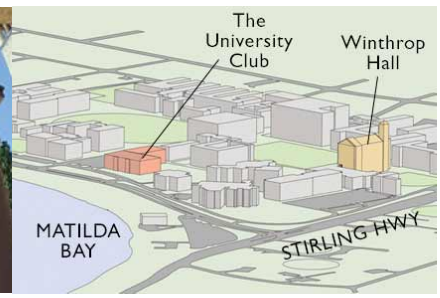
9th Annual Symposium on Precision Agriculture Research & Application in Australasia

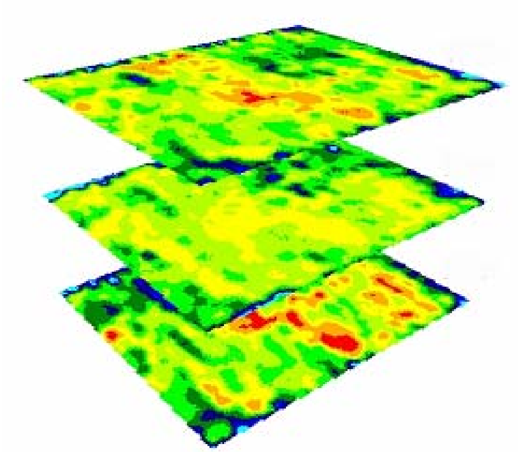
The University Club of WA

The University of Western Australia

Thursday 11th August 2005







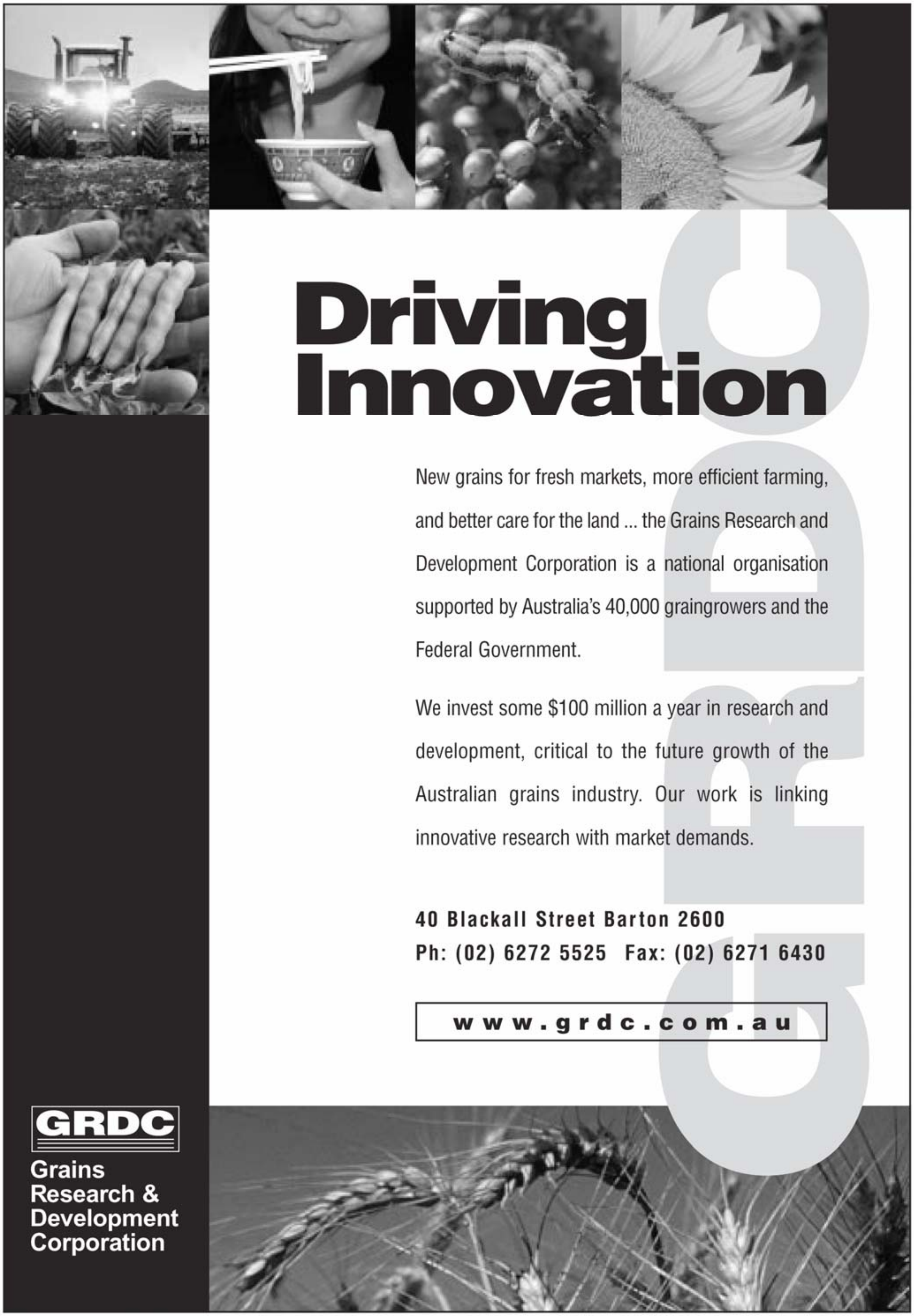
Program & Abstracts

Australian Centre for Precision Agriculture

SPAA Southern Precision Agriculture Association

wantfa NEW FRONTIERS IN AGRICULTURE

GRDC Grains Research & Development Corporation


Driving Innovation
New grains for fresh markets, more efficient farming, and better care for the land ... the Grains Research and Development Corporation is a national organisation supported by Australia's 40,000 graingrowers and the Federal Government.
We invest some $100 million a year in research and development, critical to the future growth of the Australian grains industry. Our work is linking innovative research with market demands.
40 Blackall Street Barton 2600
Ph: (02) 6272 5525 Fax: (02) 6271 6430
www.grdc.com.au
GRDC
Grains Research & Development Corporation

Welcome

Our ninth year sees the PA Symposium held for the first time in Western Australia. This is somewhat belated perhaps, because the manufacturers, growers and researchers in WA were among the first in Australia to explore and develop PA philosophies and technologies. This exploratory endeavour remains today, with many leading growers and technology/machinery manufacturers continuing at the vanguard of PA in Australasia.

Locating the PA Symposium in different regions of Australia hopefully serves a number of purposes.

- *Encompassing National Diversity:* Australian crop production covers more than 21,000,000 hectares annually and encompasses over 47 different production regions.
- *Exploring Local PA Issues:* Certain practical implementations of the PA philosophy have gained or are gaining widespread acceptance, but local needs and developments will change around the country
- *Building on Previous Experience*: The large distances in Australia often make wholly inclusive meetings difficult. Exchanging PA experiences and insights through the Symposium provides some ‘integration’ of such information into the PA community.

By including these priorities along with scientific and technological innovations within the scope of Symposium, we are aiming to identify the environmental and commercial variation to which the various cropping industries are exposed. It is this variability that has contributed to a restrained progress in the development of practical, holistic crop management systems that incorporate the PA philosophy. We believe this wise restraint will lead to sustained, useful change.

However, as always, the general goal of this annual meeting is to help link together individuals, groups and companies in the PA community. Today’s range of presentations and participants should ensure this goal is further realised.

Together with the Southern Precision Agriculture Association (SPAA) and with the kind sponsorship of the Grains Research and Development Corporation (GRDC) and the support of WANTFA, we at the Australian Centre for Precision Agriculture (ACPA) thank you for your participation and hope you enjoy and benefit from the day.

