

Precision Viticulture

What is it, who should use it and what are the benefits?

With winegrape prices in a slump and many growers facing the prospect of not having their contracts renewed at all, the idea of investing scarce funds into precision viticulture—the range of technologies that are now available to assist in the assessment of variability in vineyards—might seem a difficult pill to swallow. But, is precision viticulture really that expensive? And will it actually save you money in the long-run? The Co-operative Research Centre for Viticulture has recently renewed its focus on precision viticulture particularly through its project “Accelerating the Adoption of Precision Viticulture through Participatory Trials”, and a new guidebook on precision viticulture is due out later this year to help growers decide whether to use precision viticulture and, if so, how to go about it. With this renewed focus, we decided it was timely to pose a series of questions about precision viticulture to Jim Hardie, chief executive of the CRCV; Rob Bramley, a CRCV and CSIRO researcher and precision viticulture expert; and Luke Rolley, of Victoria’s Lake Marmal vineyard, where the application of precision viticulture was one of the reasons it was named the state’s Vineyard of the Year in 2005. Through their responses, it is hoped that growers’ understanding of precision viticulture can be furthered, including the benefits precision viticulture can deliver, why its use is being given such a high priority by Australia’s leading viticultural research and development organisation, together with some practical feedback on the use of precision viticulture technologies.



Jim Hardie
Chief executive
Cooperative Research Centre
for Viticulture

The CRCV has recently renewed its focus on precision viticulture (PV) particularly through the project “Accelerating the Adoption of Precision Viticulture through Participatory Trials”. The three main aims of the project are to generate improved practical knowledge of the theory and application of PV, leading to improved management of yield and quality variation in Australian vineyards; develop regional groups in important production regions to support the adoption of PV comprising consultants, grower liaison officers, extension specialists and vineyard managers; and to contribute PV data and examples to the development of a user’s manual on precision viticulture.

Why has the CRCV placed such an emphasis on furthering the adoption of precision viticulture (PV) technologies in Australian vineyards?

When the CRCV was being planned in 1997-8 there was an extensive industry-wide consultation process to identify emerging technologies that were likely to become important to the industry over the next 10-20 years. The concept of precision agriculture had developed in the USA and the CRCV set out to investigate the usefulness of precision agriculture technologies, such as global positioning systems, airborne remote sensing, electromagnetic soil surveys and spatial data analysis for monitoring and managing variability in vineyards. In the course of the work we have identified several uses for the technologies and we are keen to promote their application. The technologies offer particular potential to assist the management of large vineyards where monitoring and understanding the sources of variability by labour-intensive observation and sampling is cost-inhibited. In those situations the combination of economies of scale and the use of the precision technologies to reduce variability in harvest lots, either by selective harvest or selective application of resources e.g., water and fertilisers, does provide an opportunity to improve the value of the wine made from them.

Has there been any attempt to quantify the rate of PV adoption in Australia?

We do not have data on the rate of adoption however there has been a very significant increase in the provision of aerial remote sensing services in the last six years.

How much has the CRCV invested in PV research and adoption during its lifetime?

Total resources committed to this work by the CRCV amount to about \$3m since commencement in 1999.

How does Australia’s adoption of PV compare with other countries?

There is particular interest in this approach in the USA, Chile, New Zealand and France. I doubt that Australia has much of a lead overall.

Describe the current work that the CRCV is overseeing to further the adoption of PV in Australia.

The CRCV has had a team compiling all the information about the precision technologies into a ‘users handbook’ soon to be published. This book will be the first of its kind and we expect it to become the principal source of information for grapegrowers and for future workshop presentations.

What did the recent scoping study into the factors influencing the adoption of PV in Australia tell us?

