Machine vision app for automated cotton insect counting: initial results

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Sensors for better IPM in cotton

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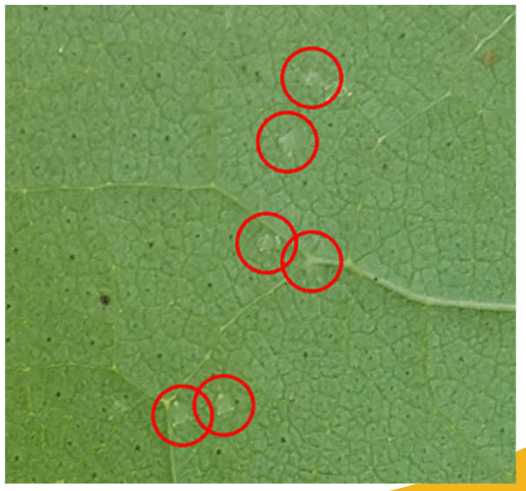
Objective Summary: To enhance capability in tracking pest population for silverleaf whitefly, cotton aphids, and mites by developing a sensing tool for industry.

After an initial review, the team focused on developing a smartphone app that analyses cotton leaves with computer vision to count pests and log population growth.

Silverleaf whitefly

Image analysis

Output



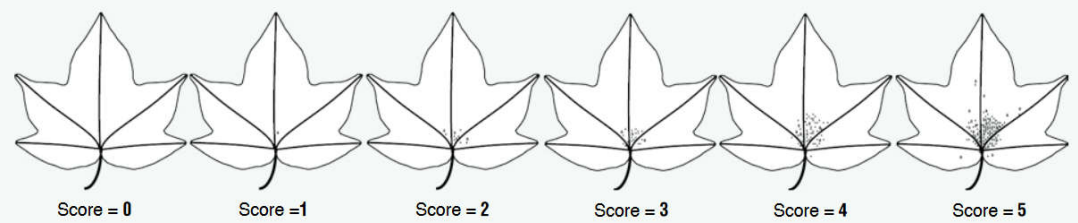
Background

Existing sampling practice for SLW, aphids and mites:

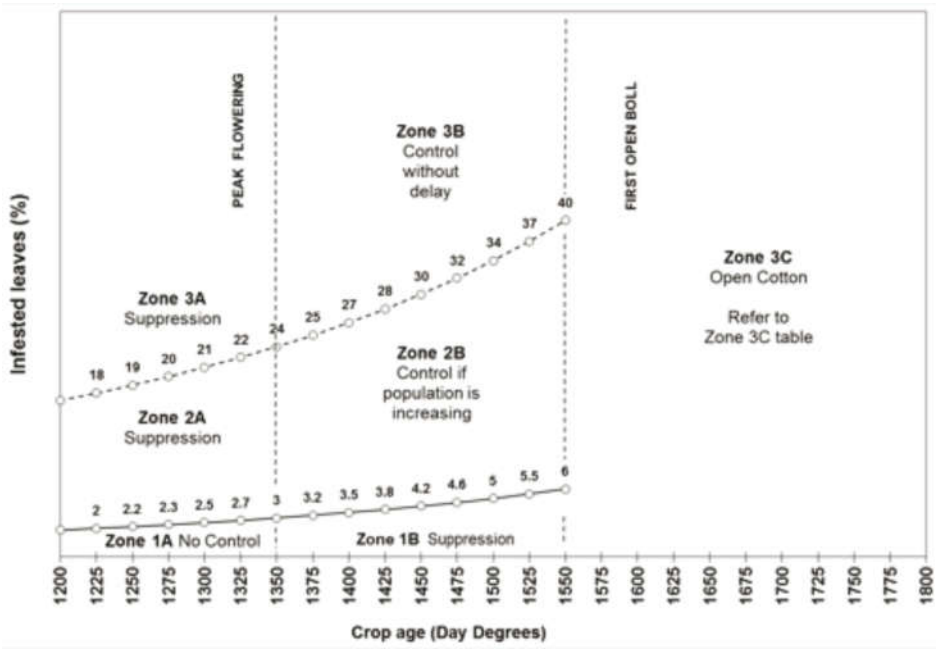
1. Check the underside of at least 20 leaves per sampling site (can be as sparse as one site per 20 hectares)

