A smarter way to count cotton pests

■ By Dr Derek Long, University of Southern Queensland

OVER the past five years, there has been significant growth in the use of machine vision in agricultural applications such as weed detection and identification. These machine vision systems have made it practical to map field variability on a large scale and enable the improved application efficiency of water and chemicals. A team, including myself, Dr Alison McCarthy from the University of Southern Queensland and Dr Paul Grundy from the Queensland Department of Agriculture and Fisheries with the support of the CRDC, is working to adapt machine vision techniques into a smartphone app for counting and tracking of silverleaf whitefly (SLW) and cotton aphid populations in cotton.

The app is expected to make pest sampling faster and more consistent between different observers and will also link in with yield loss models for pests such as cotton aphids or spray decision trigger points for silverleaf whitefly.

There is also potential to implement entire new decision models to use the expanded datasets that will be generated through the app. Current models were formed to use data that could be obtained by someone glancing at a leaf for only a few seconds. A scoring system was created for cotton aphids so that one could quickly estimate the infestation level of a leaf from 0 to 5. This yield loss model can be updated with greater granularity using a full count of the aphids on each leaf.

An update to the SLW decision model using nymph counts is underway in CRDC funded research, led by Dr Richard Sequeira, which will replace the current sampling practice which targets whitefly adults.

There are challenges with taking machine vision techniques originally proven in controlled conditions and applying them through a smartphone on commercial cotton farms. The translucent SLW nymphs become invisible to the camera when viewed in direct sunlight, so a protocol for taking pictures of leaves in shade was developed.

The quality of the images depends greatly on the quality of the auto-exposure, auto-focus and high dynamic range (HDR) in the smartphone used, so many budget smartphones and even flagship smartphones of some brands are not suitable for this application. Machine learning algorithms have been shown to achieve over 90 per cent detection accuracy on SLW nymphs in controlled conditions, and so 90 per cent accuracy is the target to achieve under field conditions on cotton farms.

Initial testing started with glasshouse trials prior to the 2018–19 cotton season. Cultures of SLW nymphs and cotton aphids were used to recreate a wide range of population sizes, nymphal stages, combinations of SLW and aphids on leaf, and severity of leaf damage from other pests. These image sets were used for initial algorithm training to detect SLW nymphs and cotton aphids as well as initial validation of classification accuracy of the two pests on the same leaf.

Data collection also took place on commercial cotton farms in southern Queensland and northern New South Wales in the 2018–19 cotton season. Images were collected using the image capture protocol, based on the use of an iPhone SE and Samsung Galaxy S7 – two flagship smartphone models from 2016. The resulting image sets were used for initial validation of pest detection accuracy.

A 75 per cent detection accuracy on SLW nymphs in the field was achieved during the first year of data collection. It is anticipated that the initial results will be improved upon with further data collection in coming seasons, bringing performance closer to what has been achieved in controlled conditions.

The app is currently moving into a closed beta test, with a group of about a dozen agronomists and researchers. The test group will provide an initial round of user feedback on structure and function of the app as well as providing crucial data collection to capture more cotton growing regions and range of lighting conditions. The nymph counting algorithm will become available for industry-wide testing in a public demo app to be released in late 2020.

CRDC and the project team are looking for a partner to take the app forward into a full release, including maintaining the app and integrating it into their services. See the Expression of Interest call on CRDC's website for more information.

