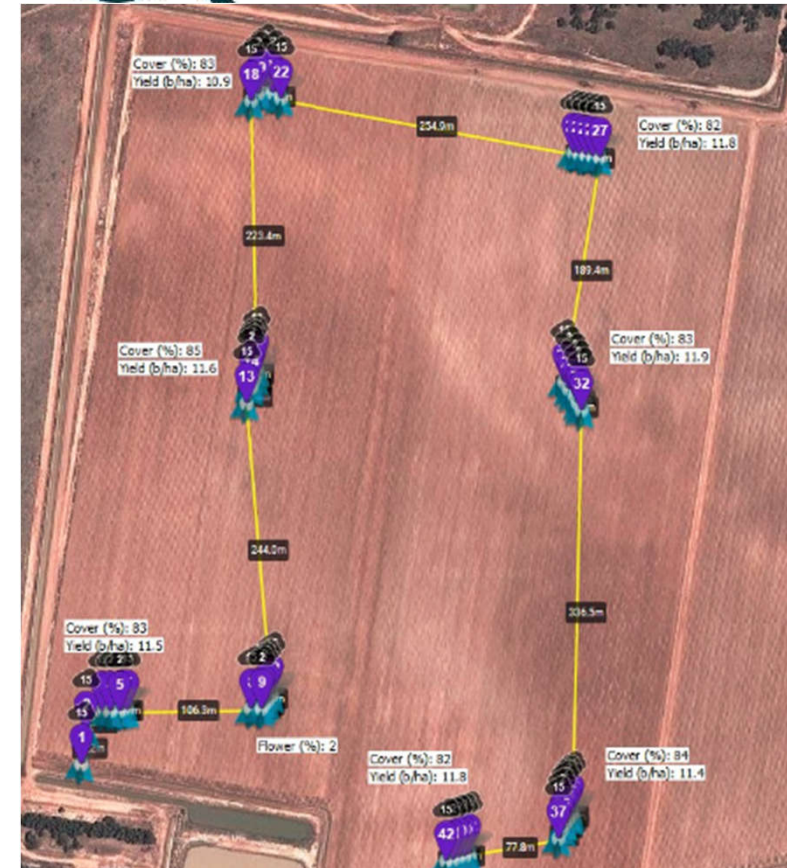
2. Evaluation of commercial scale VARIwise useability at CottonInfo trial sites:

- UAV trials conducted at 16 sites in Griffith (7 with final yield) and 1 site in Goondiwindi
- Weather and soil property information sourced online
- Field variability map identified UAV crop assessment locations
- Fortnightly UAV mapping
- Yield prediction reporting from webpage