The results of the recent scoping study showed that there had been broad coverage of the topic and many winegrape growers were using some elements of it e.g., remote sensing, yield mapping and high-resolution soil surveying. As far as further research efforts are concerned, the CRCV’s Program 1 Industry Reference Group has noted that the research has been extremely well done but is now at the stage where there is little further research required (at least not as a stand-alone project). It was suggested that the expertise (resident in the current research team), the information and the tools from this project needed to be integrated into other projects.

Who will pick up the ‘PV torch’ once the CRCV has wound down and ensure that PV adoption continues beyond next year?

Now that the CRCV’s work has revealed the possibilities I expect that much of the future promotion of PV will be by the equipment manufacturers, consultants and providers of services such as EM38 soil surveys, and aerial remote sensing. ■

Dr Rob Bramley
CSIRO Land & Water



Rob Bramley, a precision agriculture researcher with the CSIRO and CRCV.

Dr Rob Bramley started working on the development and application of precision agriculture for the sugarcane and grains industries 10 years ago and has focused on the winegrape industry, specifically, since 1999. Part of his work in the wine industry is currently being undertaken in conjunction with the Cooperative Research Centre for Viticulture (CRCV) for whom Rob leads the project "Precision Viticulture – Making Sense of Vineyard Variability".

Why is the adoption of precision agriculture desirable for any particular crop production system?

We know that crop production is variable irrespective of which crop you're talking about. In viticulture, we know that an eight to tenfold variation in yield is typical within a single block under uniform management which, for example, equates to a range of between two and 20 tonnes per hectare. Grapegrowers have known for ever and a day that vineyards are variable but precision viticulture gives them the tools to see that variation and allows them to do something about it. It ultimately results in a more efficient use of resources.

Precision agriculture could also be viewed in terms of an environmental imperative. For example, it could be used to ensure that the leakage of nutrients and water off-site is minimised. In other words, by maximising the efficiency with which resources are used, you should minimise the opportunity for them to be wasted and/or cause damage off-site.

How does the viticulture industry's adoption of precision agriculture compare with other crops?

The first grain yield map was produced in Western Germany in 1989. Since then, there's been a reasonable but not large

adoption of precision agriculture in the grains industries. In viticulture, the first winegrape yield map was produced in Australia in vintage 1999. Whilst the rate of adoption in terms of the proportion of total grapegrowers is probably not as great as in the grains industry, I think that the potential for the adoption of the technology is greater. In Australia, grain yields tend to be relatively low and grain production is low-input. So, if you're in a marginal rainfall area and all you're harvesting is two tonnes per hectare, there may not be a lot of point in getting bogged down with precision agriculture. In viticulture, on the other hand, the crop is of comparatively high value and there is a strong quality imperative. Opportunities for selective harvesting and better fruit parcelling therefore arise in addition to targeting the application of inputs, which is the main focus in grains.

Whilst a cynic might say that there's not many growers using precision viticulture in Australia at the moment, we need to bear in mind that we only started six years ago. The adoption rate is actually pretty good and it's likely to increase in the near future.

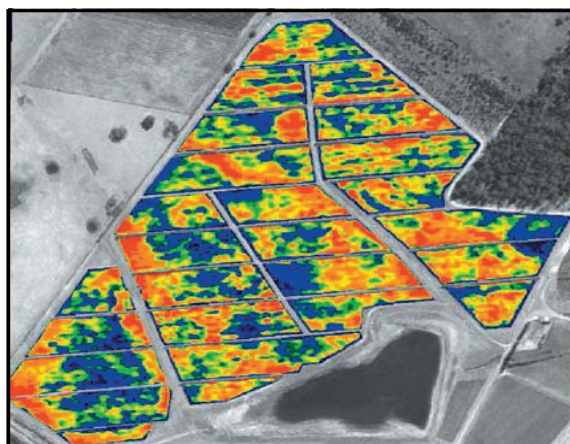
A significant proportion of the nation's vineyards have been captured using remotely-sensed imagery and we are seeing increasing use of yield mapping and high



