

Precision horticulture

– Helping make better orchard management decisions

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Horticultural production is becoming more complicated and consumers are becoming more demanding. Precision horticulture is the natural extension of precision agriculture, which has been widely applied in broad-acre production systems such as corn farming for many years. Precision horticulture considers both spatial and temporal variability at reasonably small scales when making orchard management decisions. Remote sensing tools such as multi-spectrum cameras together with computer support tools such as Geographic Information Systems (GIS) are key to collecting and analysing large amounts of information in a timely and cost-effective way. In the near future, growers will likely be able to create and use near-real-time canopy maps to help them make better management decisions.

Horticultural production is becoming increasingly complex and competitive. Consumers demand high quality, safe and sustainably grown fruit and vegetables. To meet this demand, modern farming practices need to maximise production and quality, minimise environmental impacts, and reduce costs.

Precision horticulture is a management approach that considers both spatial and temporal (time-based) variability within the orchard. In the context of the New Zealand kiwifruit industry, precision horticulture requires observation and measurement of orchard variables such as soils, topography, vine health, yield and fruit at a vine level as well as a canopy or block scale. It also requires an understanding about how some of these variables change within and between seasons. Only then can management decisions optimise the economic yield from a finite area of orchard land.

Precision horticulture uses modern tools including Global Positioning Systems (GPS) to geo-reference data and Global Information Systems (GIS) to manage and map the information. Remote sensing equipment including multi-spectral cameras can collect large amounts of data

quickly and efficiently. The data can then be used for retrospective analysis or used in real-time by “variable-rate” equipment such as fertiliser spreaders and irrigation systems.

Remote sensing in kiwifruit

Using traditional methods, the cost of monitoring at the vine level can be prohibitive. Analysis can also be technically demanding. In contrast, remote sensing offers growers an alternative way to quickly gather important information. This information can be processed and analysed either by the grower or by their preferred advisor using computer-aided analysis tools.

Healthy plants are known to reflect higher levels of Near Infrared (NIR) light compared to less healthy plants and other surfaces such as soil (Figure 1). These differences can be seen in images taken from satellites, conventional aircraft or Unmanned Aerial Vehicles (UAVs or drones) above the canopy and from ground-based vehicles below the canopy. Satellite and conventional aircraft images are typically used at larger scales whereas using a UAV enables images to be captured at centimetre resolutions. Monitoring

and assessing kiwifruit plants and even individual canes using UAVs is becoming a reality.

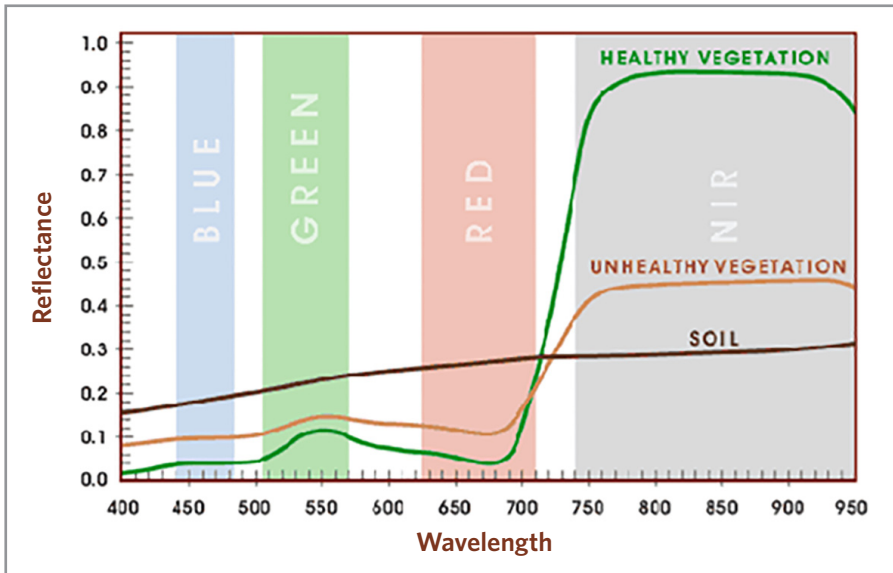


Figure 1. Healthy kiwifruit canopies reflect more light in the Near Infrared (NIR) wavelengths than stressed vines (Image courtesy of MicaSense Inc.).