ACPA Staff & Students

PRESENTATION PROGRAM

Soil properties mapped from gamma-ray spectrometry

Gabriella Pracilio *(Soil Science, School of Earth and Geographical Sciences, UWA)*,
Matthew L. Adams. *(Department of Land Information)*, **Keith R.J. Smettem** (*University of WA)*,
Roger J. Harper *(Forest Products Commision)*

gabbyp@cyllene.uwa.edu.au

Variation in dryland crop yield is often related to underlying soil properties such as water availability and soil fertility. In Australia, there are significant difficulties in adequately defining the distribution of such properties at the farm scale, since existing soil survey data are mostly only available at regional scales (1:100, 000) or coarser. Gamma ray spectrometry (radiometrics) can potentially improve the understanding of spatial distribution of soil mapping, soil texture and one component of soil fertility, plant available potassium (bic-K). An overview of the technology has shown that soil properties and type can be indirectly mapped through correlation. Results from a recent study in the northern agricultural wheat belt of Western Australia evaluated three sites based on linear correlation analysis.

At two sites, characterised by either granitic or sedimentary geology, linear correlation results between radiometrics and soil properties were weak and not statistically significant. This was due to the low range of values of soil texture across the sites and/or freshly weathered granite dominating the radiometric data. In contrast, at a site with sand to sandy loams and parent material of weathered sediment and soils, multivariate linear regression analysis using radiometric data was associated with greater than 70% of the variance in bic-K and soil texture. Soil properties were mapped at this site using multivariate linear regression and tree-based models with radiometric, topographic and location data as the inputs.

The models were dominated by the radiometric data. The generated maps were field checked with the results indicating that up to 66% and 60% of the variation in the field surface soil texture and bic-K, respectively could be predicted. The overall lowest map errors in root mean square error (RMSE) were 2.4 % for clay concentration and 103 mg K/kg for bic-K concentration. This study concludes that radiometric data for a site with weathered soils of sufficient soil texture range can reliably predict clay concentration and plant available potassium, at a precision that is useful for understanding potential yield variation across a farm.

Spectral and thermal imagery to determine stress in cereals

Glenn Fitzgerald *(USDA-ARS)*, **Garry O'Leary** *(DPI VIC)*, **Bob Belford** *(DPI VIC)*, **Daniel Rodriguez** *(DPI QLD)*, **Lene Christensen** *(NGB, Sweden)*

gfitzgerald@uswlc.ars.ag.gov

This paper describes work in Victoria to improve the efficiency of use of nitrogen fertiliser to optimise wheat yield and achieve grain quality targets to generate better economic returns to the Australian grains industry

Emerging variable-rate and site specific technologies create the need for rapid and inexpensive methods to identify spatial and temporal variability in crop nitrogen (N) stress, and to assess potential corrective measures. Precision mapping technologies offer huge potential to improve the temporal and spatial management of inputs, particularly when linked in real time to data on paddock management zones, available soil water, and seasonal rainfall prediction.

We are using hyperspectral data to determine crop nitrogen status, and thermal imagery to differentiate between nutritional and water stresses. In dryland cropping environments in Australia, nutrient application to nitrogen deficient crops is likely to be uneconomic if the crop is also under water stress and there is a low probability of adequate rainfall to stimulate growth and nutrient uptake, particularly after stem elongation commences.

Experience to date shows that hyperspectral data can assess nitrogen status over a range of growth stages (emergence to flag leaf emergence), and has the potential to discriminate between irrigated and rainfed wheat canopies. Thermal imagery also allows the degree of moisture stress to be clearly identified, and has lead to the development of a spatial 'Crop Stress Index'.

Research in 2004/5 concentrated on ground based measurement with hyperspectral and thermal equipment; in 2005/6 we are exploring aerial data acquisition using multispectral and thermal imagery to develop paddock-scale information which is likely to be of greater value for management purposes. Information from both approaches will be presented.

New developments in on-ground sensors for precision agriculture

David W. Lamb
(Precision Viticulture Research group, University of New England)

dlamb@une.edu.au

This presentation outlines progress in research conducted to evaluate

- the impact of vineyard trellising on the measurements of apparent conductivity performed by an electromagnetic (EM-38) soil conductivity meter,
- the development and application of two on-ground sensors of vine canopy biomass for measurements of canopy variability in vineyards.

EM-38 and vine trellising

Electromagnetic soil survey techniques, specifically those employing instruments like the EM-38, are becoming more widely used by vineyard managers for delineating spatial variations in soil type and/or texture in established vineyards. These techniques measure apparent electrical conductivity (EC_a) and work on the principle of electromagnetic induction whereby an electric current is induced below the ground surface by a low-frequency oscillating magnetic field and the return magnetic signal produced by the underground current is detected. An experiment was conducted to investigate the impact of above-ground vine trellising (vertical shoot positioned-VSP configuration), with row spacings of 2.5 m, 3.0 m and

3.5 m on apparent conductivity measured using an EM-38 electrical conductivity meter. Both one (single, across-row transect) and two-dimensional (GPS and multiple transect) EC_a profiles of a single test site were generated under the conditions of (i) absence of any trellising (that is bare field), (ii) wooden end posts and steel mid-row posts only, (iii) wooden/steel posts plus dripper guide-wire, and (iv) wooden/steel posts plus dripper guide-wire plus a combination of cordon, gripper and foliage wires. All treatments were applied within the duration of a single day. The EC_a profile of the bare site was found to be modified by all subsequent treatments, with the least modification from posts only, and the degree of modification progressively increasing with the addition of wires to the maximum number used. The EC_a values were found to increase from a range of 20-50 mS/m for the bare field to a range of 100-130 mS/m for the assembled trellising, with the amount of increase greatest for the smaller row spacing. The EC_a values measured in the across-row transects were elevated everywhere in the inter-row space with considerably higher values closer to the steel posts/wires.

As the 2-D profiles were created from EC_a values derived from mid-row measurements, the influence of trellising appeared as a baseline elevation for the 3.0 and 3.5 m row spacings. However, for the smaller row spacing the trellising was found to introduce an along-row modulation in EC_a values with local maxima occurring at the centre of the gaps between steel trellis posts. Overall, the results suggest that EM-38 surveys are still likely to be useful for delineating soil zones in established vineyards with trellising comprising steel posts, except for those with row spacings less than 3.0 m, but indicate that extreme care must be exercised by an operator to ensure that the EM-38 antenna/sensor unit remains mid-row throughout transects and also that changes in trellising structure/row spacing will introduce artefacts in EM-38 maps.

On-ground canopy sensors

Airborne or satellite imaging, is becoming more widely used in the grape and wine industry for identifying and mapping areas of different vine productivity within vineyards. The use of imagery relies on the implicit understanding that different levels of canopy vigour are observable from overhead. In simple vine trellising configurations like single wire, vines often express their vigour by growing out into the inter-row space. The relative mix of inter-row space and vine as viewed overhead therefore changes with different levels of vine vigour. Where the background of inter-row space or cover-crop is relatively uniform, such vigour variations can be delineated in imagery of spatial resolutions ranging from 20 cm (thereby containing many vine and many non-vine pixels) up to a pixel size that is comparable to the inter-row space (around 3 m, where all image pixels are a mix of vine and non-vine information). However, where the background is variable, additional, often time-consuming image processing is required in order to separate out vine from non-vine pixels for subsequent analysis.

