Adding value to the wine business precisely: using precision viticulture technology in Margaret River

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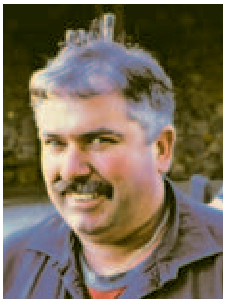

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The following article was presented at a workshop, Managing vineyard variation – precision viticulture, as part of the 12th Australian Wine Industry Technical Conference held in Melbourne, July 2004. Precision viticulture practitioners from a number of countries presented papers at the workshop and the proceedings are available at the following web site: http://awitc.com.au/workshops/Workshop_30B_Proceedings.pdf

With the increasing use of a range of information technologies, collectively referred to as Precision Viticulture (PV), it is becoming increasingly apparent that vineyards vary substantially in both the quantity and quality of winegrapes being grown. The emergence of global positioning systems (GPS) allows the traditional measures of vine productivity to be easily linked to specific locations within the vineyard. Recent advances in observation tools such as grape yield monitors, airborne optical remote sensing and soil-sensing instrumentation means that spatial data can now be more easily collected and recorded. These layers of information enable the viticulturist or vineyard manager to make more informed decisions related to desired productivity outcomes. This article describes some recent research and commercial uses of these technologies in the Margaret River region of Western Australia, with an emphasis on the economic benefits of their application.

Obtaining information on vine parameters across a whole vineyard is both difficult and expensive. However, vines, like any plants, are likely to integrate the effects of their local environment (eg. climate, soil properties, and disease, nutrient and water pressures) and express them through their canopy characteristics (Wiegand and Richardson 1984). Airborne remote sensing provides a means by which information on vine characteristics such as canopy status can be easily collected, and, as an emerging technology, has been the subject of recent PV research (Hall *et al.* 2002; Dobrowski *et al.* 2003; Lamb *et al.* 2004). Typical remotely-sensed images identify relative differences in vine canopy status across the vineyard as opposed to absolute differences, thereby making comparisons between different data-sets difficult.

Experience in the Margaret River region suggests that veraison (±2 weeks, and before the application of bird netting) is an appropriate time for image acquisition. SpecTerra Services based in Perth is a commercial provider of airborne Digital Multi-Spectral Imagery (DMSI) and has demonstrated that 0.5m resolution is required in order to delineate vine-dominated pixels from pixels dominated by non-vine features such as soil, shadow and inter-row vegetation (A. Malcolm, personal comm.) The DMSI sensor collects data in four wavebands corresponding to the infra-red, red, green and blue wavelengths from which 'images' of the ratio of infra-red to red reflectance are then produced. This ratio is generally referred to as the 'plant cell density' (PCD) index. Such images are now being used in the Margaret River region to separate vineyard blocks into areas or 'zones' of low, medium and high vine-vigour. Similarly, yield maps or 'surfaces' generated from data collected by monitors aboard grape harvesters are now being used to separate vineyard blocks into zones of low, medium and high yield. Once delineated, blocks which have traditionally been managed uniformly, are now being managed differentially with respect to both inputs (eg. fertiliser, water, mulch, canopy-management techniques) and outputs (grapes, wine).

Case study 1: differential harvesting at Vasse Felix

In February 2002, DMSI data was acquired for a winery-owned vineyard from which a PCD image was produced using a five colour scheme grading from low to high PCD. A 3.3ha block of Cabernet Sauvignon within the property was then used to ground-truth the imagery (Figure 1).

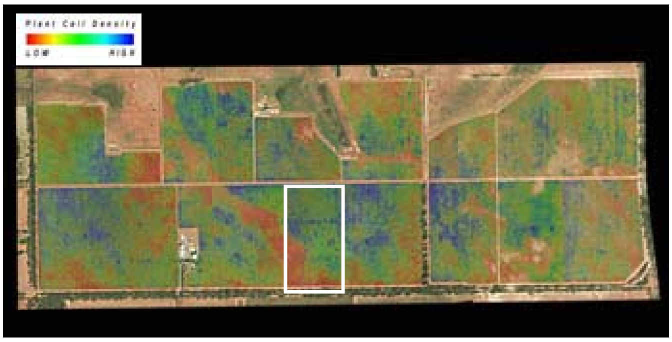

Fig. 1. DMSI data shown as a plant cell density (PCD) image grading from low PDC (red), through to medium PCD (green), to high PCD (dark blue). The Cabernet Sauvignon block (delineated by the white rectangle) was used to ground-truth the imagery and was later harvested differentially.