2. Record the pest presence on each leaf (binomial for SLW/mites, scoring system for aphids)

3. Consult pest management tables and charts to evaluate necessity of treating.



Aphid scoring guide
Source: Cotton Pest Management Guide 2019-20, CottonInfo



Whitefly control chart
Source: Cotton Pest Management Guide 2019-20, CottonInfo

Value proposition

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Speeding up the sampling process

The process of scanning a leaf manually for pests is replaced with a single button press on the phone. Agronomists could capture a larger sample in the same time to improve spray decisions, or perform the existing sampling process faster.

Providing consistent measurement

The use of image analysis could reduce inter-observer variability which benefits agronomists with assistants. The consistent measurement could also help the client trust the agronomists recommendation for treatment if the client trusts the app.

Automatic logging and interpretation

The ability for software to manage the logging of pest counts and present the pest management tables/charts in the field will further reduce labour requirements.

Challenges

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1. Mitigating the impact of field conditions on image analysis accuracy

Image analysis detection SLW nymphs and other pests have been reported in the literature achieving over 90% accuracy. However, these studies are using either controlled conditions or sensors not suitable for field use.

There are factors in this use-case that will impact accuracy:

- Uncontrolled lighting conditions
- How to pose the cotton leaf for imaging in the field
- Deploying for different sensors (smartphones) simultaneously

2. Managing and representing data in a way useful to end-users

This includes:

- Automatically drawing from other data streams (Day Degrees) to give pest numbers context
- Tracking population growth over time for each management unit
- Exporting data if desired

2018-19 data collection

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Images were collected in glasshouse cultures and on cotton farms around Toowoomba region, St. George and Goondiwindi focusing on whitefly for initial development.

A variety of smartphone models were tested to establish a baseline requirement for smartphone cameras. Low-cost models were found to have unsuitable HDR implementations unsuitable for this use-case (see right).

An image capture protocol was formed to narrow the range of lighting conditions that the image analysis needs to deal with.

Samsung S7 (left) and ZTE T816 (right) showing differences in HDR implementation

Results to date – methodology

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For validation, four samples of 20 leaves were imaged on a QLD cotton farm.

Half of the images were captured with an iPhone SE and half with a Samsung S7, and approximately half of the leaves had SLW nymphs present.

Each image was scanned by eye for nymphs, and nymph locations were recorded in a text file.

The image analysis was run over the 80 images, and software-estimated nymph locations were compared against the text file. An accuracy score was calculated using:

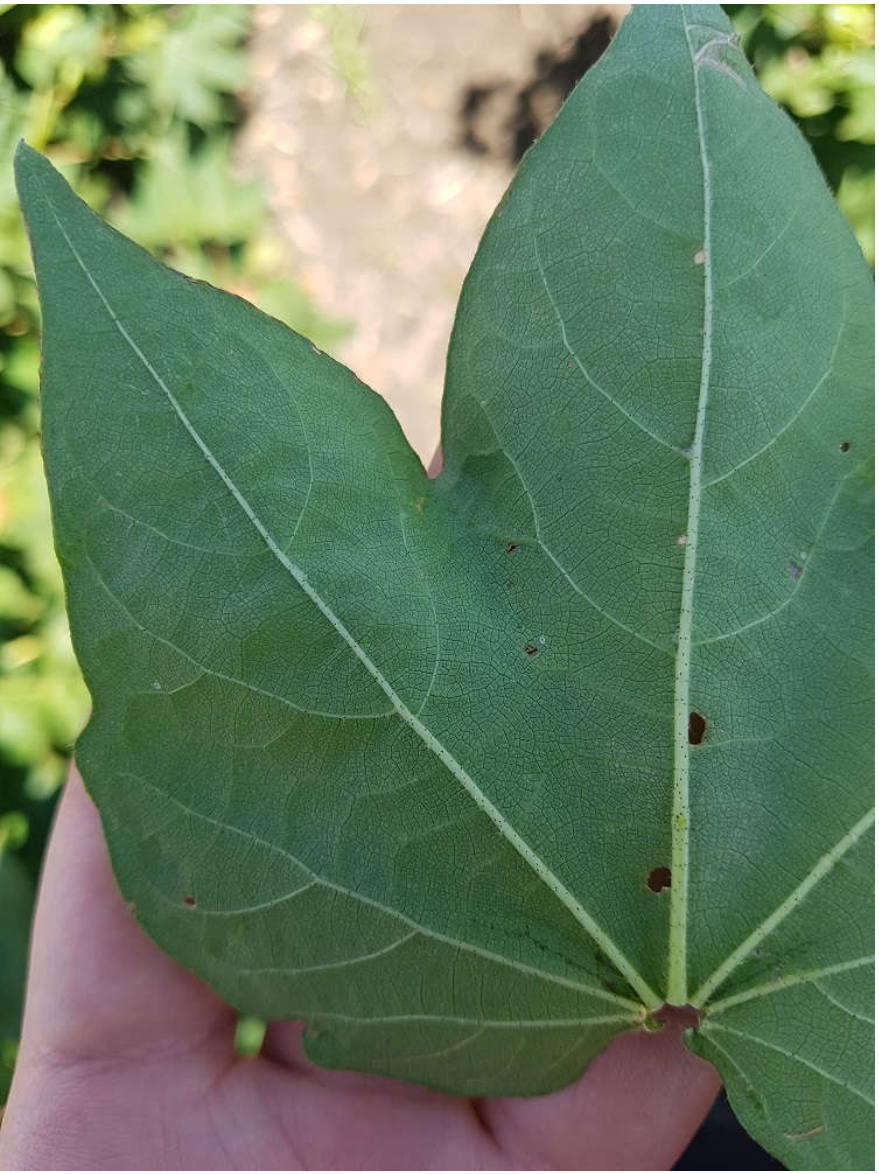
$$Precision = \frac{T_p}{T_p + F_p} \qquad Recall = \frac{T_p}{T_p + F_n} \qquad F_{score} = \frac{2 * Precision * Recall}{Precision + Recall}$$