With more vineyards adopting rigorous canopy training regimes, for example VSP, less of the vine is presenting itself to an overhead sensor, and in fact where foliage wires are regularly repositioned to keep the canopy ‘high’, the only way a vine can express its vigour is in its vertical rather than horizontal extent. This poses a significant challenge to airborne, or space-borne remote sensing as only little of the vine is observable overhead, the only parameter that is likely to significantly change, from an overhead perspective is leaf area index (effectively the number of layers of leaves per unit area in the canopy), and most wavebands of interest involve radiation that has penetrated, at most, only 5 leaf-layers within the canopy.

Motivated by this increasingly challenging problem, we have been prompted to extend our ongoing remote sensing-based research activities to include investigating on-ground, side-looking sensors for quantifying the architecture of vine canopies. One sensor, *Grapesense* (a unit developed by staff of Lincoln Ventures Ltd, Hamilton New Zealand) contrasts vine canopy against a uniform background and on-board software immediately analyses each image by counting the relative numbers of vine pixels (ie non-background pixels) and the number of background pixels. The computer records a number, porosity, associated with each image that can subsequently be calibrated to a measure of local vine area. When operated in conjunction with a differential global positioning system (DGPS) and data-logger, a map of relative vine size can be produced. A second unit, *Cropcircle* is an on-the-go sensor of NDVI (normalised difference vegetation index). In our particular configuration, we believe it may be useful to provide a measure of leaf area index and therefore canopy density (side-looking). It comprises two ultra-bright light-emitting diodes (LED's) of near infrared and red wavelength's respectively, and a pair of photodetectors. The unit is pointed at vines, the LED's are pulsed at a certain frequency and the photodetectors, via synchronous detection, measures the reflected signal (from the vine canopy) of both LED's. An on-board data-logger records both red and near infrared (nir) reflectance, and instantaneously calculates the NDVI value, using $NDVI = \left(\frac{nir - red}{nir + red} \right)$. As the unit is an active sensor (ie with its own light source), and uses synchronous detection, it is capable of operation irrespective of variations in daylight conditions and can be operated throughout the night. When operated in conjunction with a DGPS, a map of NDVI is generated (Figure 7). The nature of the measurements allows independent measures of LAI/density on both sides of the canopy, a distinction which has been largely ignored to date.

Farmscan One System and other developments.

Ole Hansen
CEO Computronics Corporation Ltd, 6 Sarich Way Bentley WA 6983

oleh@farmscan.com

Farmscan is the marketing name Computronics Corporation Ltd use for its Agritrionics Division. Computronics is a publicly listed company (CPS.AX) employing more than 80 people with 15 people dedicated to product development. Now almost 30 years in business, Computronics runs a solid research and development program to develop and commercialise new products. This research is both application and raw research driven and includes collaboration with institutions.

The latest release to the market is the Farmscan One System that enables farmers to mix and match components and to have a full upgrade path. Other products in late development stages or being commercialised are a variable-rate irrigation system, a continuous soil sampling system, a grape quality sensor and full ISO implementation.

Causes of spatial and temporal variability of wheat yields, deep drainage and nitrate leaching at sub paddock scale

Mike T. F. Wong, Senthold Asseng, Yvette Oliver
(CSIRO, Underwood Avenue, Floreat, WA)

mike.wong@csiro.au

Field measurements and crop simulation using the APSIM crop model showed that wheat yields strongly depended on plant available soil water storage capacities (PAWc). PAWc is the capacity of the soil to store water for crop use. It varies across the paddock due to differences in soil texture and rooting depth giving rise to yield variability. This variability decreases in dry years when the benefits of larger PAWc are not fully utilised. A uniform yield is simulated across the paddock in very dry years when the amount of water stored for crop use is limited by rainfall and not by PAWc. Sites with low PAWc cannot capture the advantages of good rainfall years and therefore have low temporal variability: these sites such as pale sands typically perform consistently poorly. Interaction of rainfall with PAWc therefore determines yield variability. Yield variability can be suppressed by nutrient deficiency because additional water offered by higher PAWc sites are not fully utilised.

Drainage below the root zone and leaching occur when PAWc is exceeded. Sites with lower PAWc drain more water and depending on the nitrogen (N) fertiliser use, leach more N. APSIM simulates linear relationships between PAWc and N leaching for a range of seasonal and N management scenarios.

The key to mapping yield, deep drainage and nitrate leaching using APSIM is a PAWc map. Under specific conditions, soil texture and hence PAWc can be assessed by EM38 or gamma radiometric surveys. This was possible on one paddock where the soil was deep, non-saline and generally free from superficial rocks and gravels. On this paddock PAWc was linearly related to EM38 measurements taken on wet soils in winter and to gamma emission measured on dry soils in summer. These relationships are not generally valid since some of our trial paddocks contained saline creeks that gave high EM38 values out of proportion to clay content and contained superficial rocks and gravels that emitted gamma rays out of proportion to clay content and PAWc. We developed rules to use digital terrain model, EM38 and gamma emission values simultaneously to estimate PAWc in these paddocks.

Using airborne remote sensing to improve vineyard management

Tony Proffitt *(AHA Viticulture, Dunsborough, WA 6281)*
Andrew Malcolm *(SpecTerra Services, Perth, WA 6007)*

tony@haak.com.au

The use of precision agriculture technologies within the grape and wine industry is commonly referred to as Precision Viticulture (PV). Following the introduction of PV tools such as global positioning systems (GPS), grape yield monitors, airborne remote sensing, and soil sensing instrumentation to the industry in the late 1990’s and associated research during the intervening years, grapegrowers and winemakers are now recognising the magnitude of within-vineyard variation and the causes of that variation.

Vineyard variability results in inefficiencies in the management of inputs to the production system (eg. water, fertiliser, labour and machinery), and uncertainties in both the forecasting of the potential crop yield and the delivery of fruit parcels of uniform quality. One approach for managing variable yield and quality is to use PV tools to identify different zones of characteristic performance within individual vineyard blocks and to manage them accordingly (*zonal management*). This paper describes some recent experiences in the commercial application of this approach to improve vineyard management by using airborne remote sensing. Some of these experiences have realised financial benefits.

Experience has shown that veraison is an appropriate time for image acquisition. SpecTerra Services based in Perth are a commercial provider of airborne Digital Multi-Spectral Imagery (DMSI). 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 commonly used to identify and map zones of different vine productivity in vineyards.

Applying inputs differentially

The inefficient use of inputs in a vineyard may compromise the productivity and subsequent profitability of that vineyard, as well as increasing the risk of causing undesirable environmental impacts both on and off site. Obtaining information on vine parameters across a whole vineyard in order to understand where and how much of a certain input to apply has traditionally been difficult and expensive. Airborne remote sensing provides a means by which information on vine characteristics can now be easily collected. In this case study, DMSI data was processed to generate images of various vigour related vine descriptors derived from correlations that have been found to exist between PCD and on-the-ground measured vine attributes. The establishment of such relationships now makes it possible to quantify changes in vine performance over time and to subsequently assess the benefits or otherwise of zonal management.

Irrigation water

Correlations between PCD and canopy surface area, trunk circumference and pruning weights (indices of vine vigour) were established during the 2003 and 2004 growing seasons across a 9 ha block of Cabernet Sauvignon at a vineyard located in the Margaret River region. The linear regressions for each index of vigour were similar for the two years suggesting that these correlations may be stable over time. Using the imagery and visual assessments during 2003, vines within certain zones of the block were identified as being either excessively vigorous or too weak. During the 2004 growing season, the amount of irrigation water applied was reduced in a 6 ha vigorous zone and increased in a 3 ha weaker zone in order to better manipulate vegetative growth. A comparison of the images derived for the two years shows that the application of less water generally reduced vegetative growth whilst the application of more water generally increased vegetative growth, thereby making the whole block more uniform. Costs associated with canopy and fruit manipulation in the 6 ha vigorous zone were reduced in 2004 compared with 2003 (ie. less machine leaf plucking at $250/ha, machine shoot trimming at $140/ha and hand crop thinning at $300/ha). In addition, the smaller canopy in the vigorous zone improved aeration and spray penetration which reduced the risk of botrytis which had been a significant problem in previous years, and the improved fruit exposure to sunlight hastened the rate of ripening so that fruit quality across the whole vineyard block was more uniform.