Two weeks before harvest, vines in areas of low and high PCD were assessed for canopy vigour, and fruit was analysed analytically for sugar (expressed as Baumé), pH and titratable acidity (TA) and by sensory assessment for quality. These results confirmed that differences in PCD translated into real differences on the ground. As a result, the block was divided into a northern (high PCD/vine vigour) zone and a southern (low PCD/low vigour) zone and harvested differentially in March 2002 using a mechanical harvester fitted with a grape yield monitor and differential GPS (see Figure 2).

At harvest, fruit from the northern and southern zones was picked into separate bins and then kept separate in the winery. The data collected by the yield monitor was mapped according to the protocol outlined by Bramley and Williams (2001) and showed that the mean yield for the whole block was 13t/ha, with the northern zone yielding 16t/ha and the southern zone yielding 8t/ha (see Figure 3). The variation in yield across the block was found to be similar to the variation in PCD (compare Figures 2 and 3).

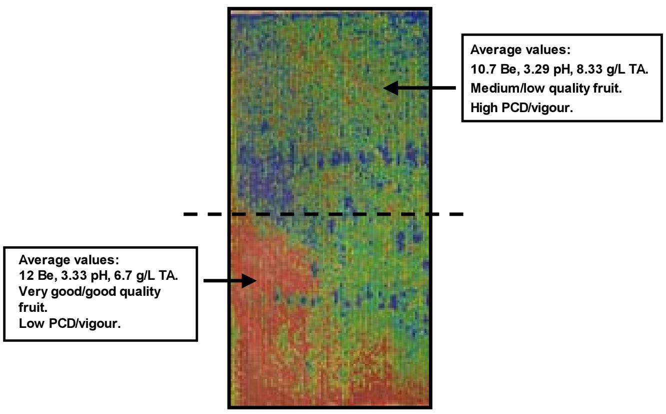

Fig. 2. Analysis of fruit sampled in the Cabernet Sauvignon block two weeks prior to harvest from areas identified as being of 'low' and 'high' plant cell density (PCD) at veraison. The dashed line delineates the areas of low and high PCD. Bé = baumé, TA = titratable acidity.

At classification, there were sufficient differences in wine quality between the two zones to allocate the batches to different end products. Wine made from fruit harvested from the northern zone was allocated to the 'Classic Dry Red' brand (retail price approximately $19 per 750ml bottle), whilst wine made from fruit harvested from the southern zone was allocated to a varietal Cabernet Sauvignon brand (retail price approximately $30 per 750ml bottle). If the block had been harvested as a single unit, the resulting wine is likely to have been allocated to the lower end-use product. Assuming that 1t of fruit produces 750L of wine, the gross retail value of production was approximately $484,500 and $380,400 for the northern and southern zones respectively. By using PCD imagery and splitting the block into different management zones, the total gross retail value of production was therefore $864,900 compared to $725,420 if the block had been harvested as a single unit. For further information refer to Bramley *et al*. 2003.

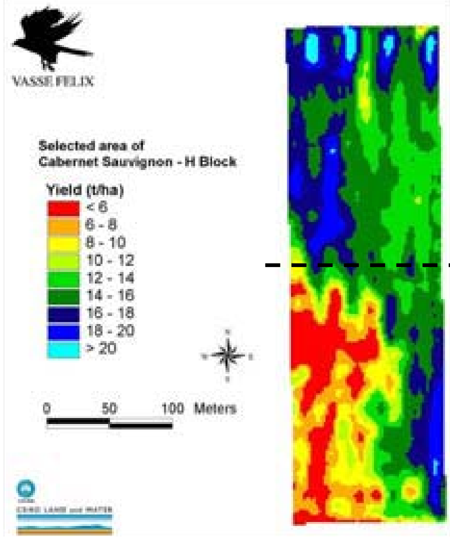

Fig. 3. Yield map of the Cabernet Sauvignon block harvested in March 2002. The dashed line delineates the areas of low and high plant cell density.

In 2003, the block was again split into two zones and harvested differentially. However, instead of picking each zone on the same day, the more-vigorous northern zone was harvested nine days later in order to enable the fruit to become more physiologically ripe. Whilst wine made from the less-vigorous southern zone was again allocated to the varietal Cabernet Sauvignon brand, wine made from fruit harvested from the northern zone was allocated to a higher end product than in 2002 because it was more physiologically ripe. Instead of making the Classic Dry Red brand it was allocated to the Cabernet/Merlot brand (retail price approximately $22.50/bottle).

