Drones in vegetable systems

Precision agriculture in vegetable systems

R&D FARM-READY
ADOPTION READINESS

The use of drones in vegetables, and agriculture in general, has been increasing in recent years. Marketing and use of drone technology has proceeded in advance of research and development.

Despite the hype around their operation, drones (or Unmanned Aerial Vehicle (UAV) or Remote Piloted Aircraft (RPA)) are essentially an aerial platform to carry out different tasks or capture data, depending on the payload and/or sensors they carry.

The advantage of drones over other crop sensing platforms is they can be deployed easily, cover relatively large areas quickly and achieve ultra-high resolution image capture.

Most drones are fitted with digital cameras to capture still or video imagery. Additional sensors or payloads can also be fitted depending on the purpose of the drone. It is the sensor that is the critical element for the data or information capture and determines which drone can be used.

The most common and accessible use of drones in agriculture is in photogrammetry. Photogrammetry is about taking a series of images that can then be interrogated to reveal some useful information about the subject (Figure 1).

Common applications of drones in agriculture include:

- digital RGB images or video capture of crop condition,
- multi-spectral sensor for crop sensing,
- thermal cameras (crop and pest),
- beneficial insect dispersal,
- spot spraying of agricultural chemicals.

Figure 1. *Drone capturing imagery in commercial vegetable crops.*

Hort Innovation
Strategic levy investment
VEGETABLE FUND
Queensland Government

Figure 2. *Top: RGB orthomoasaic of brassicas; Bottom: 3D model of sweet corn from RGB imagery.*

DIGITAL RGB IMAGERY

Digital RGB cameras (visible spectrum) are the standard sensor for most drones. As the drone flies, hundreds of individual photos are taken (normally overlapping by 70–80%). These are then 'stitched' together during processing to give one overall image known as an orthomosaic (Figure 2).

High resolution RGB digital imagery (e.g. 20 mega pixel camera) can be used for various purposes in vegetables.

In most situations it can be just as effective as multispectral imagery. Recent developments in software specialising in RGB image manipulation have now made RGB the standard in agricultural assessments. Different vegetation indices enable the assessment of crop variability such as visible differences in plant and canopy size and irrigation patterns.

This imagery can also be used to produce three dimensional point clouds that can then generate 3D products such as: crop digital surface models (Figure 2), contour lines, above ground biomass, volume and surface water drainage maps.

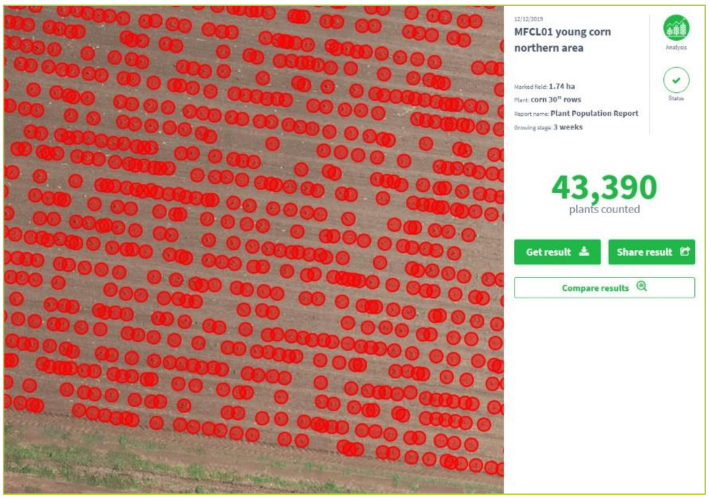

Figure 3. *Automated plant counts in sweet corn. Red circles indicate counted plants.*

Automated plant counts

Artificial Intelligence (AI) and Machine Learning (ML) now deliver automated plant counts and weed recognition (Figure 3). These analytics use specially developed algorithms that count plants visible in the orthomosaic. These algorithms are commercially available through Cloud based platforms e.g. Agremo®, Precision Hawk. Automated counts can struggle differentiating between some weeds and the crop. For more accurate counts, fields should have as few weeds as possible.

Automated plant counts can be used to estimate yield potential and field losses for crops that have a single unit of produce e.g. lettuce and brassicas. They can also be used to determine plant density, particularly for replant decisions. Validation of the count algorithms by DAF has found accuracies of higher than 99 per cent.