Pruning

For the same vineyard, the 2003 PCD imagery was used to identify zones of high, medium and low vine vigour in a 8.3 ha block of Shiraz in an attempt to reduce pruning costs and to ensure that all staff pruned an equal number of vines of varying vigour and hence degree of difficulty. Piece rates per vine were determined for each zone according to the amount of time allocated to work on the vines within that zone. As an example of the outcome of this approach, it is estimated that a saving of approximately $2,400 was made. All the pruning staff made similar amounts of money and endorsed the approach.

Estimating crop yield using a zonal sampling approach

The uncertainty in predicting crop yield costs the industry millions of dollars each year due to discrepancies between the forecast and actual tonnages of fruit delivered to wineries which often have limited crushing and storage capabilities. Surveys have shown that nationally, yield predictions differ from actual yields by ±33%.

Crop estimation techniques are currently based on a statistical approach whereby samples are taken at random from within whole vineyard blocks regardless of the spatial variation in vine performance. In this case study, the sampling of a 2.5 ha block of Cabernet Sauvignon at a vineyard in McLaren Vale 2 weeks before the expected harvest date was conducted using both the conventional statistical approach and a zonal approach whereby zones of characteristic performance were identified from PCD images. The crop yield within each zone was estimated by determining the average yield/vine (average number of bunches/vine multiplied by the average bunch weight/vine) and the number of vines/zone. The total crop yield for the block was then estimated by summing the yield estimates derived for each zone. Using the conventional statistical approach the total block yield was estimated to be 26.26t compared to 23.58t using the zonal approach. The actual tonnage delivered to the winery was 21.3t. This represents an overestimate of 4.96 t (23.3% difference) using the statistical approach and an overestimate of 2.28t (10.7% difference) using the zonal approach. More examples of this approach to crop forecasting are required before judgements to its improved accuracy can be made.

Selective harvesting

Variation in fruit quality delivered to the winery can result in ‘average’ quality from whole vineyards. This limits the options available to winemakers for maximising the production of high quality wines and producing wines that fit market demand. The selective harvesting of vineyard blocks using a combination of PCD images and harvester generated yield maps has been demonstrated to improve the uniformity of fruit parcels delivered to the winery. A number of commercial examples of selective harvesting have been reported in the literature and conference proceedings (eg. Bramley *et al*. 2005; Proffitt and Pearse 2004). In order to reiterate the potential benefits of this approach to harvesting, a case study from a vineyard in Margaret River is briefly described.

In 2002, airborne DMSI data was acquired for a 3.3 ha section of a Cabernet Sauvignon block and then processed in order to produce images of PCD. Two weeks prior to the expected harvest date, vines in areas of low and high PCD were assessed on the ground for vine vigour, and fruit samples assessed for sugar, pH, titratable acidity and sensory characteristics. The results obtained confirmed that differences in PCD translated into real differences on the ground. The section of vines was subsequently divided into a northern zone with high vine vigour (ie. high PCD) and a southern zone with low vine vigour (ie. low PCD), and selectively harvested by keeping fruit from the two zones separate. This strategy has been repeated for 3 consecutive vintages. In some years, harvesting the two zones has not occurred on the same day, but parcels of fruit from the two zones have always been processed separately in the winery. For both the 2002 and 2003 vintages, differences in quality between the wines made from the two zones have been significant enough to justify allocation to different end products. If the section had been harvested as a single unit, the resulting wines would have been allocated to the lower end-use product. This strategy has improved profitability quite significantly.

References

Bramley, R.G.V, Proffitt, A.P.B, Hinze, C.J. Pearse, B. and Hamilton, R.P. (2005). Generating benefits from Precision Viticulture through selective harvesting. *In*: Stafford, J.V. (Ed). Proceedings of 5th European Conf. Prec. Agric., Wageningen Academic Publishers, The Netherlands. Pp 891-898.

Proffitt, A.P.B. and Pearse. B. (2004). Adding value to the wine business precisely: using precision viticulture technology in Margaret River. Aust. NZ Grapegrower Winemaker. 491: 40-44.

Protein and yield monitors: combined benefits

Brett Whelan, James Taylor
Australian Centre for Precision Agriculture, University of Sydney

b.whelan@acss.usyd.edu.au

In Australia, grain protein and moisture content are important considerations in final grain sale price, particularly wheat and barley varieties. For wheat, a bonus/discount payment is made on a 0.1% sliding scale above/below the base rate in each receival grade. For malting barley, there is a restricted window of recieval standards to make Malting 1 grade (9-12% protein;;>70% retention) and all grades must be below 12.5% moisture. Malting 3 grade accepts grain with protein up to 12.8% and retention rates down to 58% but applies a sliding penalty scale based on 0.1% protein increments and 1% retention rate decrements.

Both these payment systems mean that measuring the spatial variation in these quality parameters could be financially important. At present a real-time screenings/retention monitor is not available, but at least two 'brands' of real-time protein/moisture monitor are available and all recent harvesters can be fitted with a yield monitoring system

The measurements made in a paddock from grain yield, moisture and protein monitoring systems can be combined to:

- Create true site-specific gross margin maps by incorporating spatial premium/discount data (see Figure 1) with spatial crop yield and paddock variable costs.

- Identify nitrogen export/use/efficiency patterns
- Identify areas where nitrogen supply was limiting
- Better direct soil nutrient sampling programs
- Improve the construction of next seasons fertilizer requirement maps to optimize yield and protein.
- In certain conditions, facilitate the differential harvest or post harvest grading of grain to achieve specific receival standards or maximise paddock revenue.

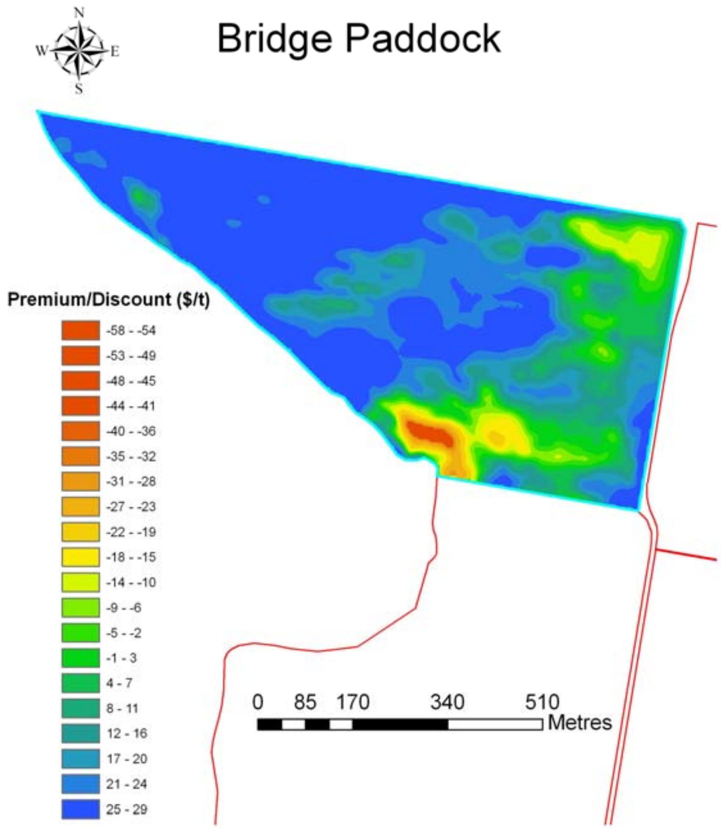


Figure 1. Premium/Discount map for APH wheat (5% screenings) using yield, protein and moisture

Pastures from Space

Richard Stovold *(DLI WA)*

richard.stovold@dli.wa.gov.au

Efficient use of feed resources in the livestock industries of Australia is a major factor determining farm profitability. Inefficient use often results from insufficient information on which to base production decisions from one season or year to the next.