Site 1: IREC 2018

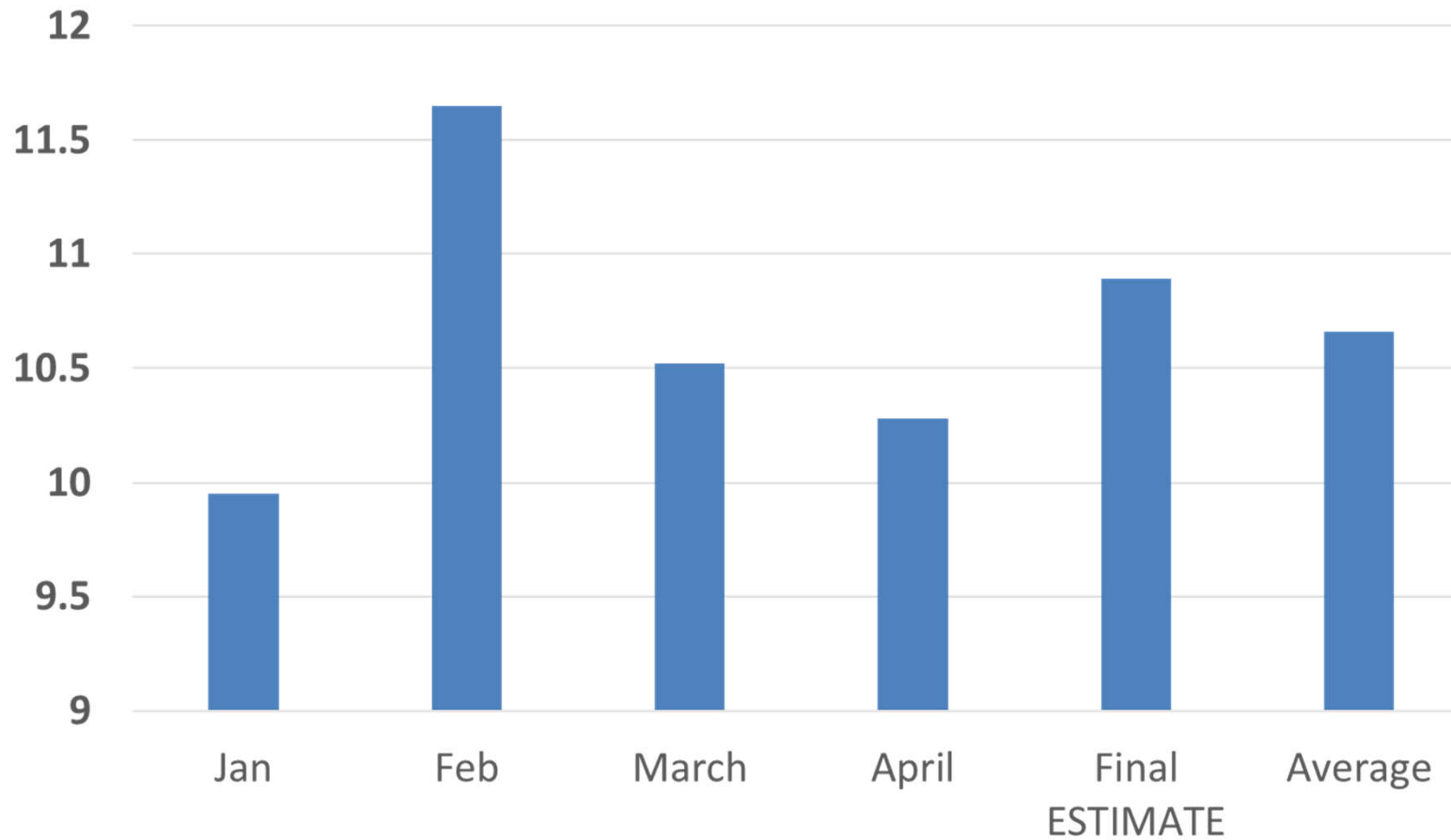
- IREC field station Whitton (30 ha) with six small roll over bays.
- IREC estimates done at the end of each month from cutout till picking.
- Average of the estimates 10.6 b/ha same as actual yield.



