Improving canola harvest management decisions with remote sensing

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Key findings

- Using advanced predictive modelling approaches, we have successfully used both satellite and drone-based multispectral imagery to predict canola maturity parameters to a high degree of accuracy (seed colour change, root mean squared error – RMSE of <10%).
- Simple normalised difference vegetation index (NDVI) based regression modelling was unable to account for location- and variety-induced variation resulting in significantly higher prediction errors than when using more advanced predictive modelling approaches.
- Significant potential exists for using this technology in a canola windrow-timing-decision support tool that would overcome the many challenges of current industry practice. However, additional investigation is required to validate the performance of this technology application across multiple seasons and further progress modelling approaches.

Keywords canola, maturity, harvest, windrow, remote sensing, 2021, Wagga Wagga, Yanco

Introduction

With an Australian annual average production of 3 million tonnes, canola is a valuable break crop and an important option to diversify and complement the traditionally cereal-dominated systems in Australia. Windrowing the crop before harvest is a common practice used to manage the risk of shattering losses. However, recent work from the 'Optimised canola profitability' project (CSP000187) as well as the Grain Orana Alliance (GOA00001) has highlighted the negative effects from incorrect windrowing timing, with potential yield losses of up to 100 kg/ha/day.

A 12-month proof-of-concept project was established to address the question: Can multispectral satellite imagery be used to develop a physiological maturity/seed colour change predictive model that is accurate and precise enough to improve on-farm canola windrow and desiccation timing decisions? This paper presents a brief snapshot of the results from this project in the 2021 season.

Site details

Locations	• Wagga Wagga Agricultural Institute, Wagga Wagga, NSW • Yanco Agricultural Institute, Yanco, NSW
Soil types	• Wagga Wagga: red kandosol • Yanco: red sodosol
Sowing dates	• Wagga Wagga: 15 April 2021 • Yanco: 19 April 2021

Growing conditions	Growing conditions during the 2021 canola season were favourable at both experiment locations. With post sowing pre-emergent surface irrigation at Yanco and a total January to March rainfall of 267 mm at Wagga Wagga, both sites started the 2021 season with a near full soil water profile. Water availability was not a significant yield constraint with consistent regular rainfall throughout the season at both sites. Temperatures during the growing seasons were also favourable, with no severe frosts (no days below –2.5 °C) at either site combined with mild spring temperatures (no days above 35 °C).

Treatments

Variety

Treatments were consistent between both locations and consisted of 3 different commonly grown commercial mid–fast spring canola varieties with differing heterosis and herbicide tolerance technology:

- ATR Bonito⁽ᵈ⁾
- Pioneer® 43Y92 (CL)
- HyTTec® Trophy.

Results

Canola maturity (seed colour change) progression over time

Once the seeds began to change colour, maturity progressed rapidly at both sites, with the progression from 20% to 80% seed colour change taking 8 days at Yanco and 6 days at Wagga Wagga (Figure 1). Seed colour change of 60% (start of optimum windrow timing window) was earlier at Yanco than at Wagga Wagga, with an average date of 26 October 2021 and 4 November 2021 respectively. Few significant differences between seed colour change were found between the varieties examined at both sites.