MULTISPECTRAL IMAGERY FOR CROP SENSING

There are a range of commercially available multispectral sensors that can be attached to drones. Multispectral sensors capture image data at specific frequencies across the electromagnetic spectrum. Additional wavelengths such as near infrared are ideally suited to measuring photosynthesis in plants. Each time the sensor is triggered, 4 or 5 individual photos are taken simultaneously in different parts of the spectrum. Additional parts of the spectrum allow very small differences in plant health/vigour to be assessed, which often won't be visible to human eyes or a normal RGB camera.

Vegetation index

Different cloud based platforms e.g. Drone mapper, Dronedeploy, Precision Mapper (Precision Hawk) (accessed by subscription) offer a range of vegetation indices derived from reflectance data captured by the multispectral sensor. The most common indices are presented in Table 1.

Multispectral imagery can primarily be used in vegetables for assessing spatial variation in crop vigour/growth and identifying areas for crop scouting. While this imagery can indicate areas that are underperforming or stressed it cannot determine the cause of this stress or growth constraint. This requires ground-truthing in the field, the imagery merely directs growers or agronomists where to look (Figure 4).

Table 1. Common vegetable indices derived by cloud based software/processing platforms.

Vegetation index	Measure of crop vigour
NDVI Normalised Difference Vegetation Index	Differentiates crop vigour based on amount of near infrared light reflected compared to red
OSAVI	Differentiates crop vigour but is adjusted for high soil backgrounds
NDRE Normalised Difference Red Edge	Uses NIR and the red edge band (the band between visible red and NIR) Capture further down crop canopy than NDVI. Can be used in mature crops when NDVI is saturated.
Chlorophyll index	Provides an indication of total chlorophyll content based on reflectance data

These indices are all essentially an indication of crop vigour.

Thermal imagery

Thermal imagery refers to the conversion of invisible radiation patterns arising from plants into a visible thermal (heat) map (Figure 5). Thermal imagery is primarily used to monitor crop moisture stress and water use. Thermal cameras have a far lower resolution than multispectral or RGB cameras. Thermal data will also require some form of temperature calibration, which is currently not easily done.

Processing and analytics

Clever analytics are critical so that imagery or reflectance data can be converted to information of use on the ground, such as crop vigour maps (vegetation indices) and automated plant count plants in a field.

There are a range of cloud based platforms that complete processing and image or data analysis (Figure 6) e.g. Drone mapper, Dronedeploy and Precision Mapper (Precision Hawk).

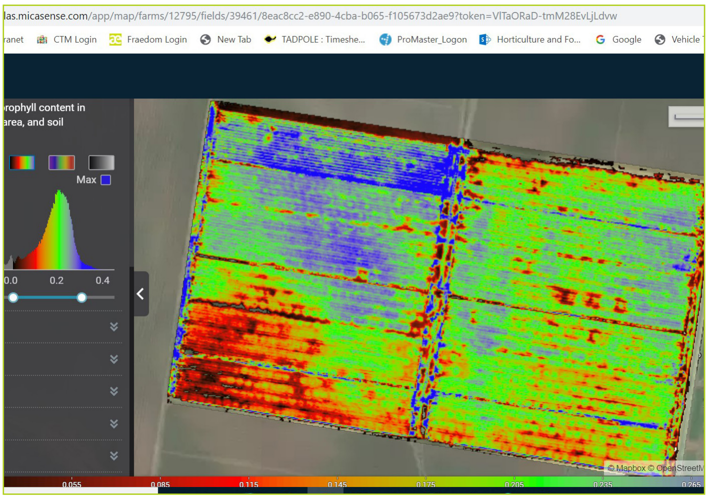

Figure 4. *Multispectral drone imagery of green beans showing Normalised Difference Red Edge (NDRE) vegetation index.*