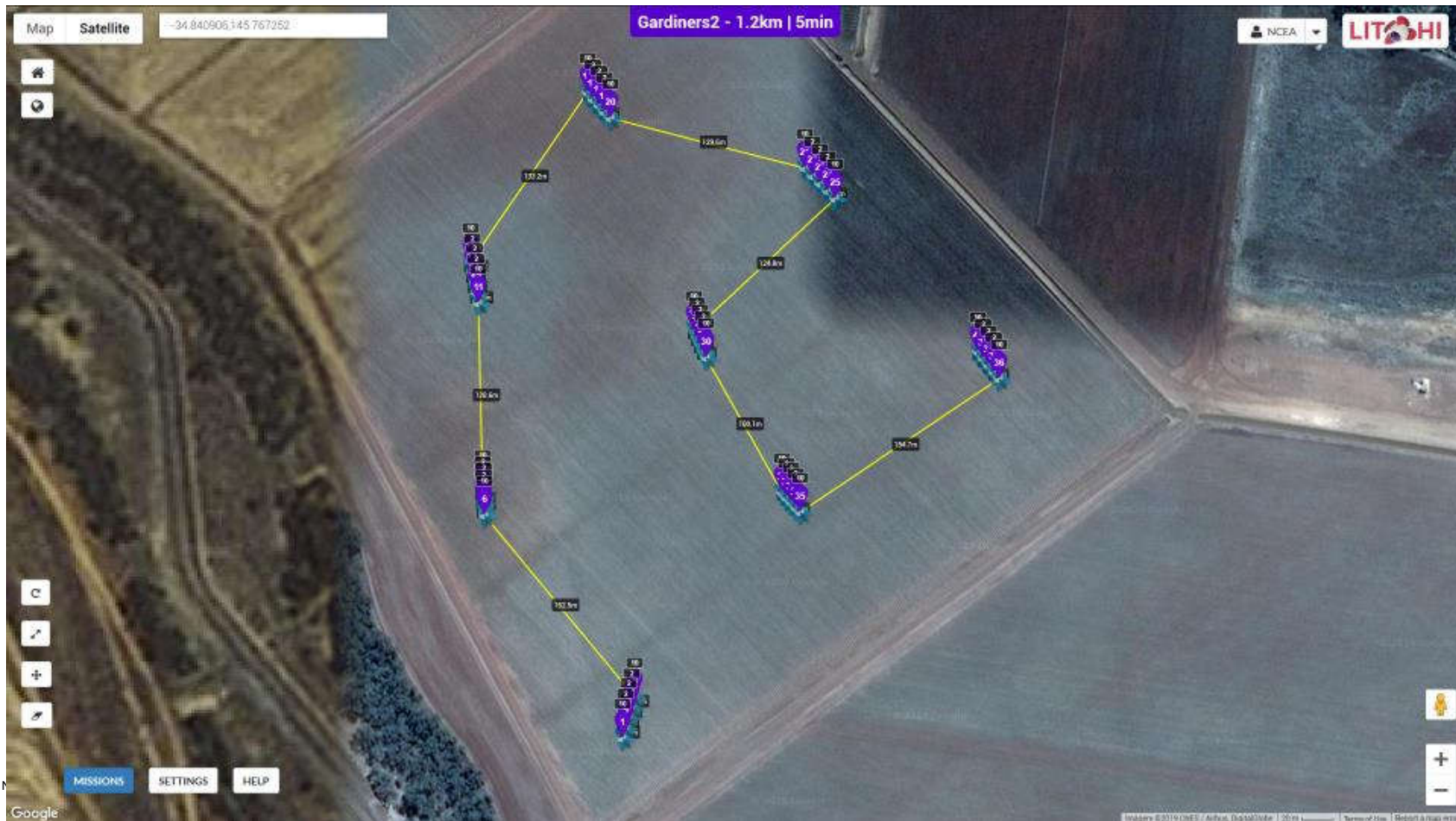
Site 1: IREC 2018



IREC Variwise yield (b/ha) estimates 2018



Griffith site 2: Coleambally 2019



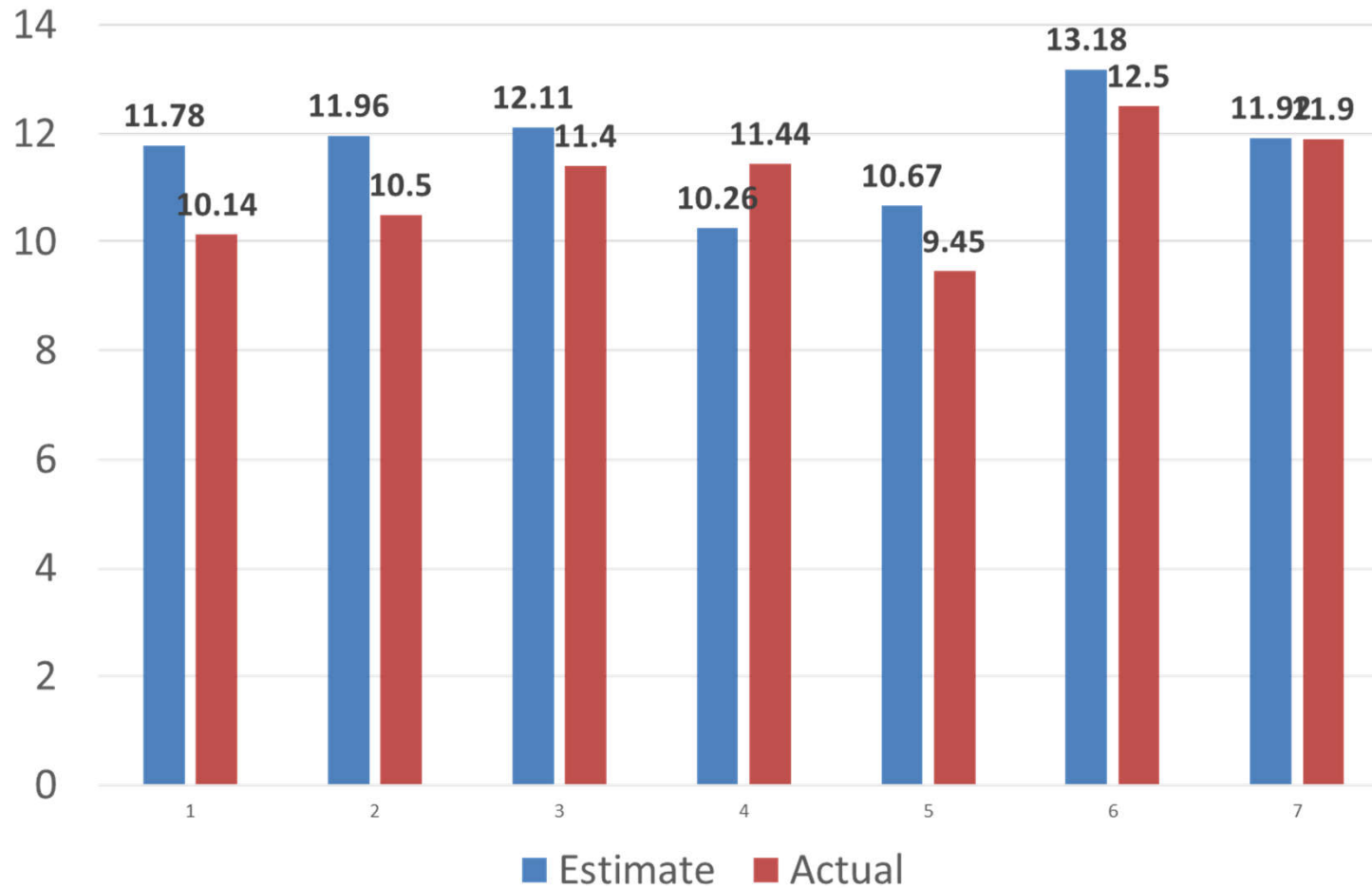
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Griffith site 2: Variation in different sectors



Griffith sites: overview of results

Variwise results, 7 crops MIA, 2019 b/ha



Griffith VARIwise summary 2019



- VARIwise flights on 16 fields from cut out to defoliation
- In the 2017/18 Griffith trial, the yield prediction errors were 10.2% in January, 6.0% in February, 2.5% in March, and 0.5% at picking
- In the 2018/19 Griffith trial the errors were 18.8% in January, 4.9% in February, 9.5% in March, and 10.1% at picking
- Most estimates in 2019 over estimated yields by 5 to 16 %. Average was 8 % over
- Two fields were under estimated by 3 % and 12 %
- One field estimate was 100% accurate

Goondiwindi site



- In the 2018/19 Goondiwindi trial, the yield prediction percentage errors were 8.7% in February, 5.9% in March, 7.1% in April and 2.6% in May.
- Challenging site for UAV yield estimates due to small plot size.
- Trial was located within a commercial cotton field
- Site was a replicated retention trial with three fruit thinning treatments implemented at three differing densities plus a control treatment.

Goondiwindi site: thinning treatments



- The three thinning treatments removed fruit on:
 - The lower plant
 - The upper plant
 - Upper and lower