Pasture utilization by sheep and cattle during the growing season is low relative to total pasture production. In many years total pasture consumption can be as low as 20 to 30 %. That is, producers forego potential production due to their inability to make informed decisions on the management of their feed resources.

In southern Australia, the environment is characterized by high winter/spring rainfall and summer/autumn drought. Pasture that is not utilized before the end of the growing season dries up, senesces and is available with a greatly reduced nutritive value.

The Pastures from Space program provides estimates of pasture production during the growing season by means of remote sensing. Satellite data is used to accurately and quantitatively estimate Pasture Biomass or Feed On Offer (FOO) or combined with climate and soil data is used to produce Pasture Growth Rate (PGR) estimates.

Estimation of PGR and FOO using remote sensing provides temporal and spatial information on feed resources allowing producers to more effectively manage their enterprise and potentially raise the productivity and profitability of their businesses. It is also possible that an objective measure of the spatial variation of pasture production will highlight opportunities to improve the environmental management of the landscape. Matched with electronic delivery of the information (email or web based) near real time decisions can be made.

The technology has been widely trialed by Western Australian farmers, where PGR information is broadcast on ABC Radio and signposted in regional areas. PGR estimates for Shires in the Southern agricultural or Mediterranean regions of Australia are now being developed and trialed nationally. This information and subscription is available through Fairport Technologies.

WA precision agriculture steering group

Bindi Isbister
(Development Officer, Department of Agriculture WA, Geraldton : Executive Officer WA PA Steering Group).
bwebb@agric.wa.gov.au

Introduction

Compatibility of equipment and software is frustrating growers adopting new Precision Agriculture (PA) technologies and holding back their adoption, despite their benefits to farming efficiency. This is a key finding by the WA PA Steering Group, which is currently identifying how to improve uptake of PA in WA. It also emerged as a key issue during a recent national survey on PA by the GRDC. Other limitations include a lack of on farm technical support for growers using the technology and technology that is too complex.

The WA PA Steering Group was established in 2004 to help guide PA research and development in WA funded by the GRDC through it's Special Initiative on PA (SIP09). It includes representatives from bodies with significant PA activity, such as the Department of Agriculture WA, CSIRO, Silverfox, Curtin University, Department of Land Information, farm consultants and eight grower groups.

The aims of the group are to;

1. Provide industry input into research, development and extension of PA
2. Foster communication and coordination of activities
3. Identify needs and opportunities
4. Raise awareness of GRDC PA and related activities in WA and identify opportunities for collaboration
5. Develop and exploit regional, state and national networks

The group meets twice a year in summer and spring. Achievements to date include identifying needs to improve the adoption of PA with consultation from respective grower groups. These needs have now been used as a basis for; developing a training program for farmers and consultants, raising awareness of equipment compatibility issues through press releases and ABC radio interviews. Linkages have also been created between groups around the state with similar interest in PA and project activities have been reviewed.

The Steering Group is keen to ensure current research and development in PA meets the real needs of WA farmers. Feedback from group members to and from their own groups is considered essential to assist this process. However, we encourage anyone to contact one of the group members (listed below) with comments or ideas on improving the adoption of PA in the WA agricultural industry.

Project / organisation	Representative(s)
DAW00084 (DAWA)	Bindi Isbister
CSO00017 (CSIRO)	Michael Robertson
SFX00001 (Silverfox)	Ian Maling
CFG00002 (CFIG)	Wes Baker
UWA00081 (SIP08)	Chris Gazey
UWA00084 (NMI)	Bill Porter
Dept Land Admin	Matt Adams
ConsultAg	Garren Knell
Muresk	Lionel Martin
Grower Group Alliance	Tracey Gianatti
Casuarinas/Walkaway Group	David Forrester, Shane Collins
Liebe Group	Brianna Peake
Mingenew-Irwin Group	Miles Obst
Facey Group	Lindsay Ward
Holt Rock Group	Owen Brownley, Geoff Marshall
WANTFA	Tim Braslin
Young River Group	Will Carmody

Thank you very much to all members of the group for giving their time and input to the Steering Group. Your support will be valuable to guiding the development of PA in WA.

Will someone please build us a fruit quality sensor ?

Rob Bramley, **Kerstin Panten**
(CSIRO Sustainable Ecosystems and Cooperative Research Centre for Viticulture, PMB No. 2, Glen Osmond, SA 5064.
Angela Reid
(Cooperative Research Centre for Viticulture and Department of Primary Industries and Fisheries, PO Box 1085, Townsville, Qld 4810.

rob.bramley@csiro.au

Research conducted at contrasting sites over several vintages using grape yield monitors, remote sensing and other technologies (Bramley and Hamilton, 2004, 2005), strongly suggests that patterns of spatial variation in winegrape yields are temporally stable and that as a consequence, adoption of a system of *zonal viticulture* would be appropriate for many winegrape-growing businesses. However, gaining an understanding of variation in fruit quality is arguably of greater importance than for yield, yet to date, there are no commercially available sensors for grape quality.

Research based on hand sampling of fruit suggests that management zones identified on the basis of yield and/or remote sensing and vineyard survey (EM38, RTK GPS) also differ in terms of fruit quality (Bramley, 2005). However, because the wine industry uses a range of indices of fruit quality (Baumé, pH, titratable acidity, colour and phenolics) to varying degrees, this issue is made more complicated than in the case of a univariate measure such as yield; to this end, we have been exploring the development of an index of grape berry quality. A further problem arises because of the reduced sampling intensity we have used for fruit quality assessment (hand sampling at ~26 samples ha^{-1}) compared to that implied by yield monitoring (~1500 ha^{-1}), and the consequent difference in statistical support underlying maps derived from these data. Thus, whether yield-derived zones are optimal instruments for fruit parcel segregation is unclear. Access to on-the-go fruit quality sensing technology would be invaluable in addressing this issue, especially if the sensor could assess fruit prior to harvest, rather than during it. However, on the assumption that the data derived from an on-harvester instrument would have a similar predictive value over time to that obtained from yield monitors, such an instrument would still offer considerable benefits.

Another major reason for needing on-the-go quality sensing derives from our present focus on whole-of-block experimentation. This approach to understanding variable vineyard response to management inputs has been well received by our collaborating growers. However, the utility of experiments designed to assess the benefit of differential management (eg pruning) with respect to fruit and wine quality are severely constrained by our present dependence on hand sampling and the time that growers have available for such a task.

This presentation will discuss these issues with a view to encouraging some appropriately skilled and entrepreneurial technologists to develop an on-the-go technology for grape quality sensing. We are certain that their efforts will be warmly received by the wine industry.

References

Bramley, R.G.V. 2005. Understanding variability in winegrape production systems. 2. Within vineyard variation in quality over several vintages. *Australian Journal of Grape and Wine Research* **11** 33-42.