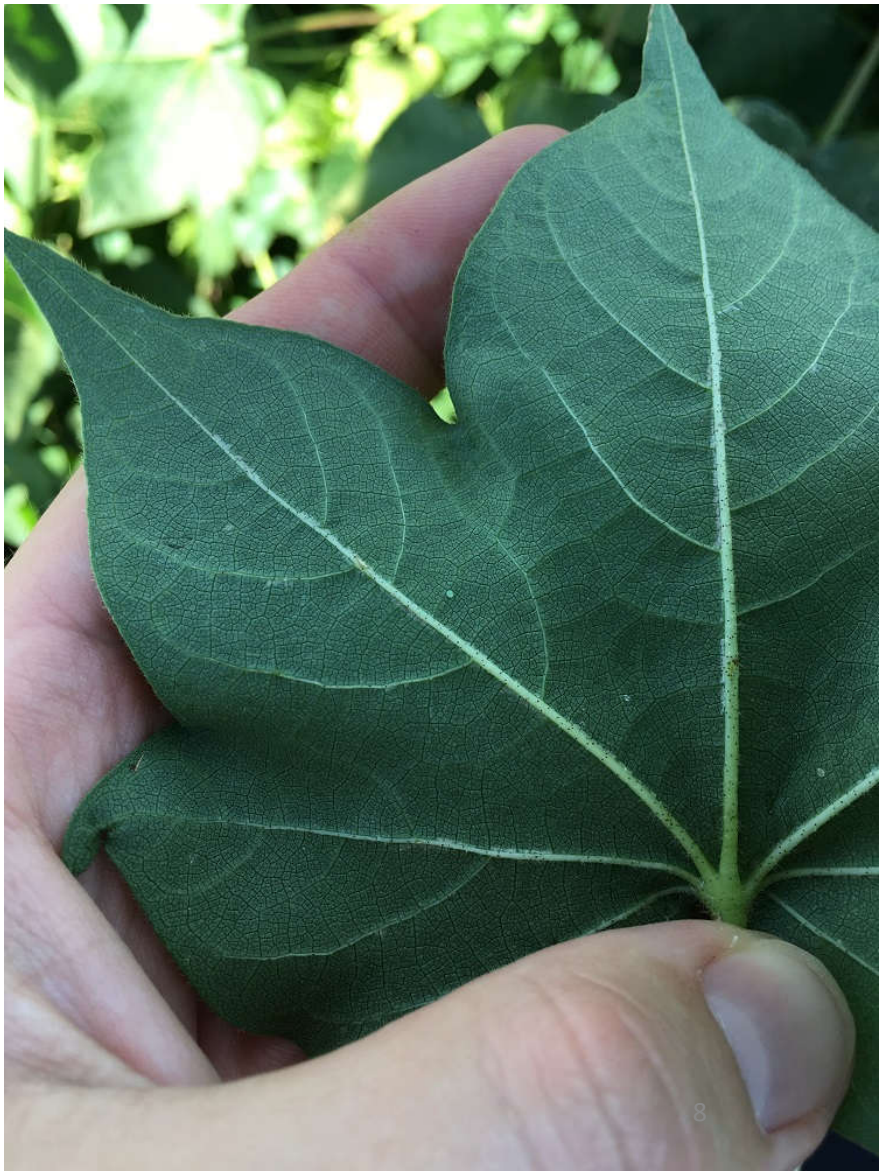
Where T_p = True positives, F_p = False positives, and F_n = False negatives.