In 2004, the block was again split into two zones and harvested differentially. Picking of each zone was done on the same day and the fruit separated during harvest into individual bins. Analytical analysis showed similar results to previous years (northern zone 13.2Bé, 3.90pH, 5.6g/L TA and southern zone 13.0Bé, 3.93pH, 5.78g/L TA.). Sensory assessment of the two wines indicate that wine from the northern zone has moderate colour intensity, simple fruit characters (herbal), and short palate length. Wine from the southern zone is riper on the palate, has good berry fruit flavours and good palate length. At the time of writing, no allocation has been made to the end-use of each wine.

Case study 2: differential harvesting at Evans and Tate

PCD imagery and yield maps are being used by Evans and Tate to separate vineyard blocks into management zones in order to gain economic benefit through differential harvesting. The following example is for a 8.47ha Shiraz block which was planted in 1998 and now managed by the company. Previously acquired PCD imagery and a yield map indicated that there were spatial differences in both vine vigour and yield within the block. Different zones were identified, with zone A representing the low vigour, low-yielding section and zone B representing the high vigour, high-yielding section. In 2002, the block was harvested differentially (two separate picking dates) with the aim of picking approximately 40t on each occasion. Fruit was kept separate in the winery and there was sufficient difference in quality to incur different fruit prices. Table 1 shows the gross returns ($/ha) for four contrasting scenarios, with scenario C being the actual scenario used.

The scenarios shown in Table 1 clearly demonstrate that there is an economic benefit to harvesting differentially as either a single pick or as two separate picks compared with harvesting the whole block without segregating the fruit. The increase in fruit value for zone B in scenario C compared with scenario B demonstrates the benefit of leaving fruit to become physiologically ripe, thereby improving quality (as demonstrated by Vasse Felix in vintage 2003). Installation of a headland is economically viable.

Case study 3: applying cultural practices differentially at Barwick Estates

In order to use remote-sensing imagery in a strategic manner for fine-tuning cultural practices and observing the benefits of applied inputs over time, it is necessary to 'calibrate' remotely-sensed images. This can be done by establishing relationships between a form of vegetation index (eg. PCD) and directly measured indices of vine vigour. In 2003 and 2004, DMSI data was acquired for a 38ha vineyard property owned by Barwick Estates. In 2003, 30 vines within a 8.8ha block of Cabernet Sauvignon were spatially located using a differential GPS. The selected vines represented a range of visually-different canopies and vine vigour. For both years, canopy surface area, trunk circumference and post-harvest pruning weights were recorded. As an example, Figure 4 shows the linear relationships between PCD and canopy surface area for both years, with similar relationships being found for each year. Linear relationships have also been obtained for PCD vs trunk circumference and PCD vs pruning weight (data not shown).

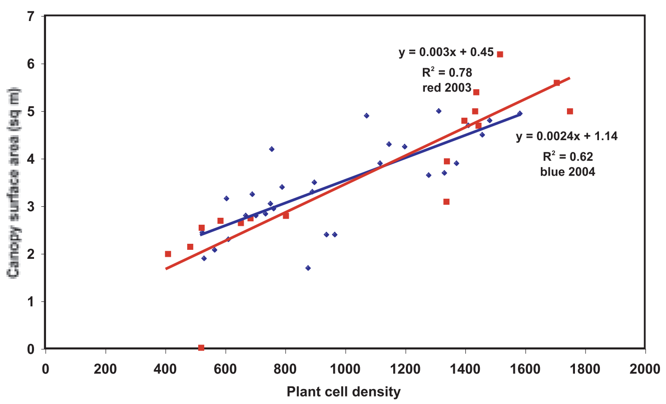

Fig. 4. Linear relationship between canopy surface area (m²) and plant cell density for both 2003 and 2004 growing seasons. Data is for Cabernet Sauvignon collected close to veraison.

Table 1. Economic benefits of using precision viticulture technologies: (a) zones A and B harvested together as one pick; (b) harvest the block differentially as one pick but using split bins to keep fruit from zones A and B separate; (c) harvest the block differentially as separate picks and keep fruit from zones A and B separate; (d) as for (c) but install headland to aid management assuming a cost of $1700 spread over 10 years and loss of fruit from that area.