FIGURE 1: Result of smartphone counting of SLW nymphs

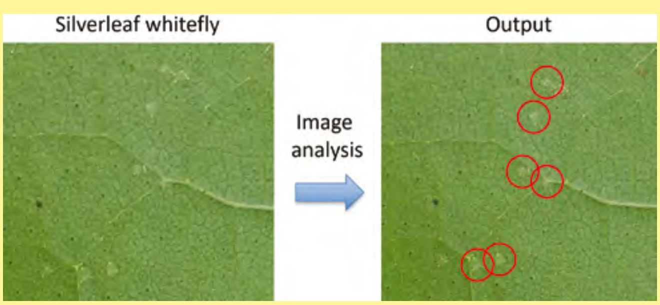
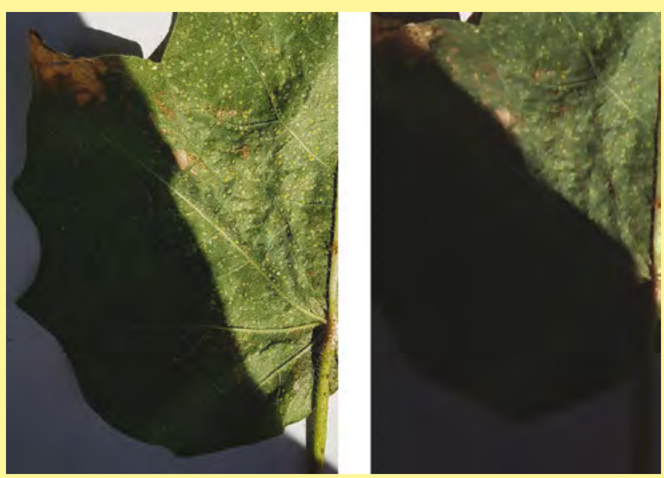


FIGURE 2: Samsung S7 (left) and ZTET816 (right) showing differences in HDR implementation



Nymphs are not visible in the shaded area with the ZTE.

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Irrigation System Assessment Tool

A software tool to support financial comparison of rainfed, surface and pressurised irrigation systems

By Erik Schmidt and Joseph Foley – USQ Centre for Agricultural Engineering

USQ'S Centre for Agricultural Engineering was commissioned by Cotton Australia (CA) to develop an Irrigation System Assessment Tool (ISAT) that would assist growers in the Darling Downs region to assess the merits of converting from dryland or surface irrigation systems, to pressurised irrigation systems, or improved efficiency surface systems. The project was funded through Queensland Department of Natural Resources, Mines and Energy (DNRME) and Cotton Australia, under the Murray-Darling Basin Regional Economic Diversification Program. The tool was presented to the Central Downs Irrigators Limited meeting in Dalby on October 17, 2019.

While there is a general feeling that irrigation systems such as lateral moves and centre pivot irrigators offer Condamine groundwater users benefits, in terms of labour and water savings, there is little detailed economic information to support these conclusions. This is particularly important in relation to potential future reductions in water entitlements.

These reductions may have significant impact on the long term economic viability of growers on the central Darling Downs. It is believed many existing growers will look to convert from furrow irrigation to pressurised systems as a way to mitigate against decreased future water availability.

ISAT assesses the merits of different irrigation systems.

While the central Darling Downs was the target area for the deployment of the decision support tool, provision has been made to be able to extend its application to other regions, should this be required.

ISAT takes into account such factors as water use, on-farm irrigation approaches, soil types, crop types and yield performance, energy consumption, labour use, as well as capital and operating costs. The web-based tool is available, free-of-charge, to irrigators via the link: *https://isat.usq.edu.au*

Analysis can be completed for a single block of land where a new irrigation system is proposed. The tool is not designed to optimise whole-of-farm water management. ISAT uses a gross margin analysis for current 'before' and a range of scenarios of the improved 'after' situation. Economic analysis includes Internal Rate of Return (IRR), Nett Present Value (NPV) and Benefit Cost Ratio, on possible capital investments.

Approach for system financial comparison

Using ISAT a grower can:

Step 1 Identify a field on an interactive map.

Step 2 Evaluate the existing system of rainfed or furrow irrigated cropping, to set baseline performance. Crop rotations of back-to-back cotton or cotton-wheat/barley-long fallow can be evaluated.

Step 3 Evaluate alternative irrigation system. New irrigation equipment investment scenarios can then be evaluated over 50-years of consecutive crop rotation, for chosen water allocation, crop sequence, planting dates and irrigation application efficiency. Results are compared with the existing scenario.

Step 4 Generate reports. Various on-line and pdf printable reports can be generated to allow for off-line side-by-side comparison of various strategies.