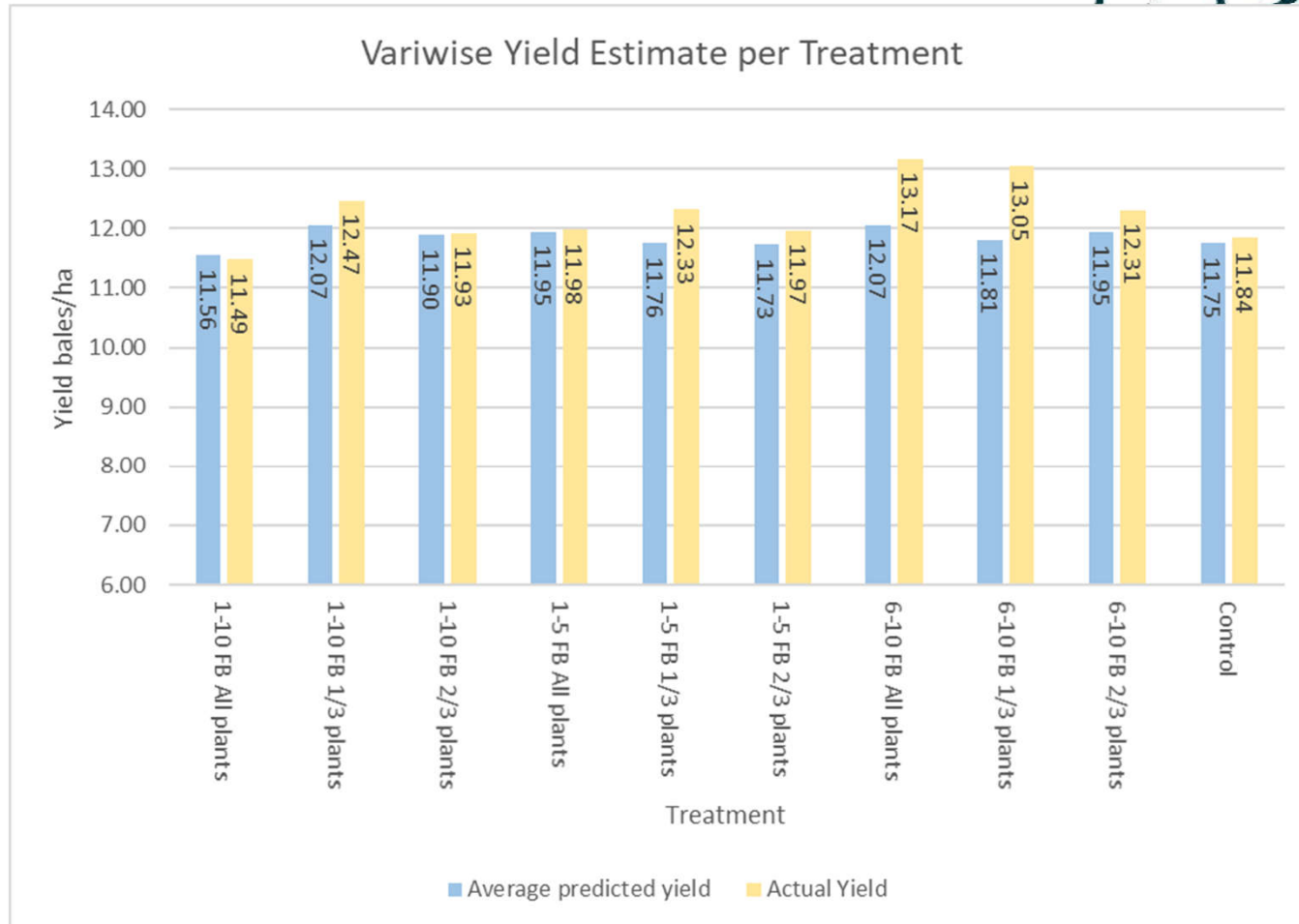
- The thinning treatments were implemented across 3 densities:
 - 1/3 of plants
 - 2/3 of plants
 - All plants

