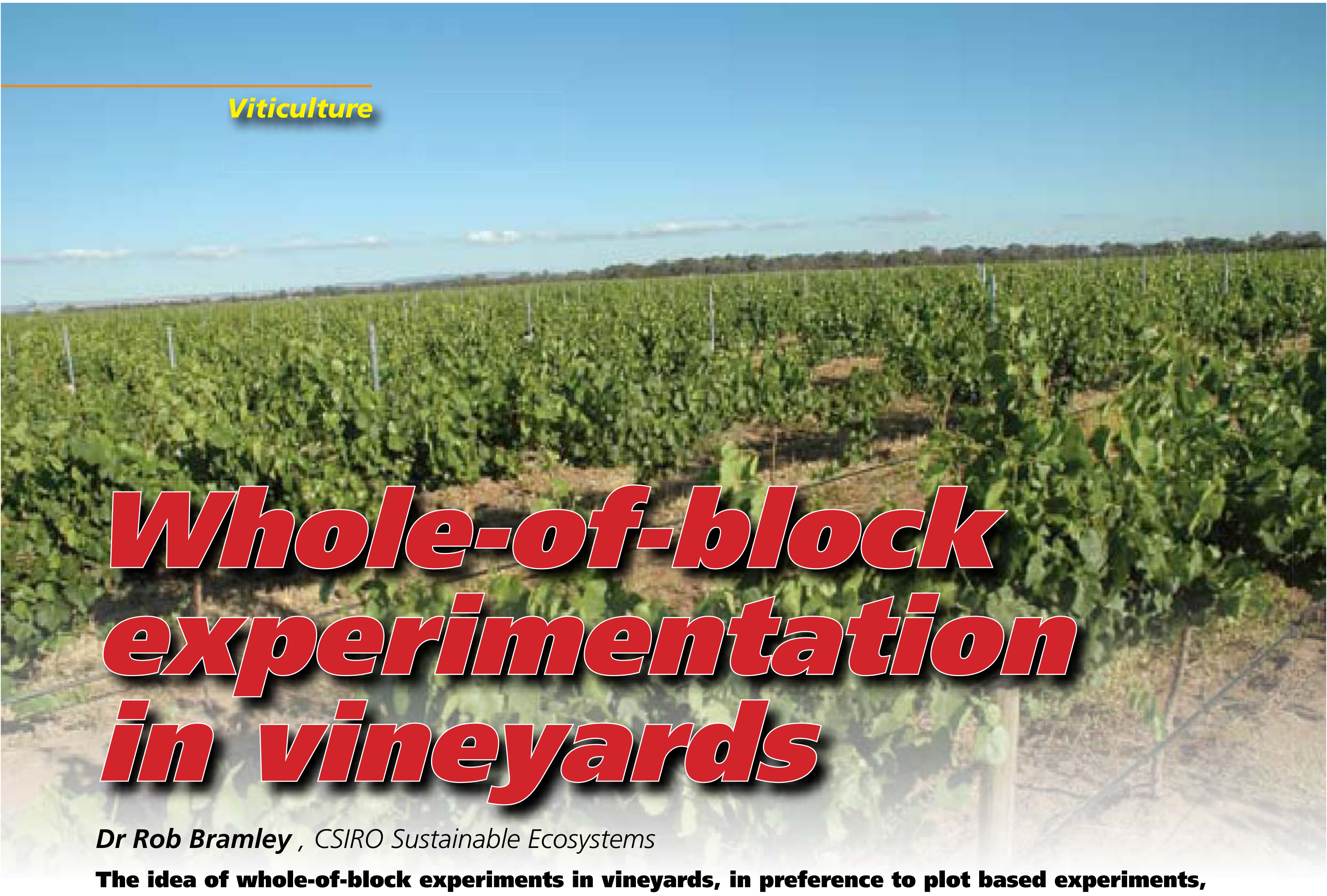

Whole-of-block experimentation in vineyards

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The idea of whole-of-block experiments in vineyards, in preference to plot based experiments, was outlined in an article in Precision Ag News Volume 3 Issue 1. Here, an update on the value of this technique is presented, using the example of spatially variable responses to treatments in an organic vineyard

PA tools, such as yield and EM38 maps, not only help detect and manage in-field variability but provide farmers and researchers with the opportunity to design trials and measure responses to different strategies across whole management units, rather than confining their work to small plots. The whole-of-block design enables treatments to be assessed over the whole range of spatial differences found in a vineyard or paddock.