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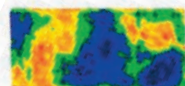
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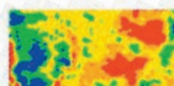
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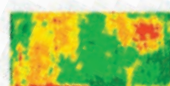
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resolution soil surveys. In fact, most vineyards in South Australia have been captured using infrared aerial imagery through the Phylloxera & Grape Industry Board of South Australia, which analyses the images to identify areas which are worthy of checking for the presence of phylloxera. [Each year, infrared aerial imagery of vineyards within a given area of South Australia is collected by a camera mounted to a light aircraft. This year, the PGIBSA is about to go back and survey the south-east of South Australia for the first time since 2001 when the board first began collecting the infrared imagery.]

What exactly is precision agriculture/viticulture?

There are lots of definitions. One definition could simply be putting the right thing in the right place at the right time. A more detailed answer relates to the certainty of decision making: any agricultural system is inherently uncertain. Precision agriculture increases the certainty of the decision making process so that any decision has an enhanced likelihood of delivering the desired or expected outcome. It does this through the provision of data at high spatial resolution which better informs decisions in comparison with those made without it.

What benefits can precision viticulture (PV) provide growers?

The main one at present is selective harvesting [the split picking of fruit according to different yield/quality criteria]. We know there are quite a few incidences of selective harvesting delivering very significant benefits, particularly to wineries, because of the value adding aspect of winemaking. [One such example of this occurred at Vasse Felix in Margaret River where, instead of consigning all of the fruit from a particular block of Cabernet Sauvignon to a product with a retail value of \$19 a bottle, the winery was able to allocate the fruit from about half the block to a product worth \$30 a bottle. Another is illustrated in Figure 1.] Growers can also gain the benefits of selective harvesting provided they go into it in partnership with their winery. But the use of precision viticulture is not confined to selective harvesting. It can deliver benefits in two other main areas: one is improved management of the natural resources that grape and wine production depends on; and the second is that it provides both growers and researchers with a much better way of doing experiments.

A lot of the advice handed out by consultants is their 'best guess' or based on generalisations derived from research conducted at either a single, or sometimes, several locations. For example, if you had a room full of consultants and you asked them for their advice on how to produce Shiraz at 10 tonnes per hectare on a particular block of land in the Barossa, suitable for bottling in Penfolds Bin 28 Kalimna Shiraz, their answers would probably all be different. Essentially, they'd be guesses, even if they were