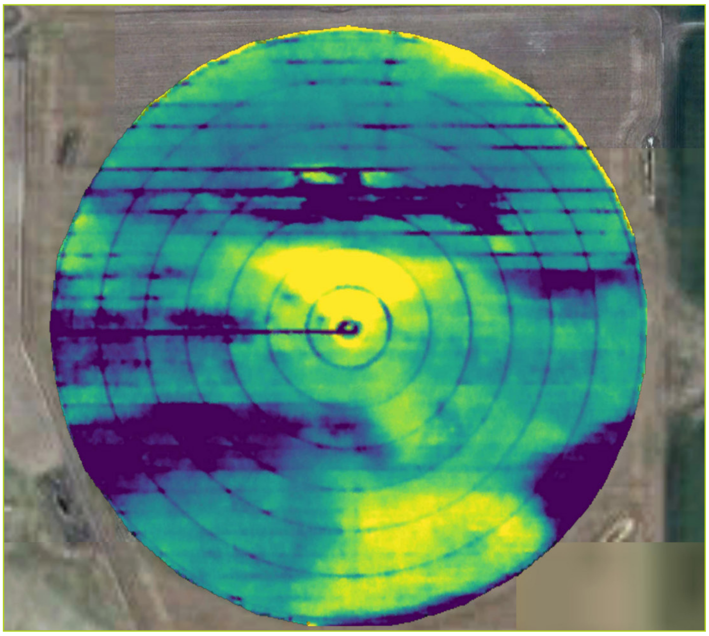

Figure 5. *Drone captured thermal imagery of potatoes. Source: Melissa Fraser, PIRSA.*

These are generally subscription based and tend to start at $150/month although some do have a pricing structure that allows for one-off analyses.

Most sensors are typically associated with specific software and processing packages and there may be compatibility or access issues if trying to mix sensors and processing packages.

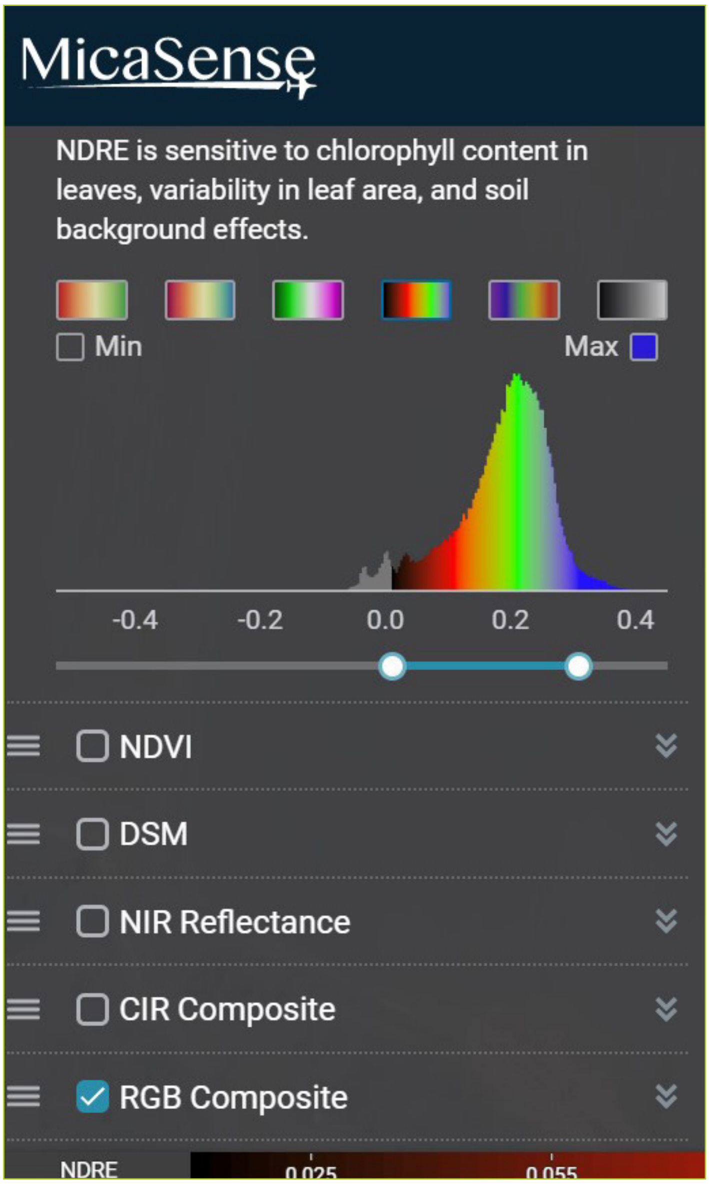

Figure 6. *Analytics available through Atlas Micasense imagery platform. Includes chlorophyll map, OSAVI, NDRE, NDVI, RGB.*

BENEFICIAL INSECT DISPERSAL AND SPOT SPRAYING OPERATIONS

These applications are generally carried out by commercial operators however, these services are still not widely available across vegetable growing regions.

Beneficial insect dispersal via drone does offer a time-effective option and also broader coverage than manual dispersal.

Spot spraying of weeds usually requires two separate operations – one to sense the weeds (Figure 7) and the next to spray them.