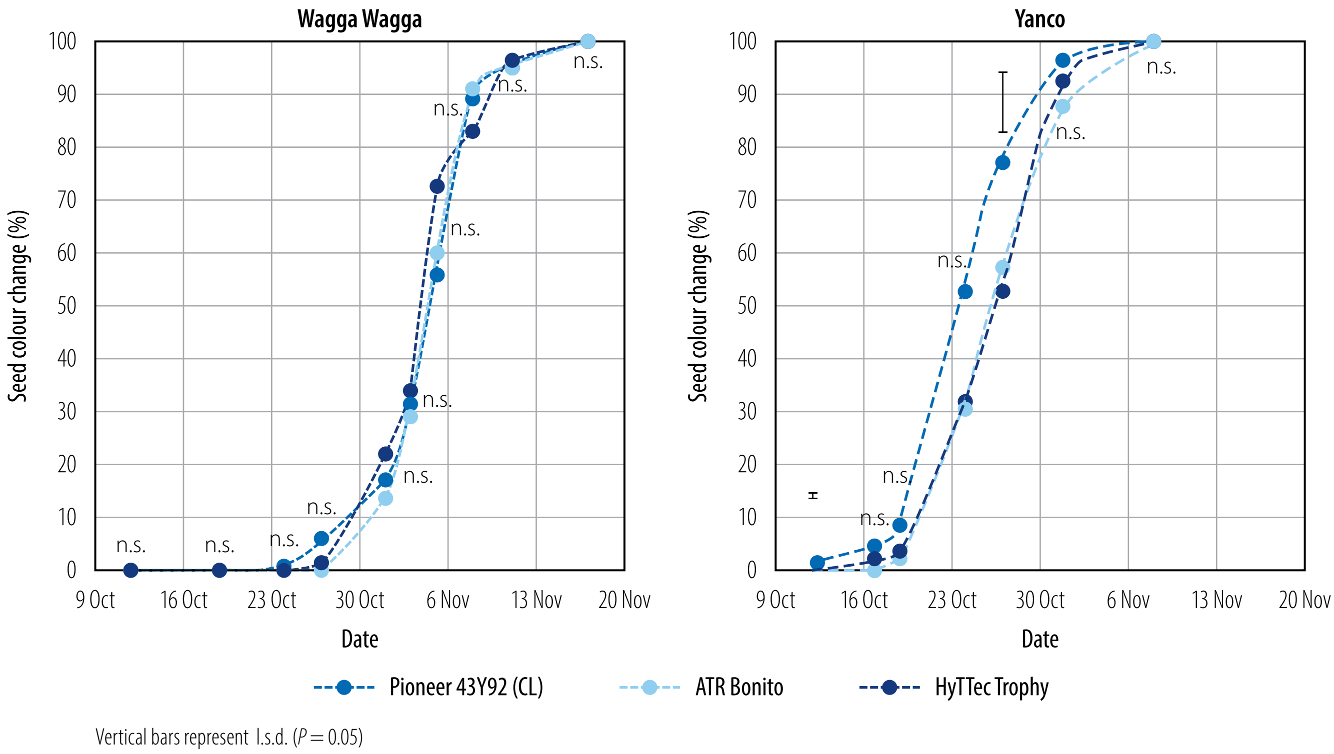

Figure 1 Seed colour change progression over time in the Wagga Wagga and Yanco 2021 field experiments.

Model development and evaluation

A range of statistical models were developed, ranging from simple regression analysis to more complicated supervised machine-learning algorithms. The aim was to predict canola maturity parameters using satellite and drone imagery with the highest possible accuracy across a range of environments and varieties. Of all the predictive modelling methods examined, a supervised machine-learning (Random Forest) method resulted in the highest prediction performance.

Random Forest (RF) regressions were performed on a range of vegetation indices derived from the RedEdge (drone), Planet (satellite) and Sentinel-2 (satellite) imagery to predict canola physiological maturity parameters. Additional variables such as weather data were also included in the modelling to assess their potential influence on prediction accuracy. The data was split into a 3:1 ratio, where 75% of data was used to train and build the model (calibration), and the remaining 25% was used to validate the model's prediction accuracy.

Root mean squared error (RMSE) was used to evaluate the model performance. RMSE is a commonly used metric to assess the relationship between values predicted by a model and observed values and, therefore, the performance of a given prediction model. In simple terms, this metric tells us the average distance between the model predicted values and the actual observed values.

The RF model developed from all 3 examined imagery sources explained the majority of the data variance (>95% for both seed colour change and seed moisture percentage) (Table 1). High prediction performance was achieved across all imagery sources with RMSE values of <10% for seed colour change and <3.5% for seed moisture.

Table 1 Random Forest model performance for canola maturity parameter predictions across a range of imagery sources.

Imagery source	Parameter	Adjusted R^2	RMSE
RedEdge (drone)	% seed colour change	0.96	7.60
	% seed moisture	0.97	2.90
Planet (satellite)	% seed colour change	0.95	8.60
	% seed moisture	0.96	2.93
Sentinel-2 (satellite)	% seed colour change	0.95	8.26
	% seed moisture	0.96	3.12

Summary

Results from this project indicate that significant potential exists for using this technology to aid canola windrow timing decisions on a broadacre scale. However, further investigation is required to assess this technology over a greater range of seasons and locations, ensuring prediction accuracy can be maintained under the highly variable growing conditions that canola producers experience.

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