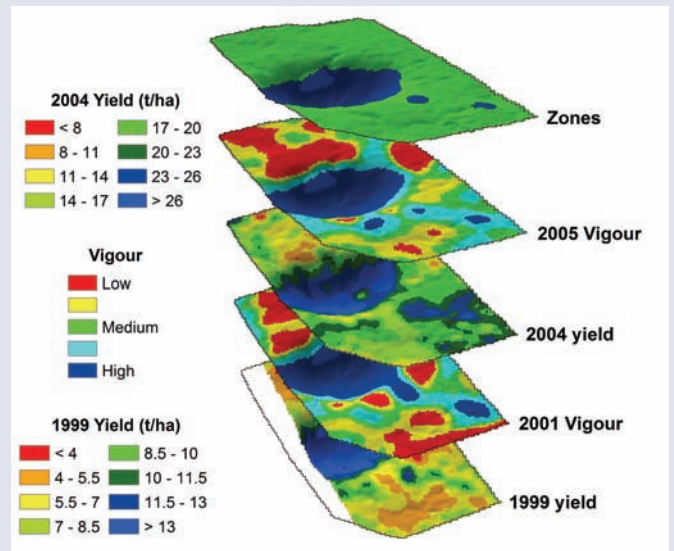


Figure 1. Data collected over a six-year period for a 4.3ha block of Shiraz in Padthaway. The yield maps were derived from yield monitoring, the vigour maps from remotely-sensed imagery acquired at veraison, and the topographic variation identified using a survey-grade global positioning system (RTKGPS). These data layers were 'clustered' to produce the zone map. Here, a two-zone solution is shown, although in a higher yielding year such as 2004, a three-zone solution might be justified. Prior to vintage 2004, vineyard management knew that the two zones were different, but did not know either what the key differences were or how large they were. However, these maps, together with analysis of both fruit and vines sampled from the 'hollow' (high yielding, high vigour zone) and the remainder of the block (lower yielding, lower vigour zone) in both 2004 and 2005 showed them to be substantially different. Indeed, in 2005, fruit from the two zones was assigned to different product streams such that the value of the fruit in the two zones differed by approximately \$1000/tonne. In fact, the fruit from the majority of the block met specification with that in the hollow down-graded due to big berries and reduced colour and flavour induced by higher vigour and the vines not being in balance. However, had the block been harvested as a single parcel, all of the fruit would have gone into a lower value product stream and the value of production would have been lowered considerably as a result. In other words, selective harvesting in this example has had a large positive impact on profitability.

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based on good experience. Inherently, their answers wouldn't take into account the variability within that particular piece of land. Precision agriculture demonstrates that a one-size-fits-all approach is not appropriate. So, the question is: how should we work out what to do where? I think that precision viticulture can help substantially with this question and working out the best way of using it as an experimental tool is the focus of much of our current work in the CRCV.

In the wine industry, selective harvesting is the main thing that has got people interested in precision viticulture at the moment. But it can also be used to enable growers to match the application of inputs and their management practices with soil properties and vine requirements as they vary across blocks. That hasn't caught on in viticulture very much yet but I'm pretty sure it will. I know of a colleague who used PA-based experimentation to shave \$20,000 per year off a cereal farmer's annual fertiliser bill without any loss of production.

Isn't the equipment needed to undertake PV expensive?

Some of the individual items of equipment are expensive, for example, a yield monitor [a system that is attached to a harvester to record yields and is linked to a global positioning system to give a spatially referenced measure of yield in a vineyard block to within a metre] costs about \$10,000. And to acquire a single item of equipment of that nature you could argue that it's expensive. But if you compare it to the \$250,000 or so that people spend on a harvester it's not that expensive. The best way to look at something like a yield monitor is to spread out the cost over five years or more and calculate the cost per tonne of production. On this basis, I think that you can make a pretty good job of precision viticulture for about \$7-8 a tonne. But there's no need for growers to buy yield monitors in any case. They can acquire the use of them through harvesting contractors.

Remotely-sensed imagery [images depicting within-vineyard variability in canopy size and condition, usually based on data collected during a vineyard fly-over by an aeroplane] costs around \$30 per hectare. That's inconsequential in dollar terms when related to the overall costs of production. An EM38 survey [used to map soil variability] costs about \$1 per tonne. That's cheap in my view, but even if you think it's expensive it's only something that you have to use once.

With selective harvesting, we know that returns of the order of \$40,000/ha/year in terms of the retail value of wine production are achievable. I really challenge people who think precision viticulture is all too expensive. Yes, it could be seen as expensive but it delivers big returns as well. As the saying goes, you need to spend money to make money.

In this regard, it is worth giving the lie to the common perception that if you want to get into precision viticulture you have to get all the bells and whistles at once. On the contrary, gradual, incremental adoption is fine. For example, in your first year you could start by acquiring some remotely sensed imagery of your vineyard. You'll then need to ground truth that imagery which may simply mean wandering through the vineyard and having a close look at the vines in perhaps the low, medium and high vigour areas shown in the images. You could then look at purchasing a yield monitor or acquire the use of one through a harvesting contractor. You don't have to ground truth the data collected with a yield monitor. In a following year, you could then carry out a high-resolution soil survey; EM38 is the most commonly-used tool for this. These only need to be done once but it is desirable that they be ground-truthed so that you get an understanding of which soil properties are driving the variation shown in the EM38 map.