An experiment was carried out in an organically managed vineyard (4.8 hectares) planted to Merlot in the Clare Valley, South Australia. The work was funded by CSIRO Sustainable Ecosystems, Foster's Wine Estates and the Commonwealth Cooperative Research Centres Program under the auspices of the Cooperative Research Centre for Viticulture

Materials and methods

This experiment was established in response to concerns that the organic system may be placing a constraint on vine nutrition resulting in low yield and vine vigour. The vineyard manager was also concerned that the permanent ryegrass cover crop in the mid rows of the vineyard was competing with the vines for water and nutrients.

This experiment evaluated the merits of three mid-row management strategies aimed at enhancing vine vigour and yield through promotion of nutrient cycling. These three strategies were:

1. Ryegrass combined with under vine compost (RGC; control);
2. Ryegrass combined with under vine mulch (RGM);
3. A cereal cover crop sown in alternating rows with a legume in the intervening rows (CL).

The treatments were implemented in winter 2004 with one buffer row between treatments, (Figure 1a).

The use of the k-means cluster technique on bulk soil conductivity (EM38) data and the pre-experiment yield map from 2004, resulted in the delineation of two potential vine performance classes (Figure 1b).

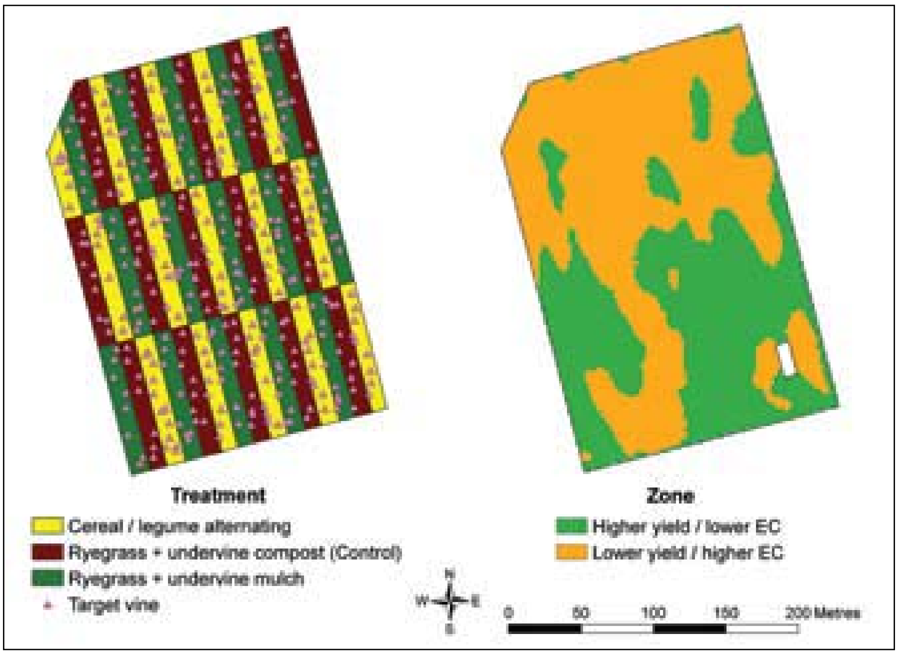
Airborne remote sensing data obtained at 50cm resolution from a commercial provider was used to calculate plant cell density (PCD = Infrared/Red) for the vineyard at veraison, the stage of maturity when grapes soften, colour and ripen, in 2004 (before the experiment was established) and in 2006. PCD data is commonly available from providers of remotely sensed data in Australia and allows the evaluation of spatial variation in vine vigour.