DRONE OPERATION

Engaging commercial drone operator services

Key considerations:

- Be clear in what the drone will be used for, and discuss what kind of data will be captured. Different applications require different cameras or sensors, and have different flight specifications. For example, plant counts use RGB imagery and have lower flying height (30 to 40 m) to achieve the necessary resolution compared with higher flight height of 80 to 100 m for multispectral crop sensing imagery.
- When using commercial drone service providers, be clear on which data formats are required. Often spatial data is sent as a report in a PDF file, but this cannot be used with location services in the field. To use spatial data in the field it needs to be delivered as a spatial layer file such as a .kmz or .shp layer that can be loaded into spatial platforms with location services e.g. GoogleEarth.
- Highlight the turnaround time necessary to receive the crop sensing data. Many vegetable crops have short growing seasons so a fast turnaround is required to be able to ground-truth the data in the field.
- The costs of commercial drone services vary greatly. Generally, the cost of these services are lower as the area of coverage increases. Travel costs will usually be additional.

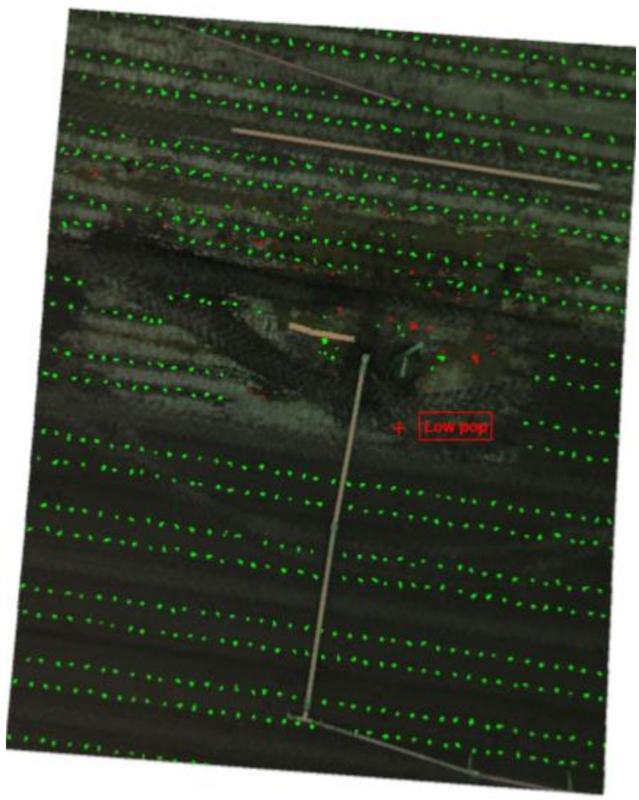

Figure 7. *Weed detection analysis from drone imagery in sweet corn. Weeds appear as red and the sweet corn plants green. Source: Airborn Insight.*

Before becoming a drone owner-operator

Key considerations before purchasing a drone:

- Determine the sensor required for the data to be collected. This will determine which drone/s will be suitable for that payload. Beware of hype. Sensors and analytics packages may not correspond to actual fit for purpose.
- Consider what analysis is needed i.e. plant counts, and aim to have access to a number of vegetation indices.
- If processing your own imagery, having sufficient processing power and RAM is important for processing drone imagery. Check recommended specifications for processing software as upgrades to computer equipment may also be needed.

Rules and regulations for self operators

The Civil Aviation Safety Authority (CASA) is the regulatory body for all aircraft in Australia including drones. Regulations for drone operation are regularly changing so it is best to check directly with CASA for the latest requirements. As many vegetable growing regions are located in close proximity to both civil and military restricted airspace, this should be checked before any drone flights.

For more information:

Julie O'Halloran: 13 25 26
julie.o'halloran@daf.qld.gov.au

Author:

Julie O'Halloran, Queensland Department of Agriculture and Fisheries

Acknowledgements

The Queensland Department of Agriculture and Fisheries would like to acknowledge the contributions of Airborn Insight and Marcus Bulstrode, Queensland Department of Agriculture and Fisheries.

Disclaimer

The information contained herein is subject to change without notice. The Queensland Government shall not be liable for technical or other errors or omissions contained herein. The reader/user accepts all risks and responsibility for losses, damages, costs and other consequences resulting directly or indirectly from using this information.

Mention of a particular product or brand name does not imply endorsement in preference to other products that are capable of offering similar performance or service.

Funding and Project Partners

This project has been funded by Hort Innovation using the vegetable research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au