I've said all the way along that precision viticulture is really a continuous cyclical process in which initial observations (e.g., remotely sensed imagery) are supplemented by information obtained through soil surveys, topographic mapping or perhaps petiole analysis. Analysis of such data in GIS [Geographic Information Systems] can then lead to the implementation of a management plan. Growers can then go back into the observation phase and work through the process again to find out whether their targeted management strategies are doing any good. This continuous, cyclical process lends itself to incremental adoption of precision viticulture and also to incremental improvement to the management of the production system.

What about the grower who feels that he or she is managing the variability in his or her vineyard satisfactorily?

Every grower knows that their vineyard is variable; they roughly know where the good and bad bits are. But whenever I've given somebody a yield map or a remotely-sensed image of their vineyard, even though he or she might say those images merely confirm what he or she already knew, almost without exception he or she is amazed by the amount of variability—the magnitude of the variation is always a surprise. So I question whether growers are as informed about the variability in their vineyards as they think they are. Having said that, if your winery only carries out large ferments and cannot cope with processing fruit into various parcels then you can understand why a grower might think that he or she is doing OK as far as managing vineyard variability is concerned. Even so, I would question whether growers are doing as well as they can as far as management of inputs such as fertilisers and sprays is concerned. The fact is that until recently growers haven't had the tools available to do things differently. They generally use the same management for the whole block. But, we now know that vineyards are not uniform and that their patterns of variation tend to be stable in time, so why not now start thinking about how to better manage inputs?

Explain the importance of growers forming partnerships with their wineries should they choose to selective harvest.

The partnership of wineries is critical in regard to selective harvesting. If you're harvesting fruit into two or three different parcels then you need to be confident that your winery isn't going to mix them together later. Even if the winery does ultimately mix the wines produced from them together, it is much better off if it knows that the fruit has been harvested in as uniform a parcel as possible at the outset and then introduces some complexity through the blending of different parcels in a controlled and informed way, rather than just taking pot luck—which in essence is what happens at present with uniformly-managed blocks that are harvested into large (100T) ferments.

Is precision viticulture suitable for every grower?

Yes, because every grower's vineyard is variable. But having said that I'm mindful of the necessity and in some cases difficulty of forming partnerships with wineries for the benefits of selective harvesting to be gained. But it's still potentially suitable for every grower. It would be reasonable, in my view, depending on the intended end use for fruit, for a grower to command a price premium if he or she has reduced the variability within a parcel of fruit delivered to the winery through selective harvesting. Furthermore better targeting of inputs should lead to improved profitability. ■

Luke Rolley

Viticulturist, Lake Marmal, Victoria

Lake Marmal Vineyards was named Victorian Wines Show Vineyard of the Year for 2005. The award was partly an acknowledgement of the way in which the 172-hectare vineyard, located between Boort and Charlton in north-west Victoria, has embraced precision viticulture technology.

When did Lake Marmal Vineyards first utilise precision viticulture (PV) technology?

Lake Marmal Vineyards first implemented precision viticulture technology for the 2003 vintage. We purchased a new Pellenc harvester and had yield mapping hardware fitted to the machine. In addition, we purchased a mobile dGPS unit (giving sub-metre accuracy) and field data collection software and hardware.

What were the company's initial reasons for utilising PV technology?

The initial reasons were twofold:

1. Good decisions are made with good information. Managing a large vineyard, we wanted to be able to produce consistent and reliable fruit for our customers. In order to achieve this we needed to be able to easily capture information in the vineyard and use it to make robust decisions relating to our management of the vineyard.
2. To allow better data collection for the Vineyard Benchmarking Project we were involved in. We had to collect vine and berry data from 42 different vineyards and the best way to make it all happen during vintage was to collect the data on a field computer. This also allowed us to spatially see the variability within vineyards.

How did you go about adopting PV?

We talked to others who were involved in PV and went for a relatively complex system that would allow us to collect and analyse the depth of information that we wanted.