Bramley, R.G.V. and Hamilton, R.P. 2004. Understanding variability in winegrape production systems. 1. Within vineyard variation in yield over several vintages. *Australian Journal of Grape and Wine Research* **10** 32-45.
Bramley, R.G.V. and Hamilton, R.P. 2005. Hitting the zone – Making viticulture more precise. *In*: Blair, R.J, Williams, P.J. and Pretorius, I.S. (*Eds*) Proceedings of the 12th Australian Wine Industry Technical Conference. Winetitles, Adelaide. pp. 57-61.

Three years P.A. research! Is there a pot of gold at the end of the rainbow?

Garren Knell (ConsultAg)
Wes Baker (Corrigin Farm Improvement Group)

gk@consultag.com.au

Matching inputs to productivity zones
Ivan and Helen Lee, Corrigin 2004.

Aim
To investigate if matching fertiliser inputs to productivity zones increases whole paddock returns. To demonstrate if variable rate technology is likely to increase returns compared to managing the paddock as one unit.

Method
The paddock was divided into high, medium and low productivity zones using biomass imagery and grower experience.

High medium and low fertiliser treatments were then applied across each zone at seeding or early post emergent (Table 1). The paddock was sown up and back.

Each treatment was 4 air seeder widths wide and 2 boom widths to allow a large treatment area so that responses can be measured using biomass imagery as well as with the header. There are 2 replications of each treatment, however plots were sub-sampled to allow for replication and statistical analysis.

Table 1) Fertiliser Inputs 2003

Treatment	Agrich Kg/Ha	Flexi N seeding L/Ha	FlexiN Post L/Ha	MOP Rate Kg/Ha	P rate	N Rate	Cost $/Ha
Low	50 kg	30	0	0	6	17.5	$35
Medium	100 kg	30	50	50	12	45	$103
High	150 kg	30	80	50	18	64	$136

Note. Fertiliser priced based on 2004 list price ex GST.

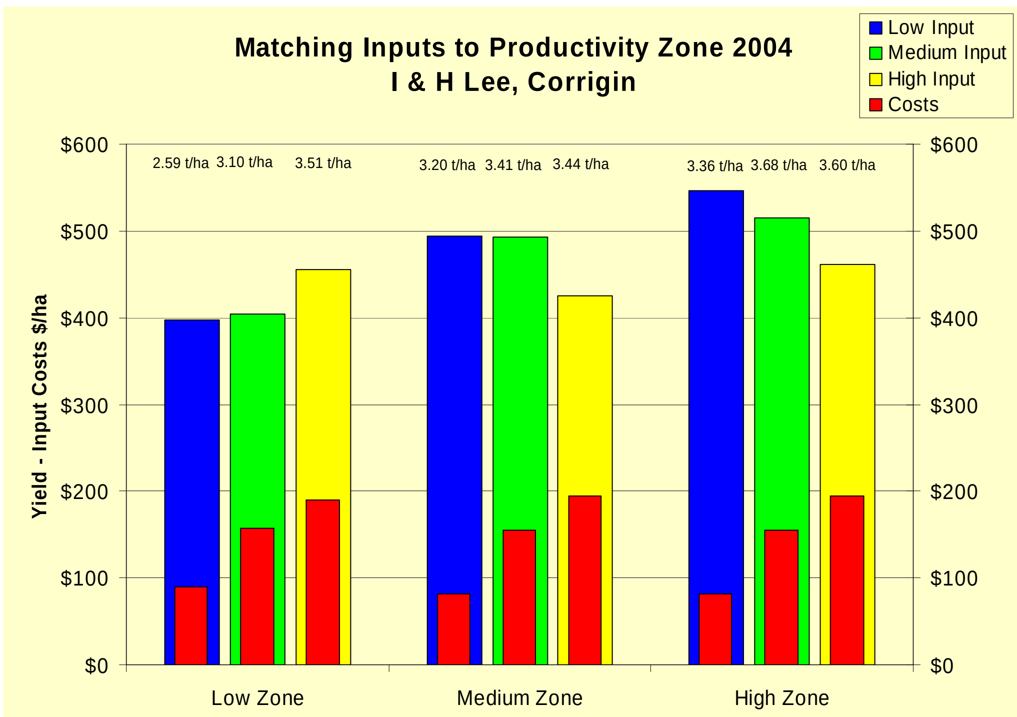
Results

The 2004 growing season was very good with most treatments yielding over 3T/Ha. September was a dry month with only 15mm of rainfall however the early October rains (27mm) enabled this crop to finish well.

Figure 1, shows the economic impact of applying the high medium and low fertiliser treatments across each zone. With the left axis showing gross margin (gross return – input cost) The right axis shows money spent on fertiliser. The actual yield is listed above the columns.

Figure 1 shows that as fertiliser inputs are increased the gross margins decrease (especially in high zone). The yield increases were not adequate to cover the cost of additional fertiliser. In 2003 the performance of the zones was consistent with, the high zone giving the highest yields and return and the low zone giving the lower yields and returns.

Figure 1)



CFIG precision agriculture lessons learnt

The performance of a productivity zone is determined by the ability of a soil to store water and supply it back to the crop (J Whitwell, UWA honors thesis with CFIG).

Although VRT is available for farm machinery the in-paddock agronomy is lagging behind and in paddock research often raises more questions than it answers.

We have found that paddocks that have a high degree of stability in yield performance are much more likely to give responses when matching fertilizer inputs to productivity zones (VRT).

Rule of thumb for paddock stability :

- Paddock stability >70% Highly likely to profit from adopting VRT.
- Paddock stability 55% - 70% Possible to achieve positive return from VRT (not all seasons).
- Paddock stability <55% Unlikely to profit from adopting VRT.

(Proposed by, CFIG and I Mailing, Silverfox)

Unstable zones within our paddocks are usually impeded by a soil physical or chemical constraint. These commonly include water logging, acidic sub soil or subsoil compaction.

Why use precision agriculture.

Zone paddocks for soil testing and interpretation.
If you have high P levels (>25ppm) varying P rates is unlikely to give responses in the short term (unless high PRI).
Focus on varying N. Apply extra N on high performing zones in good seasons.
Ameliorate by zone – Ripping, Potassium, Lime, gypsum.

Planned 2006 and 2007 research.
1) Compare zoning methods.
Radiometrics Vs Biomass Analysis (Silverfox, Sky Plan).

2) VRT – Focus on nitrogen and fine tune fertiliser inputs by productivity zone.

Corrigin Farm Improvement Group Contacts:
CFIG cfig@cfig.asn.au , Wes Baker wes.baker@bigpond.com
Garren Knell gk@consultag.com.au , Alison Slade aslade@agric.wa.gov.au

CORRIGIN
Farm Improvement Group

Extending Site-Specific Crop Management from individual fields to an entire farm

Madeleine Florin
Australian Centre for Precision Agriculture, University of Sydney

mflo8633@mail.usyd.edu.au

Precision Agriculture (PA) is a farming system that integrates information and production to increase long-term economic and environmental efficiencies for the whole farm (National Research Council, 1997). One form of PA is Site-Specific Crop Management (SSCM) of which the principal practice at this point in time is the division of fields into management classes. Given the present state of technology and knowledge, gathering adequate amounts of spatially-dense data to derive management classes is expensive. This is one reason why most PA studies oriented towards SSCM have focused on two or three fields and few authors have investigated PA over an entire farm.

Decision-making often occurs within the context of a whole farm and the ability to measure economic and environmental outcomes from PA requires a whole-farm perspective. These are two reasons why whole-farm studies are desirable. A number of practical implications associated with moving PA to a whole-farm scale require consideration. Some challenges include the minimisation of data costs, accommodating for inconsistent data and quantifying and integrating economic and environmental outcomes from a PA system.