Photo 1. UAV takes multi-spectral images of G3 Kiwifruit, December 2015.

Case study

Zespri is currently working with the University of Waikato to better understand how plant stress can be detected in Gold3 kiwifruit using a multi-spectrum camera suspended from a UAV (Photo 1).

Because plant stressors can be many and varied, the study is specifically looking at some of the most typical symptoms of plant stress, namely leaf area and biomass, leaf chlorophyll levels and leaf nutrient levels.

Measuring leaf area and biomass

Kiwifruit leaves are the powerhouse that drive both yield and fruit quality including dry matter production. Current methods for calculating Leaf Area Index (LAI) using a ground based sensor (for example, a Licor LAI2200C meter) is time-consuming, complex and somewhat dependent on the skill of the operator.

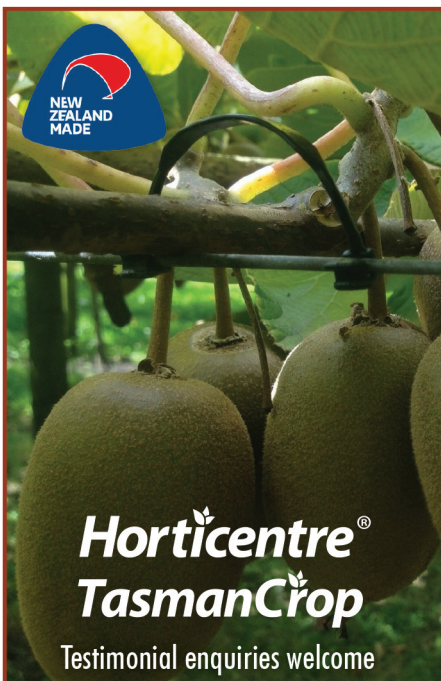
Using remote sensing (see Figure 2), a canopy map can easily be created for each block that shows the unfilled canopy area. Preliminary assessments indicate that some areas within the canopy

contain between 13-69 percent holes. This represents lost production. Filling canopy holes with canes could significantly increase yield with few, if any, increases in production costs.

Monitoring leaf nutrient levels

The importance of plant nutrition is well documented. Where nutrients are limiting, this can often be seen in the leaves using remote sensing. However, if nutrients are not significantly limiting, then variability in canopy reflectance may be caused by other factors such as water stress. Preliminary results show low to moderate correlations

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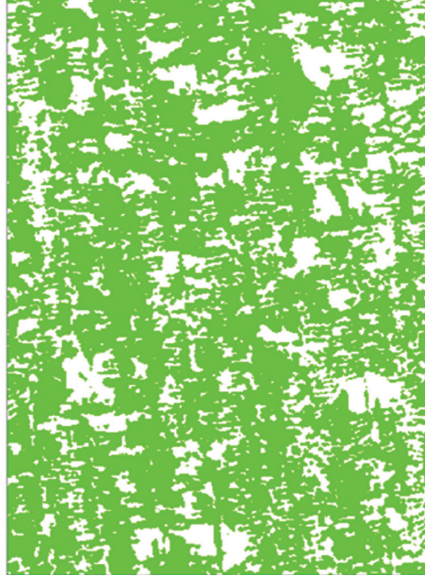
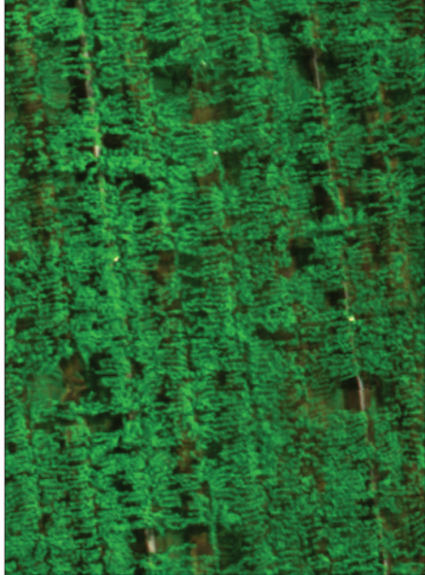


Figure 2. (Above left) Gold3 canopy taken from a UAV at 120m above ground level showing individual vines and canes. (Above right) Canopy map created from photo showing the extent of canopy holes.