We have made plenty of mistakes in the process. The application of the technology is evolving and it's really only through trial and error either in the industry or at a specific location that progress can be made.

In the end we worked with three providers of the technology who provided the support we required to implement our system; then set about measuring things in the vineyard to determine what was influencing fruit quality and quantity.

How easy or otherwise was this information or technology to come by?

Sourcing the hardware, software and expertise to implement it was a little frustrating and expensive. I believe that the process is probably much easier now than when we started in 2003. Once you do a little homework and talk to people involved in the process it is quite easy to work out who to talk to for the best results. There are now some excellent service providers who can look after PV requirements.

What type of precision viticulture technologies has Lake Marmal utilised?

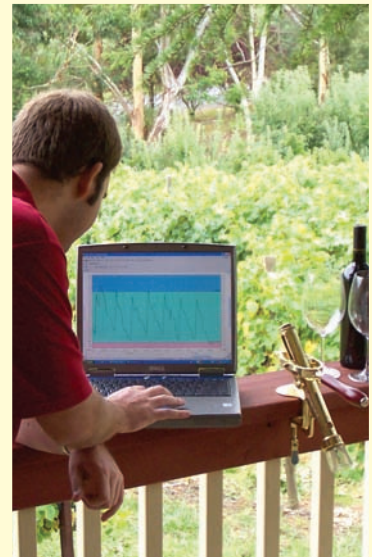
One of the objectives of Lake Marmal's PV system has been to better understand the "cause and affect" relationships of specific management techniques to the quality and quantity of fruit produced. To understand this we have measured or manipulated the following items spatially:

- Grape quality measurements
- Pruning measurement & analysis

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- Differential harvesting of fruit
- Targeted soil amelioration (ripping/hilling).

What are the main benefits that Lake Marmal has experienced through precision viticulture?

We are still refining the measurement and analysis of the PV system and each year we have a greater understanding of how the vineyard performs. At this stage the main benefits have been:

- Improved crop estimation
- Ameliorating under-performing sections of vineyard
- Understanding how management techniques are influencing quality and quantity of fruit.

Would you regard precision viticulture as an expensive undertaking and do the benefits outweigh the costs?

Lake Marmal Vineyards has been researching different aspects of PV. Of course some are more beneficial and related to dollar outcomes than others. There is certainly a cost associated with the adoption of PV. Some aspects of Lake Marmal Vineyards' PV program have easily recaptured the costs incurred. Others are less definable, for example, it's hard to gauge the dollar benefit of increased accuracy in crop estimation.

There are certainly opportunities to be exploited where PV will show a good economic return. There will also be situations where PV will yield little or no economic benefit.

What do you say to growers who believe their current means of managing variability issues are satisfactory or that their yield and quality targets are being met without the use of precision viticulture?

There are likely to be some situations where PV will have little influence on existing practices. However, there are many opportunities to be better than satisfactory. Are you content with satisfactory? If there was an opportunity to get an extra two tonnes per hectare at the same quality or \$500 per tonne because your fruit was more consistent you'd have to have a good look at it wouldn't you? (Maybe that's just the capitalist in me coming out!)

What changes in management practices have resulted at Lake Marmal Vineyards following the adoption of precision viticulture?

- Soil management – targeted ripping and hilling.
- Altered irrigation applications.
- Evaluation and adoption of different pruning strategies.
- Windbreaks to divert cold, frosty air.
- A greater understanding (with data!) of yield vs quality relationships.

Do you have any other advice for growers who see little advantage in managing their vineyards at a more detailed level than they are presently or who are contemplating the utilisation of precision viticulture?

It will be really interesting to see what happens in the next three to five years with PV. Obviously the technology is new and really needs to be validated in specific viticultural situations. After saying that, there are already opportunities to use this technology and make a dollar. However, a considered approach is necessary. Good decisions can only be made with good information. ■

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