Apps, traps and LAMP's: 'Smart' improvements to pest and disease management

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Key messages

- Tools that improve the accuracy and decrease time spent on pest and disease diagnosis will give growers a better ability to spray pesticides when and where required, saving them money on unnecessary sprays and reducing the risk of further development of pesticide resistance in pests and diseases.
- Rapid detection tools for early warning: automated native budworm and diamondback moth traps were tested in WA to expand DPIRD's existing manual budworm trapping network, and a remote imaging system was developed to monitor Sclerotinia apothecia germination.
- Rapid diagnostics tool for virus risk and early warning: using a technique called 'LAMP', presence of *Turnip yellows virus* in green peach aphids and plants can be identified in the field in less than 30 minutes.
- Rapid decision-support tool for targeted sampling and spray decision support: CropScout is a new smartphone app which automates the sequential sampling process for cabbage and turnip aphids in winter/spring canola, and maps results relative to the spray threshold.

Aims

Investigate and develop rapid detection, diagnostics and decision-support tools to improve pest and disease management during the cropping season and communicate timely information to growers and consultants through PestFax.

Results

Rapid detection

Automated moth traps

Automated traps and sensors can provide real time surveillance for pests and diseases and timely decision support of when and where crop protection practices need to be implemented. An additional benefit to industry will be the provision of data determining that exotic pathogens and pests were actively looked for and found to be absent. The diamondback moth (*Plutella xylostella*; DBM) and native budworm (*Helicoverpa punctigera*) were monitored using three automated trapping systems to assess their suitability in expanding DPIRD's current pest trapping network:

1. Spensa Z-Trap: uses a moth-specific pheromone to attract a target species and electrified pins to zap insects and record the number of 'zaps' that have occurred. Results are uploaded remotely to the Spensa database and can be viewed by logging in. The trap can also measure the electrical impedance when the insect is 'zapped', so off target insects such as aphids and flies are not counted.
2. ADAMA Trapview: also uses moth-specific pheromones to attract target species. The trapped moths are photographed by cameras in the trap and images are automatically uploaded to the Trapview website where they can be viewed. The Trapview website also comes with image recognition software that can determine the number of moths on the trap from the image.
3. DPIRD moth trap: similar to the commercial traps, the moth trap being developed at DPIRD uses a pheromone to attract the target species and a camera to image moths falling into the trap. Once an image is taken, it is uploaded via the mobile network to a computer and can be checked for moth numbers.

Four Z-Traps were first evaluated in Carnarvon from March to July 2017 (Fig. 1), then at Wickepin and Katanning from July to October 2017. Seven Trapview traps were tested from August to October at Dandaragan, Northam, Wickepin, Irishtown, Katanning and Moora (Fig. 2). Both the Z-Trap and Trapview were able to count the pests either by measuring each time a targeted insect hit the electric prongs (Z-Trap) or image recognition software (Trapview). Some calibration of the Z-trap sensitivity was necessary to record accurate numbers and the Trapview requires a visual count of images to increase the accuracy of numbers in the trap. Both traps performed well in the field and it is planned to increase the numbers of both so as to run further trials in 2018. Two working prototypes of the DPIRD moth traps were completed and will be tested in the field during 2018. Trapping results will be disseminated to growers and consultants through avenues such as the PestFax newsletter.