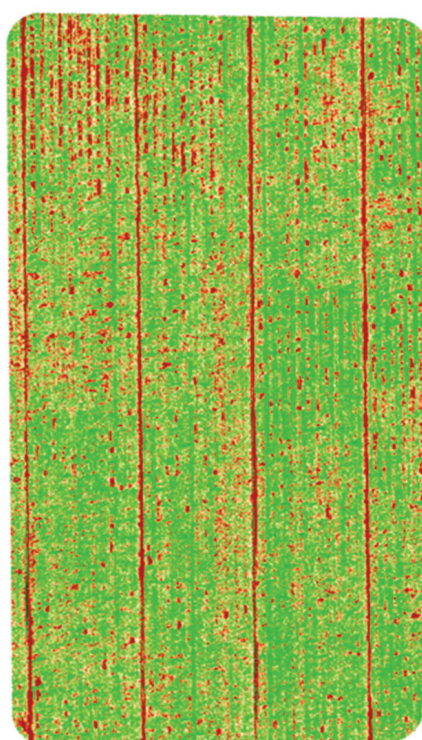
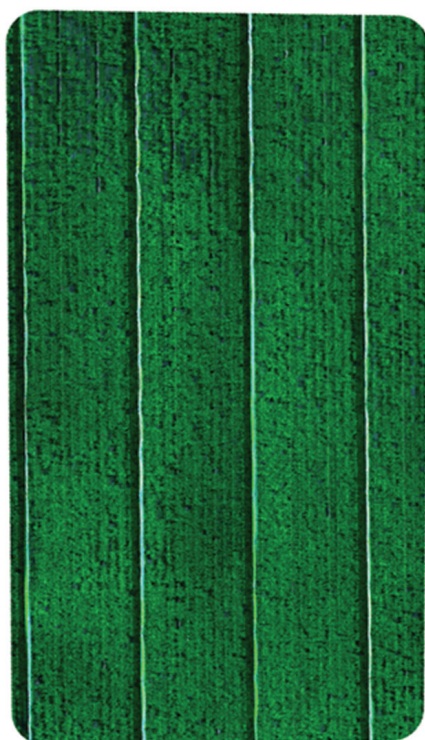


Figure 3. (Above left) Gold3 canopy taken at 120m above ground level using a UAV. (Above right) NDVI image created from photo, highlight early season variability in chlorophyll levels.

with leaf nutrient levels possibly because nutrients are not limiting on the study orchards.

Detecting chlorophyll levels

Kiwifruit orchardists instinctively understand that low chlorophyll levels are an indication of poor vine vigour. Vines under water, nutrient or disease stress often appear yellow with an associated reduction in fruit yield and/or fruit quality. Measuring chlorophyll levels using a hand-held meter (for example, a Minolta SPAD meter) is time consuming, albeit a relatively simple procedure. Regular monitoring of chlorophyll levels is rarely undertaken.

Using remote sensing, chlorophyll levels can easily be monitored at a plant or bay level (Figure 3). Monitoring five hectares with a UAV can take as little as eight minutes. While the final analysis of the study has yet to be completed, early indications are that Normalised Differential Vegetation Index (NDVI) and several other selected Vegetation Indices (VIs) are strongly correlated ($R^2 > 0.65$) to the quantity of chlorophyll.

Future applications

Ultimately, the aim of precision horticulture is to provide growers with a suite of decision support tools that are simple to use and cost effective to implement.

The preliminary research Zespri is undertaking in collaboration with the University of Waikato is the first step towards understanding the relationship between vine health and key vegetation indices. Once these relationships are better understood, then the obvious question becomes "how does this relate to fruit yield and quality?"

In the near future, up-to-date, digitised canopy maps of an entire orchard, regardless of size, are not an unreasonable expectation. Growers will also be able to use remote sensing tools to create 'management zone maps' that identify areas requiring different management strategies or inputs. Monitoring the rate of canopy development early in the growing season may also provide valuable insight about seasonal climate variations specific to a particular block or orchard. Remote sensing opens up opportunities to monitor both summer and winter pruning in near-real-time as well as to track the spread or recovery from diseases such as Psa.

Acknowledgements

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Further reading

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