Investigating pay-offs to zone management of fertiliser in a variable climate: a study of nitrogen fertiliser on wheat

Lisa Brennan and **Michael Robertson**
CSIRO Sustainable Ecosystems

lisa.brennan@csiro.au

For tactically-managed crop inputs such as nitrogen fertiliser, climate variability presents challenges to land managers seeking to gain an economic benefit from implementing spatially-variable management. In this context, yield maps have limitations in guiding spatially-variable management because they are historical depictions of yield levels and variability, whereas the decision to apply nitrogen fertiliser is about an uncertain future. At the time of fertiliser application, the current season's crop yield for each management zone in the field is not known, because it depends on uncertain weather conditions, and this means that it is not possible to precisely identify the economically-optimal nitrogen rate.

This issue is explored in the context of the north-eastern Australian wheat belt. We present a framework for systematically investigating the interaction between spatial and temporal (or seasonal) variability on economic performance, their relative importance, and the value of spatially-variable nitrogen management to a manager with and without seasonal knowledge. We also consider the degree to which economic performance is influenced by the relative sizes of management zones for fertiliser inputs, the costs of inputs and prices for outputs and the shape of the biophysical response to the input in each zone.

The economic performance of four nitrogen management strategies on a single paddock is investigated: a) *uniform management*, a benchmark strategy, where no spatial or seasonal adjustments are made to the nitrogen rate applied to the paddock, b) *spatial management*, where only spatial adjustments are made to the nitrogen rate, with no seasonally-adjusted management, c) *seasonal management* where adjustments to nitrogen rate are seasonally-adjusted only, with no-spatially variable application of nitrogen, and d) *seasonally and spatially adjusted management*, where the nitrogen rate is varied on a seasonal and spatial basis.

The seasonal and spatial interactions in nitrogen management require close attention for decision-making. In this case, knowledge of seasonal variability is worth more than knowledge of spatial variability, but knowledge of seasonal variability greatly increases the value of spatial information. Another important issue concerns the functional relationship between yields and fertiliser levels for a given crop, which determines the economic value of PA. As shown in this analysis, a paddock may exhibit yield variability but this does not automatically present a case for spatially-variable nitrogen management. If economic optima of different payoff curves are aligned then returns to zone management will be limited, despite significant differences in yield between different zones.

PA Technology Issues Update

Rohan Rainbow
Executive Officer, Southern Precision Agriculture Association - SPAA

admin@spaa.com.au

Precision agriculture continues to grow in interest in Australia, however most of the interest by farmers has been focused on DGPS guidance and autosteer products rather than variable rate application technologies. The large learning curve and the longer-term return on investment of time and costs followed by some poor seasons has dampened the adoption of VR technologies. The increased use of GPS related products has increased farmer awareness of the potential use of these products and add-on systems such as auto spray boom and air cart switching has attracted wide interest. The adoption of yield mapping continues to grow slowly

CANBus ISO11783 or ISOBus compatibility continues to create widespread debate in the PA industry. It appears that the CANBus ISO11783 standard, which is still continuing to evolve, will gain greater industry recognition with the introduction of ISOBus standards approval stickers being introduced on compatible equipment. The CANBus ISO 11783 appears to becoming the predominant standard in agricultural tractor controller systems, particularly in the OEM market, however there continues to be many proprietary CANBus standards used by a number of manufacturers. Go to www.isobus.net for further information.

SPAA has received very good feedback on the Autosteer & Guidance day held in February 2005 at Gawler. All Companies have reported significant sales of autosteer and guidance equipment since. Considering the poor season in 2004, the sales of this equipment has given a very positive spin for PA’s future.

A need for a strategic approach to PA training in Australia

There have been discussions within the GRDC SIP09 PA initiative on developing a more strategic approach to PA training with a national focus, rather than the add-hoc workshop programs that have been used to date. Much of the training to date has been predominantly computer and software training in GPS and PA systems. It has been felt anecdotally that much of the training to date has not been very successful.

A survey of training needs by SPAA highlighted that PA data management and interpretation, satellite imagery and EM and setting up management zones are the highest priority for training. It was interesting to note that computer and software training ranked very poorly.

SPAA PA Equipment Survey

- SPAA have recently completed a detailed survey of PA equipment to all SPAA & SANTFA members in SA receiving surveys on 92 different items of precision agriculture equipment, predominantly guidance and auto steer equipment. This survey funded by the SA Grain Industry Trust was conducted by Scott Boyle, Regional Skills Training.
- The survey documented farmers experiences on equipment reliability, ease of use and technical support. All but six surveys where returned from South Australian farmers.
- The average size of the property that the PA equipment was used over was 2,490 hectares and the grower produced on average 3,659 tonnes of grain. The average number of years survey respondents had been involved with PA was 2.78 years. Almost 18% of respondents where practicing some form of controlled traffic.
- Following this survey, it has become evident that there is a need for broadening the survey to other states outside SA, particularly WA, Victoria & NSW to get a better total aggregate of single models of PA equipment. SPAA would like to seek additional funding to broaden this survey.

PA Equipment Survey Findings

There are several main areas of issues and problems the PA equipment industry needs to address that emerged from this survey.

Signal accuracy and reliability – 56% of all survey respondents had some form of signal problem. 25% specifically indicated signal loss occurring. It was supported by a number of owner comments, slightly lower overall GPS signal rating and 9% of owners who used more than one signal source. Obviously, if the signal disappears, then the main reason for GPS PA equipment is made redundant.

There was also confusion by owners as to the make and model of equipment used to source the GPS signal. Some of the confusion relates to who fitted the unit, and the GPS signal receiver manufacturer being made clear. Most knew who the signal provider was, but indicated that the make of the receiver was the manufacturer of the cabin mounted unit. This data needs to be checked with survey respondents to make more accurate survey data analysis possible to possibly find trends in signal problems, and in particular the hardware behind the problems.

Software and data removal and storage – With more than 40% of all survey respondents having software problems of some sort and some of the lower ratings, this is another area warranting more information.

This needs to be discussed with the manufacturers to find the reasons why software problems are occurring and changes they are making to rectify them. Secondly, to get a clearer picture of the core of these problems, the survey respondents need to be followed up who have had major problems and also to clarify the models and year they where made to verify if the problems are related to equipment that hasn't had the latest upgrades performed.

Screens – The predominant screen problems related to glare and reflection on the screens. This is an area of interest with manufactures and requires more investigation as to what the industry can do to handle this problem. One possibility is for testing of screens for glare and reflection. Brightness at night should also be assessed.

Operators manual and fitting instructions – This was the lowest rated feature in the survey and has significant OH&S considerations. This is an area in need of further investigation. Consistently machinery reports over the years by Kondinin Group showed inadequacy of operators manuals of particularly Australian made products.

Individual manufacture information – From this survey, there was only adequate information collected from one manufacturer to be able an individual report on a PA unit. Three other manufacturers, there was about 50% of the number required. At least three other major suppliers in Australia had very limited numbers of machines reported on. Recommendation is that this survey be taken to other states to obtain more survey numbers to enable reporting on individual PA equipment.

Other reporting – This survey mainly ended up concentrating on auto-steer products. There needs to be a further survey conducted on the ease of use, signal and software issues of harvester yield monitor and the auto-boom spraying systems. Harvesters didn't feature predominantly in the survey and there were problems with auto-boom systems. VRT is emerging and requires investigation.