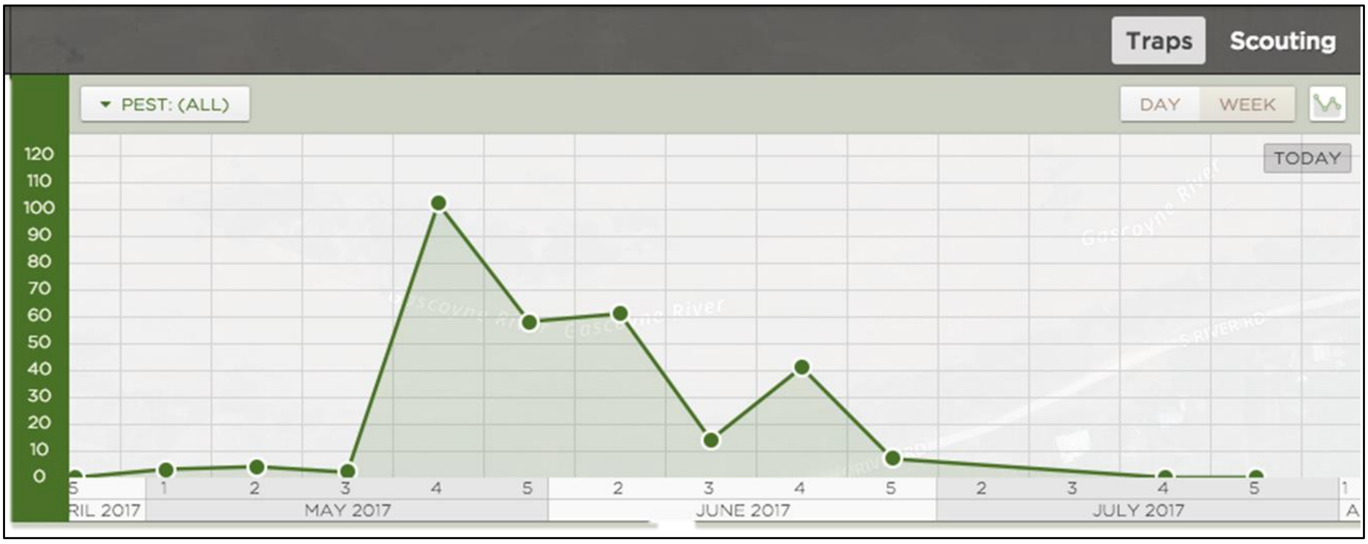

Figure 1. Z-Trap moth results from first calibration test at Carnarvon, WA during 2017.

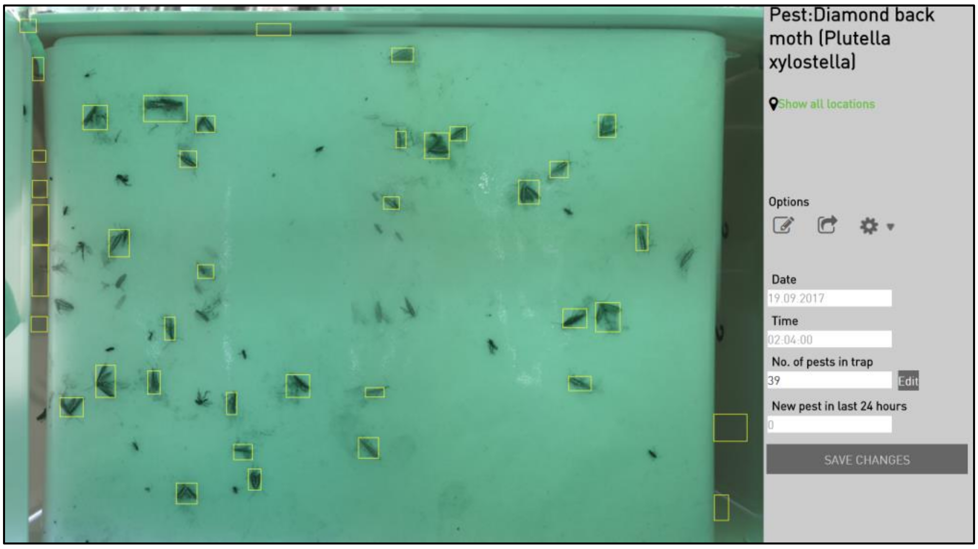

Figure 2. Trapview image of sticky paper to monitor diamondback moth numbers at Moora, WA during 2017.