Goondiwindi site: trial site

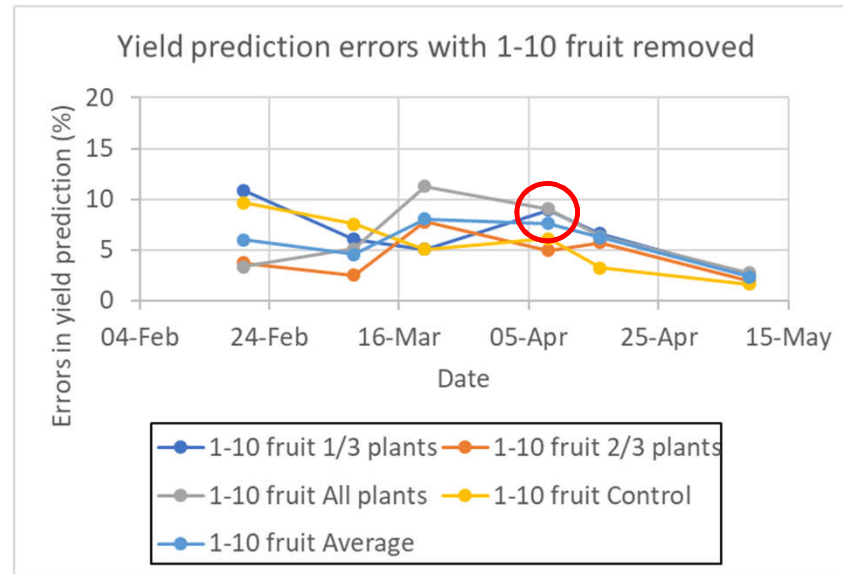
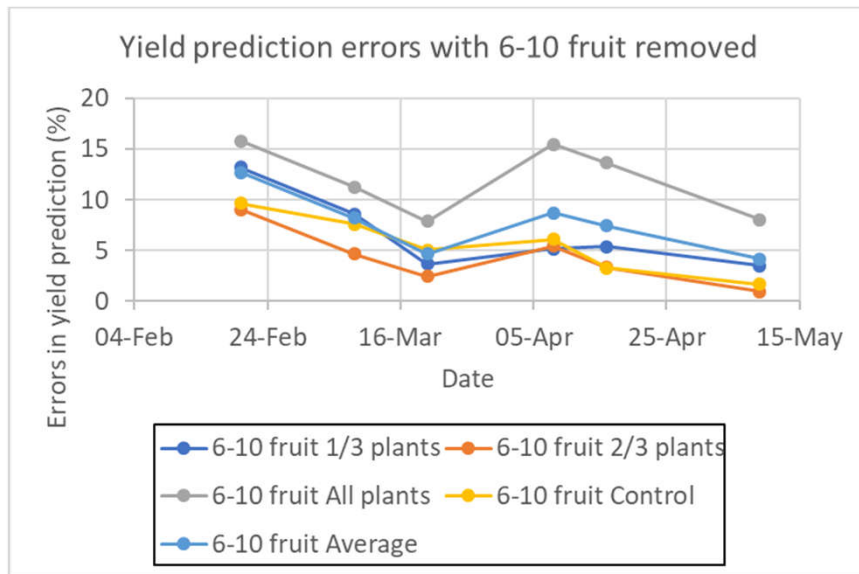