A Philosophy and Application of Site-Specific Crop Management in Northern NSW

Michael Smith *("Tarnee", Gurley, NSW)*

tarnee@bigpond.com

Our property of 1600ha is situated 44km SSE of Moree in Northern NSW. The soils are black vertisols, formed from old larva flows, which vary in depth over a decomposing layer of sandstone. Annual rainfall is around 620mm with 200mm in winter, although the general distribution varies quite a bit. Crops grown are Bread & Durum wheat, Canola, Chickpea, Barley, Sorghum, and Sunflower.

The topography is undulating (2.5% slope) and consequently all farmed fields have farm-over contour banks to help control runoff during storm events. Farming methods employed are based around the need to preserve ground cover for erosion control, moisture storage and soil health. No Till and controlled-traffic are employed to try and achieve these goals, along with allowing operations to be performed in an efficient manner.

Due to the variable depth of black soil it appeared that crop production would be linked to this in the form of plant available water stored during the fallow. (60cm 70mm PAW, 100cm 120mm, 180cm 240mm). So in 1996 yield and soil depth mapping was commenced to try and quantify what was really happening. The general trend seems to hold true, although getting good yield data depends on getting the basics right and some cooperation from the weather. Frost and rain at harvest can be a source of frustration.

The move into variable-rate (1999) seemed to be a logical extension of existing practices to better match inputs with outputs from each field. Generally the amount of fertiliser used has not increased but the distribution within each field has. This is allowing better targeting of yield potential for each zone within the field.

Over time we have tried variably applied insecticide as it was found that the heliothis moths preferred to lay in chickpea in the deep soil areas where the crop showed the most potential.

This year where cereals are sown back to back they are planted in between the previous crops rows to help with crown rot disease management as there is some evidence to suggest this may help. We have also tried a variable seeding-rate with sorghum to look at better matching plant populations to potential given the heavy reliance on stored water.

Generally working with PA has created plenty of food or data for thought and farming can still be as much an art as science at times.

AgriView – Farmstar Australia : advanced remote sensing services for Australian agriculture

Jonathan Medway (*Terrabyte Services, Wagga Wagga NSW*)

jmedway@terrabyte.net.au

Ongoing improvements in the acquisition, processing and delivery of remotely sensed crop imagery continue to generate considerable interest across a wide range of dryland and irrigated cropping farming systems. With quantitative assessment capability under current development set to further enhance the opportunities to improve the efficiency of allocation of resources and inputs.

Of particular interest to broadacre cropping managers will be the potential ability to;

- Estimate crop leaf area and biomass,
- Quantify crop growth rate,
- Directly measure crop nitrogen uptake,
- Predict crop yield and quality parameters, and to
- Incorporate spatial variability assessment into risk management strategies.

Background

Since incorporation in 2000, Terrabyte Services has been actively involved in the development of crop imaging services for dryland and irrigated farming. Typically this has involved the use of standard vegetation index calculation to highlight within field differences in crop growth. This information has then been used to develop directed crop monitoring strategies to investigate the cause, magnitude and implications of the variability.

For many existing growers, this imagery has highlighted crop growth variability associated with; Crop establishment, Weed infestation, Pests, Irrigation development, Crop nutrition, and Crop yield.
To date, wheat, canola, rice, cotton and corn have successfully used remote sensing to highlight crop variability to develop targeted sampling strategies. While these activities are typically being used to determine the most appropriate whole field management plan, some growers are now implementing variable rate management strategies utilising the imagery, targeted field monitoring and available historic productivity or resource information.

Figures 1 to 3 shows a crop vigour image, the derived nitrogen fertiliser management plan and subsequent crop vigour image.

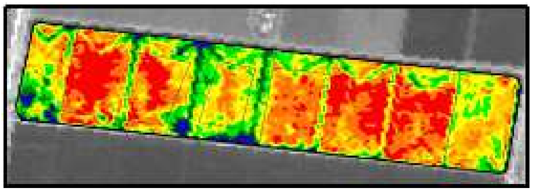


Fig.1

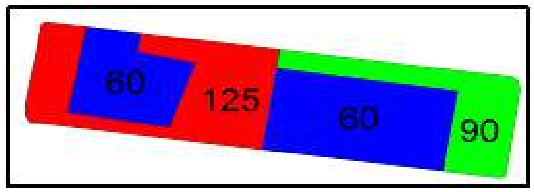


Fig.2

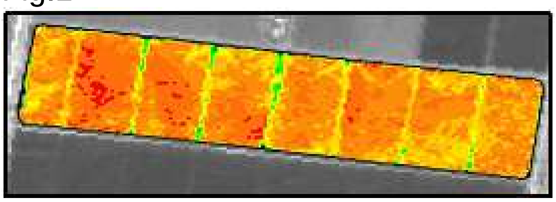


Fig. 3

Time series showing variable, initial crop vigour image (fig.1), Nitrogen application plan (fig.2) and post fertilisation, uniform crop vigour (fig.3)

Such plans are being routinely developed for irrigated cropping and are likely to become more common in dryland winter crop production as the imaging service evolves.

Future remote sensing services

Operational experience has demonstrated the while Crop Vigour Indices offer a reliable means of mapping variations in crop growth and health across a paddock, there is significant scope to extend the diagnostic capabilities of the service in relation to crop assessment, growth regulator and nitrogen management together with yield and quality prediction.

To achieve this, Terrabyte Services is working with EADS Astrium, the European Aeronautical, Defence and Space Organisation that currently offers the Farmstar Crop Imaging service in Europe with more than 6,000 subscribed farmers monitoring over 16,000 fields. This collaboration is working towards the development of quantitative imagery services customised for Australian crops, climate and management systems.

Current development activities are working towards calibration and evaluation of capability to directly estimate;
Crop leaf area (fig 4.) and biomass,
Crop growth rate,
Crop nitrogen uptake (fig 5.), and
To predict crop yield and quality parameters.

Through the incorporation of the imagery data and daily climatic information with a range of agronomic parameters provided by the growers and including;

- Crop variety,
- Sowing rate and date,
- Row spacing / planting configuration,
- Soil type, and
- Target plant population and yield.

The resulting capability will provide quantitative assessment techniques that will enable direct comparison of estimated parameters across regions, through time and within fields against standard benchmark values, and utilisation of the evolving application of agro-meteorological crop models to simulate crop growth and evaluate likely implications of proposed management activities.

During 2005, Terrabyte Services will be continuing the validation of the more advanced image processing techniques while providing its standard Leaf Area Index service across Australia. The standard service consists of a Leaf Area Index map for each ordered field and subject to initial validation, the nitrogen uptake estimate will be provided at no additional charge.

Image ordering involves supply of paddock boundary and location details together with crop type, variety, sowing rate, sowing date and row spacing details. Costs will be $3.60-$4.00/ha depending on area.

Fig 4. Sample Leaf Area Index map

Fig 5. Sample Nitrogen Uptake map

Update on European PA

Allan Mayfield *(Allan Mayfield Consulting)*

Mayfield@chariot.net.au

European Precision Agriculture Conference

Interestingly there is very little wide-scale application of variable rate management of crops internationally. Many of the papers were on imaging systems and analytical processes to define zones. Less than 5% of the area mapped (180,000ha) using FARMSTAR is managed with variable rate. An exception is the use for the N-Sensor in northern Europe. This varies the rate of nitrogen fertiliser according to the crop density and nitrogen status. There are over 350 of these units now used commercially. Other uses of the N-Sensor being tested are variable rate desiccation of rape crops and variable rate applications of fungicides. Another more portable type of scanner (the Crop Circle) with similar output to the N-Sensor is being used by some contractors.

Other practical applications at or near commercial use include the Zeltex protein tester for harvesters and on-the-go soil pH testers.

One of the great needs for precision agriculture to develop is a skilled support industry. A highlight of the conference was the number of students developing these skills.