Responses to the experimental treatments at vintage 2006 were assessed through a combination of data collected at high spatial resolution (airborne remote sensing, yield mapping) and through a program of intensive hand sampling of target vines (126/treatment). The latter permits the evaluation of vine vigour parameters such as bunch numbers, bunch weight, berry weight and berries per bunch, for which sensors are not currently available.

Comparing the average treatment responses (Table 1) revealed that the alternate rows of cereal and legume cover crop (CL) treatment had the strongest effect in terms of increasing bunch number, bunch weight and the number of berries per bunch. These three variables also showed significant differences between the treatments. However, by analysing treatment effects according to potential performance class, more information was gained.

For example, bunch numbers in the CL treatment were generally higher than in the RGC and RGM treatments, and this increase was much bigger in the lower yielding areas than in the higher yielding parts of the block. These results can be taken as a first indicator that the treatment effects indeed vary spatially.

Figure 1. The Clare experiment showing (a) the experimental layout, and (b) an indication of the inherent variability in the block derived from k-means clustering of a pre-experiment yield map and EM38 soil survey.



If these experimental results are to be used for decision making, knowledge of the location of beneficial treatments is required. One way to evaluate this is the use of the PCD data. Comparison of normalized PCD maps from veraison 2004 and 2006 shows that the spatial structure of the PCD values changed, following imposition of the experimental treatments. The difference map reveals that the most positive vigour effects can be found in the CL treatment areas and that the control treatment (RGC) seems to perform poorest (Figure 2).

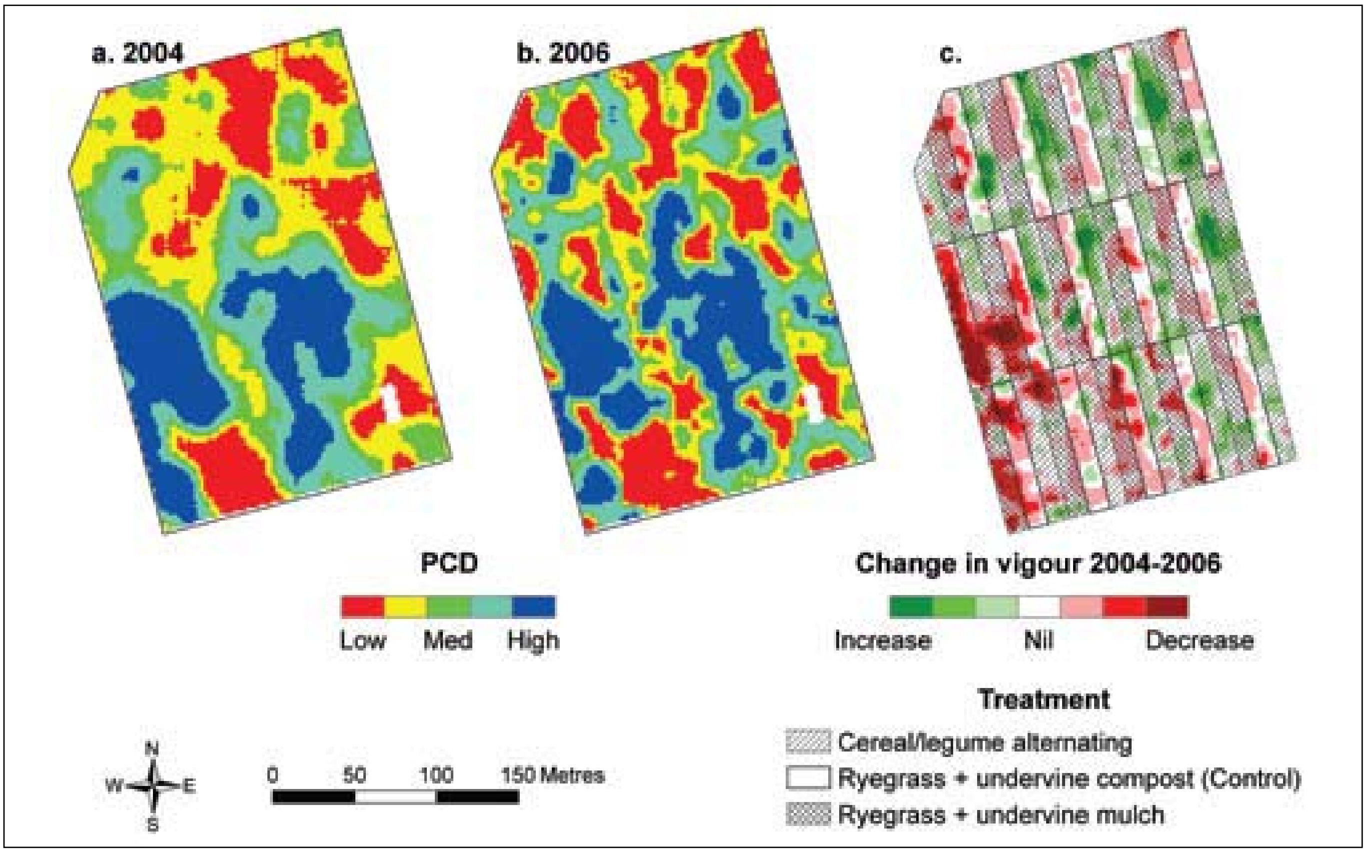
Table 1. Treatment averages and statistical results of vine performance parameters recorded during vintage 2006 on 378 target vines.