Trial site - Goondiwindi

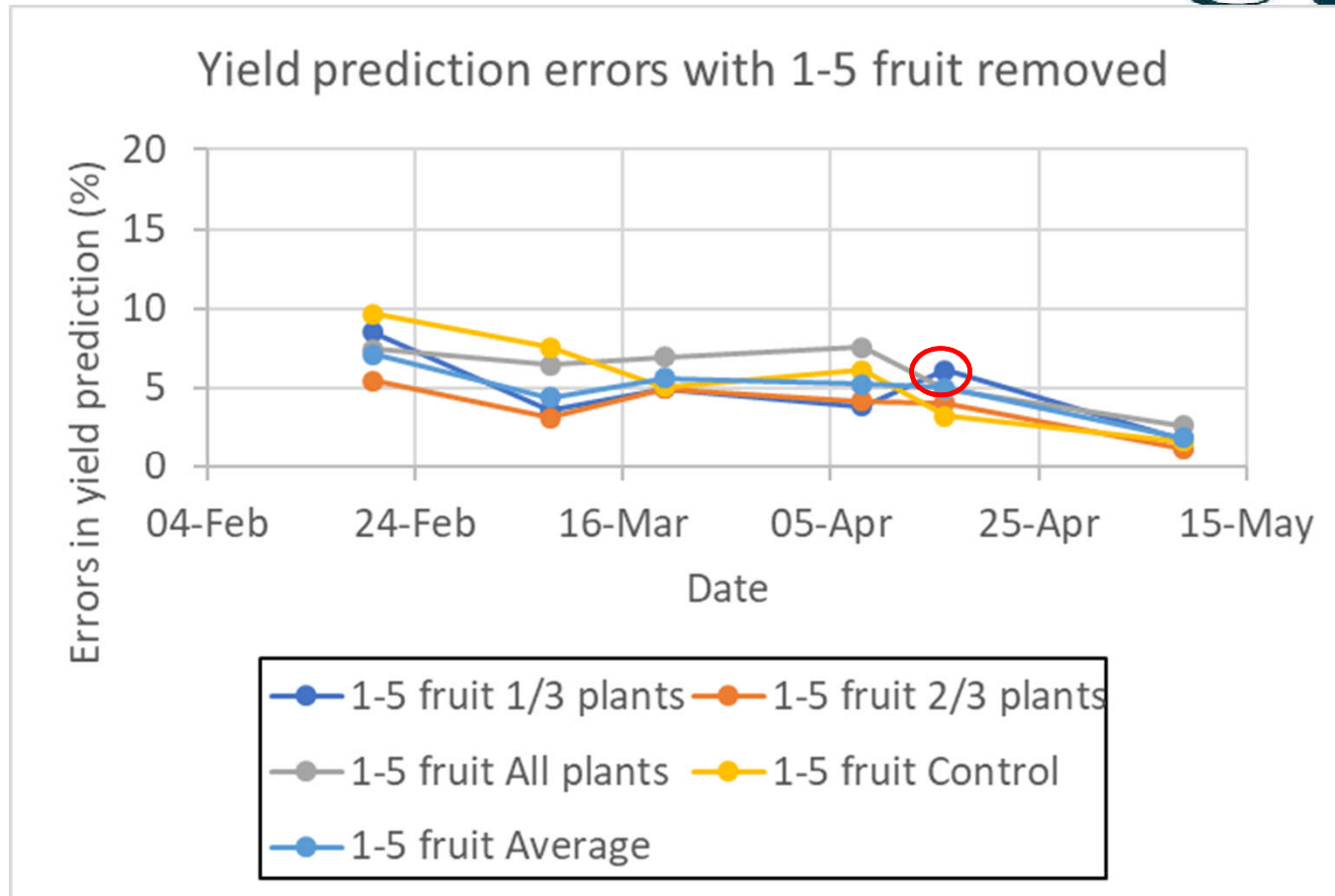
Goondiwindi site: overview of results



Goondiwindi VARIwise trial



Goondiwindi site: VARIwise trial



Goondiwindi site: VARIwise trial

bales/ha	Yield Average	Predicted accuracy %	Predicted accuracy %	Predicted accuracy %	Predicted accuracy %	Predicted accuracy %	Predicted accuracy %	Average accuracy treatment
11.961								
10.685								
11.637								
11.680	11.49							
12.440								
11.973								
11.765								
13.795	12.47							
12.901								
11.856								
11.156								
12.191	11.93							
11.685								
13.586								
10.755								
11.855	11.98							
13.121								
12.116								
12.410								
11.659	12.33							
12.953								
11.416								
12.350								
11.161	11.97							
12.856								
12.688								
14.329								
13.812	13.17							
13.590								
12.724								
12.942								
12.948	13.05							
11.866								
12.143								
12.763								
12.472	12.31							
10.796								
11.378								
12.850								
12.338	11.84							



Goondiwindi site: VARIwise trial



- Largest errors were associated with high yield from removal of 6-10 fruit – in all cases predicted yields were below actual.
- These were mostly driven by a single replicate where actual yield was high. Averaging replicate results reduced error level.
- Prediction accuracy improved as season progressed

Conclusions

- Calibration data requirements identified from Darling Downs trial:
 - Infield soil data more important than on-farm weather data
 - Yield prediction improved with more frequent data and as season progressed
- Overall percentage yield prediction errors were: 10.2-18.8% in January; 4.9-8.9% in February; 2.5-9.5% in March; 0.5-10.1% at picking
- Yield prediction accuracy using VARIwise was more variable with thinning

Further work



- Provide irrigation recommendations based on yield potential of fields
- Refinement for hail, insect and heat stress damaged crop
- Commercialisation of VARIwise with CRDC

Acknowledgements



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