Samsung S7

Same leaf

iPhone SE

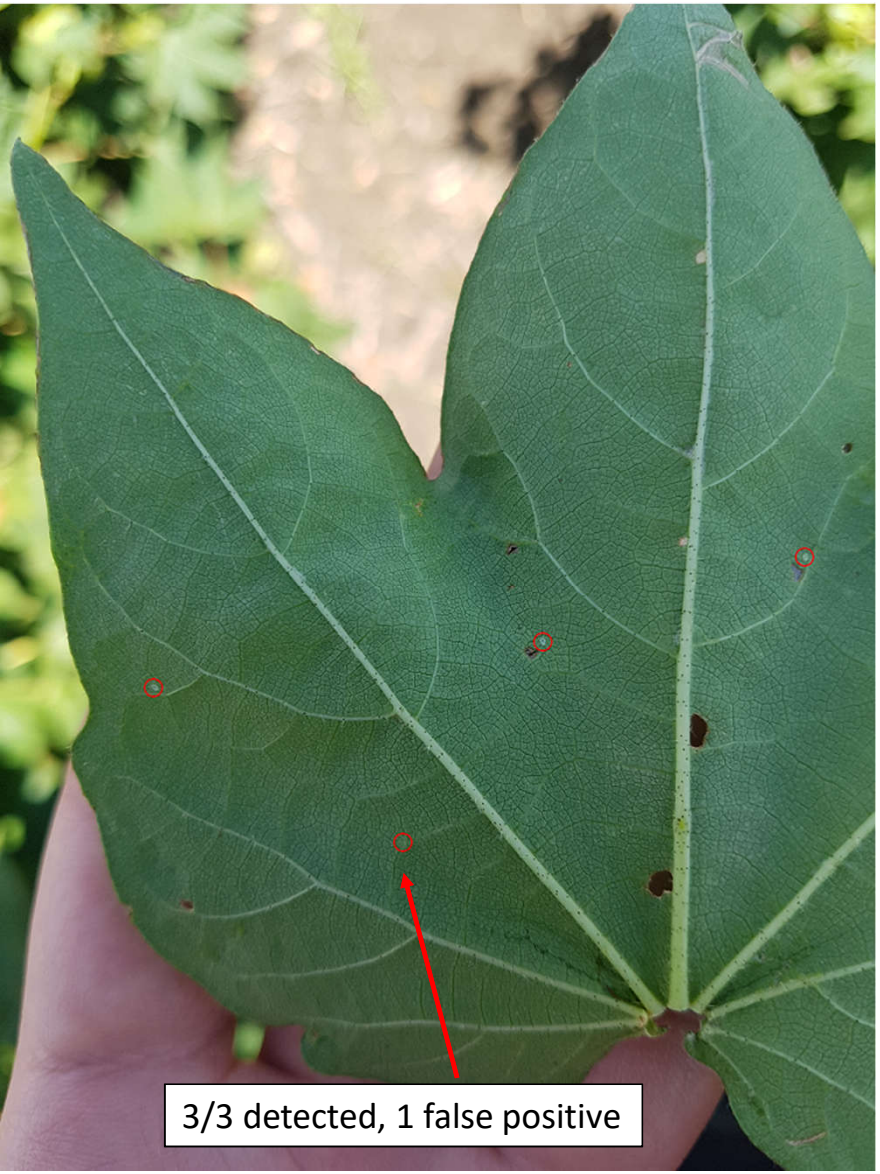




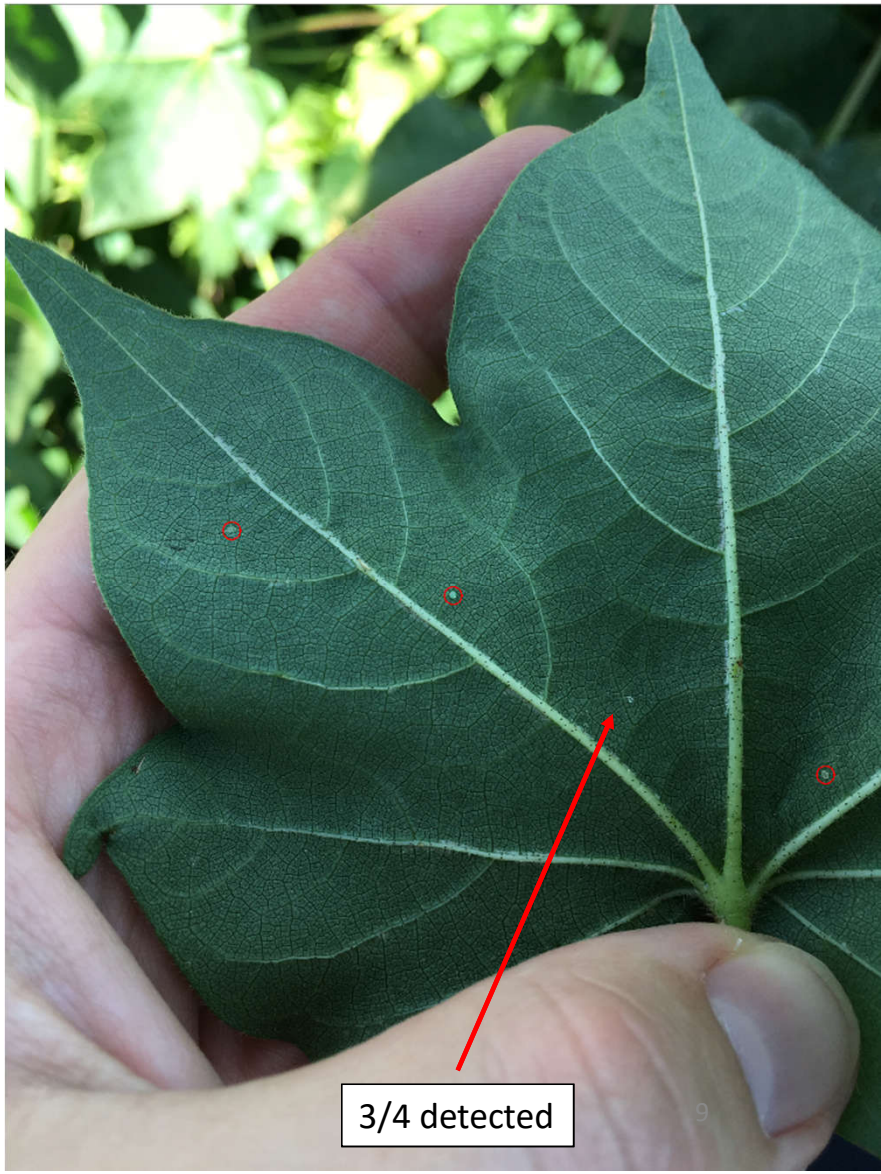
Samsung S7

Same leaf

iPhone SE



80 image F_{score} = **73.6%**



Where to from here – 2019-20

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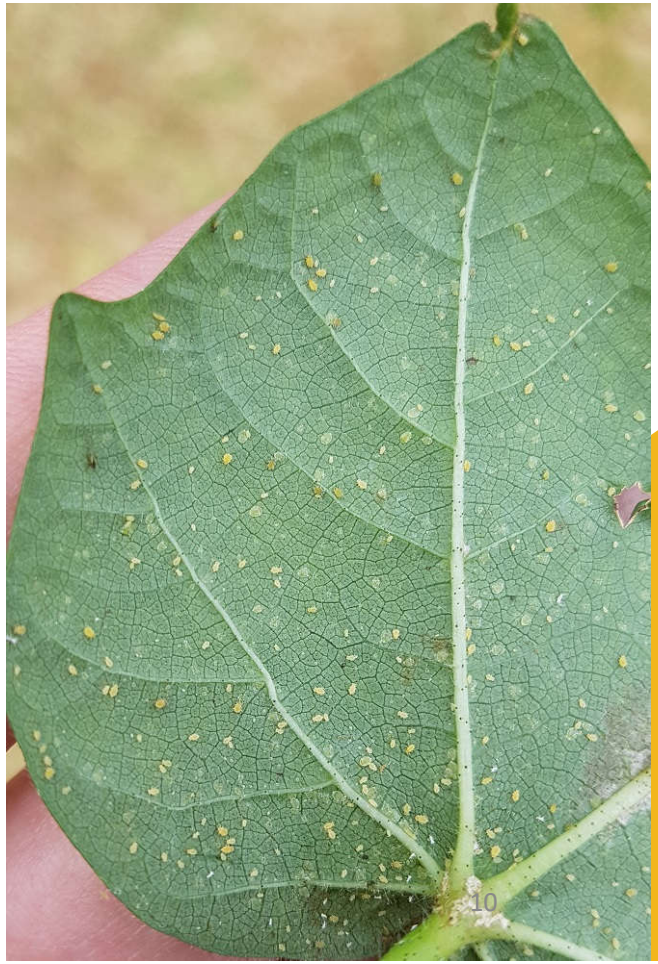
A test version of the app will be deployed to a small group of agronomists for field trials in the 2019-20 cotton season. Objectives for progressing the work are:

1. Improve image analysis performance to 90%
2. Gather a larger database of images to validate algorithm robustness to different lighting condition and smartphone models and improve accuracy.
3. Get end-user feedback on the image capture process and data logging/presentation.
4. Incorporate discrimination of other pests. Images of aphids are currently being collected from glasshouse cultures.

Whitefly and aphid nymphs on leaf



Where to from here – Area Wide Management (AWM)

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With this app comes a mechanism for easily sharing data. What are the potential benefits to AWM?

- Tracking pest movement on a large scale (e.g. west to east) to inform optimal spraying windows

- Getting a local or valley average to compare on-farm numbers

Can a compromise be found between sharing information and respecting client's privacy?

Where to from here – commercialisation

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1. System refinement through workshops and industry engagement.

2. Assess potential paths to market.

3. Expression of interest to attract commercial partners.

The project team acknowledges CRDC for supporting the project both in funding and facilitating engagement with end-users.

Thank you

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