	Treatment			
Variable	**RGC**	**RGM**	**CL**	**ANOVA - *p***
Bunch numbers	45	43	56	****< 0.0001*
Bunch weight [g-1]	57	63	68	*** 0.0024*
Berry weight [g-1]	0.77	0.82	0.81	*n.s. 0.0819*
Berries/Bunch	71	76	84	****< 0.0001*
n	*126*	*126*	*126*	

	Treatment & potential vine performance class						
Variable	**RGC HY**	**RGC LY**	**RGM HY**	**RGM LY**	**CL HY**	**CL LY**	**ANOVA - *p***
Bunch numbers	53	35	49	37	59	54	****< 0.0001*
Bunch weight [g-1]	76	35	77	48	87	60	****< 0.0001*
Berry weight [g-1]	0.87	0.66	0.92	0.71	0.92	0.77	****< 0.0001*
Berries/Bunch	86	53	84	68	96	79	****< 0.0001*
n	*67*	*59*	*65*	*61*	*38*	*88*	

RGC = Ryegrass and compost under the vine; RGM = Ryegrass and mulch under the vine; CL = Row alternating cereal and legume; HY = Higher yield and lower EC; LY = Lower yield and higher EC

Figure 2. Maps of normalised PCD obtained at veraison in (a) 2004, (b) 2006 and (c) the difference between these. However, normalisation of the data to take out the effects of seasonal climatic and atmospheric differences enables the comparison shown in (c) which indicates that not only has there been a change in vine vigour, but that this is aligned to the experimental treatments imposed.