Sclerotinia imaging system

An automated imaging system was developed to monitor germinating apothecia from sclerotes to determine if it could be used as a prediction tool or early warning system for growers. Eleven sites were selected across the grainbelt with each site containing 1 or 2 solar powered cameras. Each site was inoculated with sclerotes, and the cameras uploaded images every three to four hours via the mobile network. Two sites (Irishtown and Wickepin) successfully produced apothecia, and the sclerotinia monitoring cameras were successful at providing real time images of germination from remote locations. More work is needed to improve the field inoculation methodology so sites can confidently be used as a representation of disease development in the paddock and used to model the disease so that an early warning/forecasting tool may be implemented. The sclerotinia model will inform growers, through media such as PestFax, of risk scenarios and timely management of the disease during the cropping season.

Rapid diagnostics

Accurate detection of plant pathogens such as viruses commonly requires collecting leaf samples and sending them to a diagnostic laboratory for testing with expensive and time consuming protocols. For viruses, the main limitation of these protocols is the assay sensitivity and the need for virus levels to be high enough in plants for the assay to accurately detect. Symptoms can take 3-6 weeks to appear following infection by vectors. By this time control measures are usually limited to pesticide application to control further spread by the aphid vector. Using a portable and user-friendly machine that performs a diagnostic method called loop-mediated isothermal amplification (LAMP), we have developed and validated a protocol that enables earlier, quicker and cheaper in-field detection of *Turnip yellows virus* (TuYV; previously communicated as *Beet western yellows virus*) from leaf material and the vector green peach aphids (GPA) caught in traps. We have shown, using this assay, TuYV can be readily detected when 1 infected leaf is combined with 99 healthy ones, and when 1 viruliferous green peach aphid (GPA) is combined with 99 healthy aphids (Fig. 3). TuYV can be reliably detected by LAMP in GPA caught on yellow sticky traps or ethylene glycol pan traps and from specimens stored in 70% ethanol.

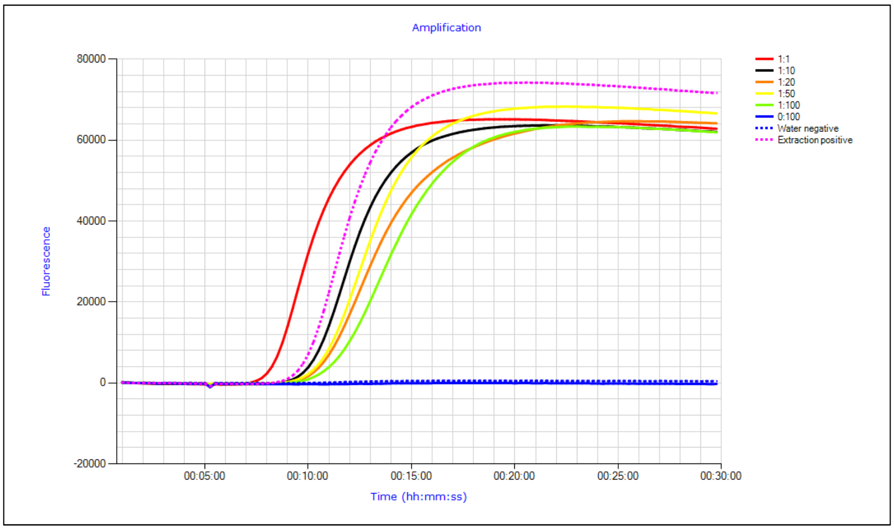

Figure 3. Reverse transcription loop-mediated isothermal amplification (LAMP) of TuYV from serial dilutions of one viruliferous GPA in groups of non-viruliferous GPA.

During the 2017 growing season, LAMP was used to test >3,500 GPA taken from 858 yellow sticky traps that were deployed at 15 different field sites sown to canola. These were located at grower's farms around Northam, Mt Barker, Ravensthorpe and Esperance, and a cultivar trial in Irish Town. Traps were collected every two weeks and winged aphids were tested for presence of TuYV using the LAMP assay. Also 100 leaves from each crop was tested for TuYV to provide virus incidence in crop at 50% flowering. Due to a relatively dry March and April period, TuYV did not reach high levels, ranging from 1-43%. The Irish Town trial was an exception with TuYV incidences reaching 100% of plants infected. This may be due to the non-application of imidacloprid seed dressing and the presence of TuYV-infected and GPA-infested volunteer canola plants nearby.