Capital costs of new irrigation systems are input by the


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TABLE 1: Assessing the impact of new irrigation systems

Scenario	Gross margin ($/ha/yr)	Median yield cotton (b/ha) barley (t/ha)	Application efficiency for irrigation (%)	Capital investment $/ha	Increase in gross margin with new irrigation equipment ($/ha/yr)	Benefit cost ratio	IRR (%)
Rainfed	$494	Cotton 4.6 Barley 1.9			—	—	—
Optimised furrow	$2471	Cotton 12.2 Barley 4.5	65%	$1000	$1977	27.7	198%
Lateral move	$2831	Cotton 13.4 Barley 6.4	85%	$1800	$2337	16.1	130%

grower. If total costs are unknown, side calculators can be used to assist in determining capital cost. Typical costs and technical parameters for different irrigation systems have been provided as defaults.

Revenue from the existing and alternative irrigation systems is calculated from yield and crop price. Revenue can be adjusted to account for risk of crop failure based on damage to an irrigation system due to wind, flooding and so on. This is based on the probability of occurrence and the percentage loss of crop. Gross margins of before and after system scenarios can be compared. The NPV, IRR and Cost Benefit are determined by assessing discounted life time costs and benefits over a 30 year horizon.

Climate records from local weather stations were used to predict crop yields with the APSIM model, based on different scenarios of crop, soil type, water allocation and risk. Soil information from the ApSoil database was used to guide local soil selection. Data sourced from AgMargins (*http://agmargins.net.au*) was used to support economic analysis.

Crop yields, from crop rotations over 50 consecutive years, and resulting economics are provided for 'average,' 'good' and 'bad' years. Sensitivity analyses can be undertaken to assess changes to any selected input parameter (eg water allocation, input cost, yield expectation).

Cotton grower Ian Hayllor evaluated the ISAT tool to assess the potential for converting a 200 hectare rainfed field (cotton-barley long fallow rotation) at Ranges Bridge (current system), to surface irrigation and a new lateral move. The soils have a high plant available water content (PAWC = 240 mm).

Current cropping analysis

Modelled crop yields, based on 50-years of Macalister weather data, adjusted based on local experience, were used with AgMargins economic data to estimate current revenues and new gross margin. The median rainfed cotton yield was estimated to be 4.6 bales per hectare and barley yield was 1.9 tonnes per hectare, resulting in a gross margin of $494 per hectare per year. This increased to $2445 per hectare per year in a 'good' year (exceeded in only 25 per cent of years), and reduced to $99 per hectare in a 'poor' year (exceeded in 75 per cent of years).

New irrigation equipment scenario

Assessments were completed on the potential improvements using optimised furrow irrigation or a lateral move, based on a 3.5 ML per hectare per year water allocation (equivalent to 700 ML per year across the 200 hectare block). Results are summarised in Table 1.

Crop yields were estimated to be slightly higher under the $360,000 lateral move when compared with surface irrigation given better irrigation performance and more flexible irrigation management (smaller applications more frequently to maximise rainfall capture). Furrow irrigation performance was assumed to be high (65 per cent) given the extensive experience with these systems.

The overall pumping costs used with the lateral move were $47 per ML compared to $29 per ML for the furrow system, given higher pump pressures. Labour costs used for the lateral move were significantly lower.

The lateral move resulted in a higher increase in gross margin ($2337 per hectare per year), when compared to furrow irrigation ($1977 per hectare per year), given better yields. But the higher capital investment resulted in a lower benefit-cost ratio and IRR. Both systems provided a very good return on investment.

The ISAT tool allows assessment of the impact of a range of water allocation scenarios on profitability. The sensitivity of changes in cost of labour and energy can also be assessed. Field shape can also be taken into consideration when comparing systems as some systems (eg centre pivot) may not allow the full area to be irrigated. "The tool is very useful to look at a range of scenarios, test assumptions (eg impact of reduced water allocation or capital cost) and guide investment decisions," said Ian Hayllor.