(a)

Vineyard zone	Area (ha)	Yield (t)	Yield (t/ha)	Price for fruit ($)	Total fruit value ($	Harvest cost ($)	Fruit value less harvest cost ($)	Gross return ($/ha)
A+B	8.47	82	9.7	1,200	98,400	4,462	93,938	11,091

(b)

Vineyard zone	Area (ha)	Yield (t)	Yield (t/ha)	Price for fruit ($)	Total fruit value ($	Harvest cost ($)	Fruit value less harvest cost ($)	Gross return ($/ha)
A	6.00	41	6.8	1,800	73,800			
B	2.47	41	16.6	900	36,900			
A+B	8.47				110,700	4,800	105,900	12,503

(c)

Vineyard zone	Area (ha)	Yield (t)	Yield (t/ha)	Price for fruit ($)	Total fruit value ($	Harvest cost ($)	Fruit value less harvest cost ($)	Gross return ($/ha)
A	6.00	41	6.8	1,800	73,800			
B	2.47	41	16.6	1,200	49,200			
A+B	8.47				123,000	8,924	114,076	13,468

(d)

Vineyard zone	Area (ha)	Yield (t)	Yield (t/ha)	Price for fruit ($)	Total fruit value ($	Harvest cost ($)	Fruit value less harvest cost ($)	Gross return ($/ha)
A	6.00	41	6.8	1,800	73,800			
B	2.37	39.4	16.6	1,200	47,280			
A+B	8.37				121,080	6,560	114,520	13,521

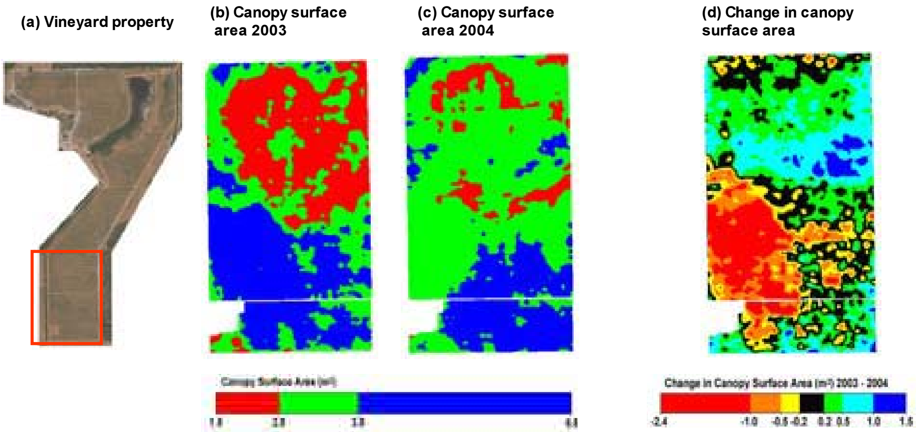

Fig. 5. The Cabernet Sauvignon block is delineated by the white rectangle in (a), the vineyard property. Using established regression equations for 2003 and 2004, plant cell density was converted to canopy surface area (b) 2003 and (c) 2004, with the change in canopy surface area shown in (d).

Using these relationships, it is now possible to use remotely-sensed data to determine the variation in these vigour indices across the block and to then use the information to manage the block differentially (Figure 5). Using the imagery and on-the-ground visual assessment in 2003, certain areas of the Cabernet Sauvignon block were identified as being excessively vigorous. During the 2004 growing season, irrigation was managed differentially so that water was restricted in the vigorous areas in order to reduce vegetative growth. The application of less water during the season appeared to reduce vegetative growth (compare Figures 5b and 5c), with the greatest decrease in canopy surface area being recorded in the most vigorous areas (Figure 5d). It is too early to directly assess the economic benefit of these changes in management practice.

Summary

Vineyards and wine companies in the Margaret River region are experimenting with precision viticulture technologies such as airborne remote sensing and grape yield monitors. The case studies presented show that these early adopters of the technology are beginning to realise the potential economic benefits of understanding and working with vineyard variability.

Acknowledgements

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Get out, quickly – new evacuation guidelines

Emergencies can happen at any time, in any workplace.

Whether it's a fire in an office, a bomb threat over a telephone or a chemical spill in a wine laboratory, exiting quickly and safely can be crucial.

Every employer has a duty of care to workers to ensure preparations have been made for emergencies, according to WorkSafe WA Commissioner Nina Lyhne.

"By law, all WA workplaces are required to have evacuation procedures," Lyhne said.

"Under the OHS legislation, employers and people who have control of workplaces, such as the building manager or site manager, are responsible for developing evacuation procedures."

The Commission for Occupational Safety and Health has developed a new guidance note, Preparing for Emergency Evacuations at the Workplace, now available to all workplaces.

For a copy of the guidance note, contact WorkSafe on (08) 9327 8775 or download it free of charge from the website at www.safetyline.wa.gov.au