In general, earlier TuYV and GPA detection correlated with higher TuYV crop incidences. Three examples representing high, medium and low risk scenarios from Cascade, Mt Barker and Gibson, respectively, are given in Figure 4. In the high risk scenario, both TuYV and GPA were detected in early-April prior to sowing and TuYV incidence in crop was 43%. In this scenario, this rapid diagnostic tool would be an effective early warning system allowing the grower to deploy an effective integrated management strategy including eliminating nearby broadleaf weeds, sowing into stubble with high seeding rates, applying insecticide seed dressing and follow up applications of systemic insecticides after crop emergence if conditions continue to support virus spread by GPA. In contrast, in the low risk scenario TuYV was detected in late-July and GPA in mid-May, this being well after sowing and TuYV incidence in crop was just 3%. This represents a scenario where late detection indicates the risk of yield loss to TuYV infection is low and expensive insecticide application (e.g. sulfoxaflor) is unnecessary. In the medium risk scenario, TuYV was detected in plants before sowing but GPA were not detected, suggesting the presence of viruliferous cabbage aphids, an inefficient TuYV vector which can still contribute to an epidemic by providing initial internal infection sources for later and more rapid spread by GPA. In this case, the control options mentioned above should be employed at sowing time but a follow up spray is unlikely to be cost-effective.

Further field validation will be done in 2018, and results extended through media such as PestFax.

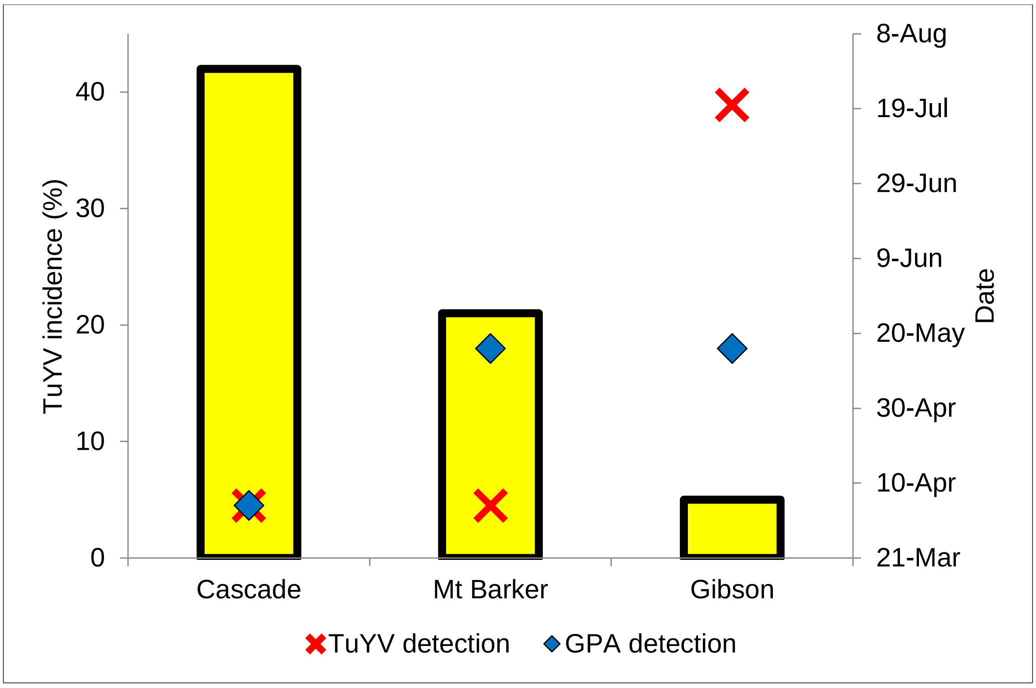

Figure 4. TuYV incidence at 50% flowering (left Y axis) and LAMP detection date of TuYV and GPA (right Y axis) in canola crops at three locations representing high (Cascade), medium (Mt Barker) and low (Gibson) yield loss risk scenarios (Date of sowing 20-30 April).