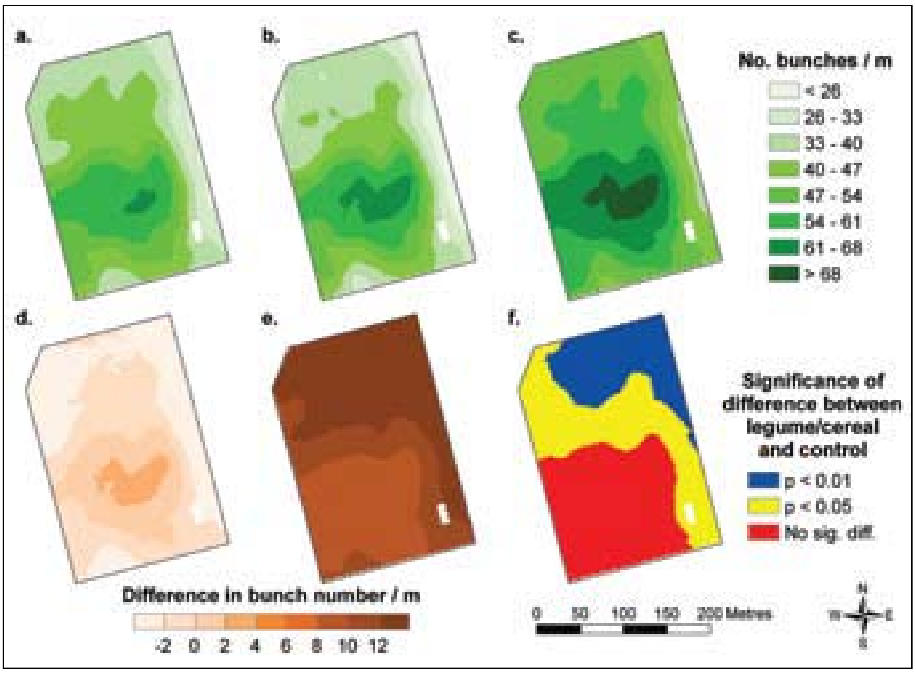


However, normalisation of the data, to take out the effects of seasonal climatic and atmospheric differences, enables the comparison shown in (Figure 2c). This indicates that there was a change in vine vigour, and that this is aligned to the experimental treatments imposed in 2006.

A direct evaluation of statistical significances between treatments is not possible on these data sets, although random extraction of data points would permit ANOVA statistics to establish statistical treatment differences. Unlike researchers, most vineyard managers will not base their decisions on a significance test but will be more interested in the absolute magnitude of the difference. Nevertheless, it would help to have the ability to delineate areas of the vineyard where significant treatment benefits can be expected.

The spatial variation in the treatment effects was examined using a method developed by Bishop and Lark (2006). Using bunch number as an example, this method was used

Figure 3. Bunch number per metre 2006 for (a) the ryegrass and compost, (b) ryegrass and mulch and (c) cereal and legume treatments, as well as difference maps for (d) the ryegrass and mulch treatment minus control and (e) cereal and legume treatment minus control. Map (f) shows the significance of the difference shown in (e) as determined by per pixel tests of significance.



to determine if and where the two treatments had significant beneficial effects in comparison to the control. Figures 3a, 3b and 3c display the three maps for each treatment if each had been applied over the whole area. It is obvious that the CL treatment (Figure 3c) outperforms the other two treatments. The difference maps gained by subtracting the control treatment (RGC) from the RGM treatment (Figure 3d) and the CL treatment (Figure 3e) exhibit the absolute difference between the treatments. The z-statistic reveals where in the vineyard significant differences are obtained (Figures 3d and e).

No significant differences can be detected between the RGC and RGM treatment (Figure 3d). Most of the significant differences between the RGC and CL treatment were achieved in the potentially poorer performing areas of the vineyard (Figure 3e). With this information, along with consideration of economic factors and other yield influencing attributes, the vineyard manager would be able to decide if and where to target mid row management for a specific outcome in this vineyard. Furthermore, correlation of treatment response with an indicator variable (eg EC) promotes a much greater opportunity to extrapolate these results to other vineyards than would be possible in the case of a small plot experiment in which the chances of finding such a correlation are smaller.

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A copy of the full paper including details of statistical methods was presented at the 6th European Conference on Precision Agriculture held in Skiathos, Greece in June 2007.

Conclusions

This case study demonstrated the potential of whole-of-block experiments to measure spatially variable responses to experimental treatments in vineyards. The technique could equally be applied in other production systems such as grain growing. It can be concluded that on-farm trials established as whole-of-block experiments provide valuable spatial information about treatment responses and will therefore aid farmers in improved decision making. With more high spatial resolution sensors available, the data recording will become easier and more economically viable which will improve the practicality for farmers to set up their own whole-of-block experiments.