Detection of viruliferous aphids from smart traps would enable a unique advantage to disease risk forecasting. The trend towards automated pest and disease surveillance and its potential hybridization with epidemiological modelling could provide useful forecasting and rapid decision support for growers faced with difficult and expensive crop protection issues. Once validated for other target pathogens, LAMP will enable surveillance of a wide range of pathogens in smart-trapping programs currently being established in the WA grainbelt.

Rapid spray decision-support

Rapid inspection of crops for pests and diseases is prone to error, resulting in either spraying unnecessarily (when infestations are overestimated) or not spraying when infested areas are overlooked and localised infestations have already caused economic damage. Figure 5 shows that average infestation levels calculated from assessments of cabbage aphids in flowering canola can easily be over or underestimated. For example, although the overall average aphid infestation levels were about 20% (i.e. 0.2 proportion) of plants infested, inspecting 10 plants could result in as low as 0% or as high as 50% estimates. Even sampling 50 plants could result in averages as low as 10-15% or as high as 30% of plants infested.

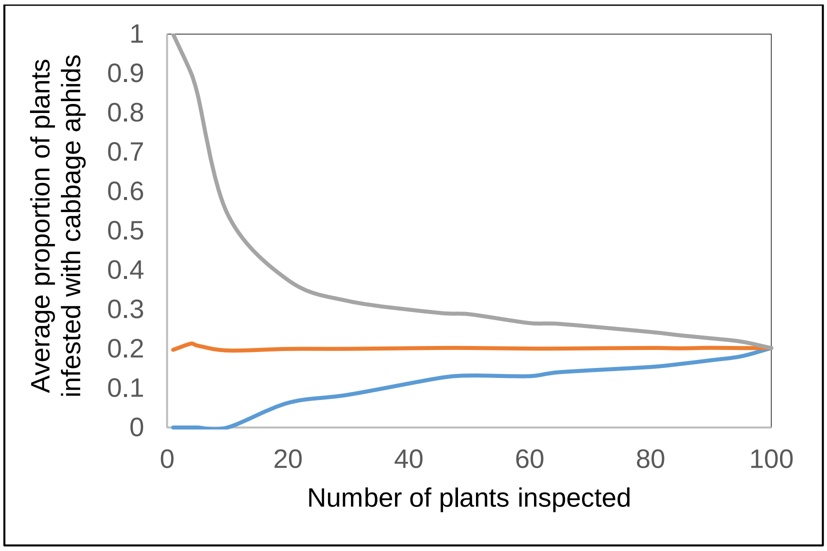

Figure 5. Resampling statistics from a flowering canola crop at New Norcia, WA showing the maximum, minimum and overall average (middle line) from 1000 plant inspections for cabbage aphids throughout the crop.

The CropScout app uses the canola aphid sequential sampling plan which is designed to decrease the number of plant inspections required to assess aphids in canola, at a set level of accuracy, relative to the spray threshold of 20% of plants infested with cabbage or turnip aphids on the racemes.

Cabbage and turnip aphids are often aggregated along crop edges where they have initially colonised the crop (unless the crop is patchy or has been moisture stressed during colonisation). The user inspects canola plants in a transect starting along crop edges, and the CropScout app automates the calculations in the background and stops when there is 90% confidence that the areas sampled are either 1) above threshold (mapped as red), 2) below threshold (mapped as green) and below but close to threshold (mapped as amber) (Fig. 6). Maps produced on the phone and on the user's CropScout online personal page (www.mypestguide.agric.wa.gov.au/cropscout) are displayed as coloured polylines, enabling a whole-paddock or multi-paddock view of where crops were inspected for aphids and what the spray threshold results were for those locations. The accuracy (error) and threshold may be changed in the settings.

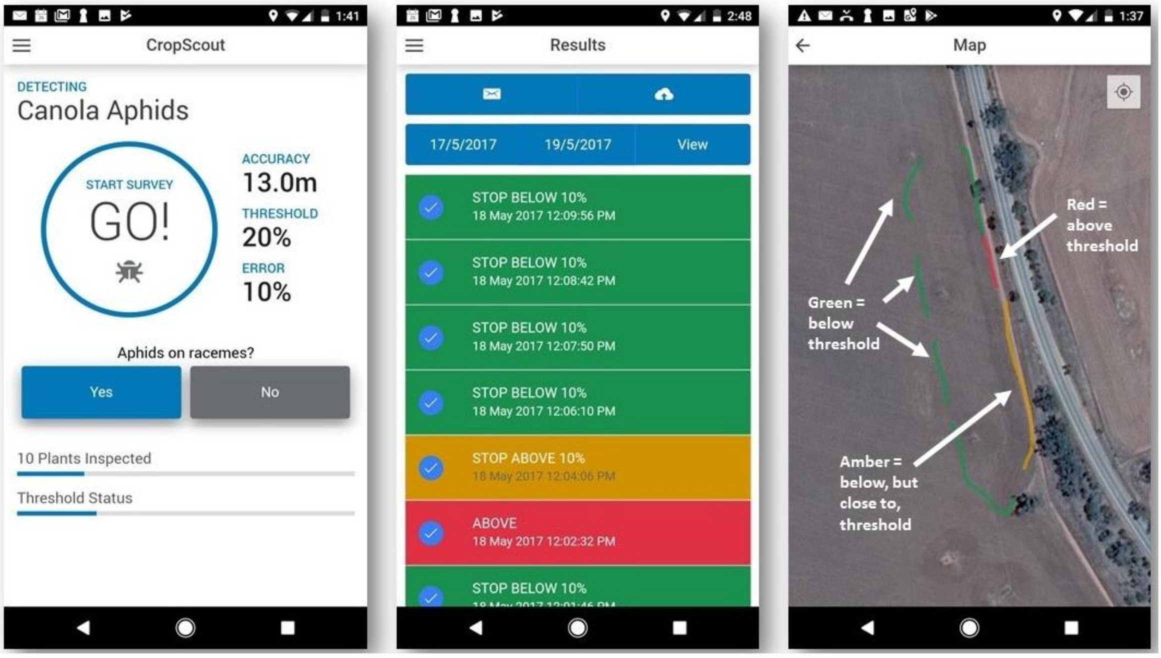

Figure 6. Three mobile phone screen views of the CropScout app showing the sampling interface (left), results list with data export/sync tools (middle) and colour coded maps of spray threshold results (right).

The CropScout app was released on iOS and Android stores on 31 July, 2017 as part of the MyPestGuide suite of apps from DPIRD. The canola aphid is the first module with others being developed including a cereal aphid module. For more information, visit the DPIRD's CropScout page at www.agric.wa.gov.au/apps/cropscout.

Conclusion

Recent advancements and decreases in costs associated with technology can be used to benefit growers and consultants in the WA grains industry through rapid and improved detection (e.g. automated budworm moth trapping), diagnostics (e.g. aphid and virus detection), and spray decision-support (e.g. CropScout app).

Rapid and improved crop protection is important at the paddock scale as well as regional scale where pests and disease development and movement can be monitored over large areas and provide an early warning which can be communicated and interpreted through media such as PestFax.

Tools that improve the accuracy and decrease time spent on pest and disease diagnosis will give growers a better ability to spray pesticides when and where required, saving them money on unnecessary sprays and reducing the risk of further development of pesticide resistance in pests and diseases.

Key words

Smart traps, LAMP, diagnostics, CropScout, early warning, detection, pests, diseases

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