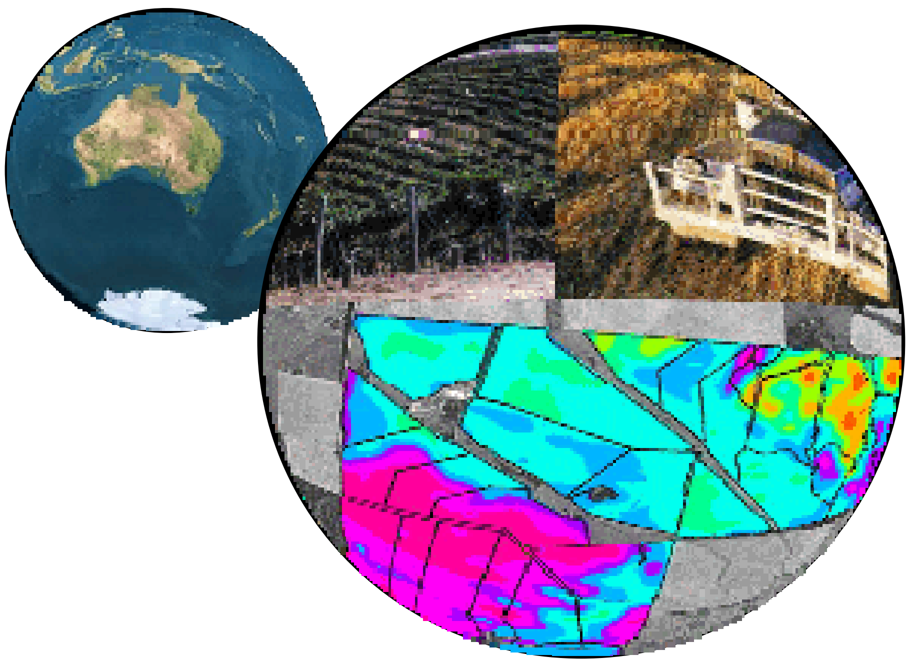
10th Annual Symposium on Precision Agriculture Research & Application in Australasia

The Australian Technology Park
Eveleigh, Sydney
Friday 18th August, 2006



Program & Abstracts

Australian Centre for Precision Agriculture

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SPAA
Southern Precision Agriculture Association

GRDC
Grains Research & Development Corporation

Welcome

The PA Symposium has reached its 10th year and returns to it's beginnings in Sydney. It is a timely reminder that the philosophy behind PA has held strong and continues to stimulate the agricultural community. The definitions of PA have multiplied over those years but all still embody the original philosophy:

Observe, assess the importance, and respond to fine-scale variation in causative components of an agricultural production process in a timely, economically and environmentally diligent manner

The response, or managerial decisions, need to be at the strategic as well as tactical levels to make the most of the information gained by using PA technologies. We all know that the costs of the equipment and techniques need to be recouped in economic, environmental or social gains, and this usually requires their application in a variety of operations. In Australia, the uptake of guidance and steering-control systems is a good example of both strategic (e.g. choice to move the whole farm operation to controlled-traffic) and tactical (e.g. allow inter-row sowing to reduce disease risk in some crops) use of a new technology.

More and more people are beginning to see the many ways the PA philosophy can be used at the whole-farm (strategic) operational level. This is increasingly involving product quality and supply chain tracking in a number of agricultural industries.

So what is a 'good' definition of PA these days. Well a definition tabled in the US House of Representatives still seems to do the job quite well:

Precision Agriculture: an integrated information- and production-based farming system that is designed to increase long term, site-specific and whole farm production efficiency, productivity and profitability while minimizing unintended impacts on wildlife and the environment".

The value in this definition is that it identifies PA as a "whole-farm" management strategy (not just for individual paddocks or cropping for that matter) that utilises information technology and that the aim of management is to improve production and minimise environmental impact. It also refers to the farming system, which in modern agriculture may include the supply chain from the farm-gate to the consumer.

Obviously research and application must also continue to be targeted at the within-paddock management options. Site-Specific Crop Management (SSCM) tools and techniques continue to be a high focus of the Australian community. Today we will see some of the very best work in this field in the world - allowing us to improve our decisions on resource application and agronomic practices to better match soil and crop requirements as they vary in the paddock.

What a tactic to help fulfill a PA farming system strategy!

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

ACPA Staff & Students

PRESENTATION PROGRAM

9.00am *Welcome* *Chair: Brett Whelan*

9.02am Introduction *Martin Blumenthal (GRDC)*

9.05am Symposium Opening and Launch of the GRDC Precision Ag Manual
Hon. Sussan Ley MP, Parliamentary Secretary to the Minister for Agriculture

9.20am Digging Down with EM38
David Lamb (UNE)

9.40am Use Of Geophysical Survey To Estimate Plant Available Soil Water Storage Capacity, Yield And Environmental Performance Across Paddocks.
Mike Wong, Yvette Oliver, Michael Robertson, Kathy Wittwer (CSIRO)

10.00am Getting More From Gamma Radiometrics
Alex McBratney, Raphael Viscarra Rossel, James Taylor, Henry Taylor, Michael Short (ACPA)

10.20am *Morning Tea*
Chair: Rob Bramley

10.50am Pasture Measurement: The First Step Towards Precision Dairying
Ian Yule (NZCPA), Bill Fulkerson (USYD), Hayden Lawrence and Robert Murray (NZCPA)

11.10am Weedseeker
David Brownhill (Merrilong Pastoral Company)

11.30am Hyperspectral & Thermal Technologies For Assessing Nitrogen & Water Status In Wheat
Glenn Fitzgerald (DPI VIC), Garry O'Leary (CSIRO), Robert Belford (DPI VIC), Adam Tilling (RMIT), Daniel Rodriguez (APSRU), Lene Christensen (NGB, Sweden), Mohammad Abuzar (DPI VIC), Tom Clarke (ALARC)

11.50am The Use Of Yield Prophet In Zonal Management Decision Making
Dale Grey (DPI VIC)

12.10pm Measuring Whole-Farm Crop Variability Using Pseudo Yield Mapping
Peter Fisher, Mohammad Abuzar (DPI VIC)

12.30pm *Lunch*
Chair: Rohan Rainbow

1.30pm New Products From John Deere - How To Influence The Process
Broughton Boydell (John Deere)

1.50pm Methods Of Mapping Actual Fertiliser Distribution In The Field
Ian Yule, Hayden Lawrence and Robert Murray (NZCPA)

2.10pm Using Variable-Rate Technology in Cotton Fields
Steve Madden (Steve Madden Agriculture)

2.30pm Addressing Variability In Soils
Ian Delmenico (Crop-Rite Pty Ltd)

2.50pm Spatial Distribution Of Soilborne Disease Inoculum
John Heap, Alan McKay (SARDI)

3.10pm *Afternoon Tea*
Chair: Alex McBratney

3.40pm Towards Autonomous Precision Implement Guidance
Jayantha Katupitiya, Ray Eaton, Tomonari Furukawa (UNSW)

4.00pm Precision Agriculture Around the World – A Nuffield Experience
Mark Branson ("Clifton Farm" & Nuffield Scholar)

4.20pm 8th International Conference on PA update
James Taylor (ACPA)

4.40pm *Close*

The GRDC Precision Agriculture Manual

The PA Manual is the first major product from GRDC's national PA research initiative. It is being released as a CD at the Symposium, and later on the GRDC website 'Grainzone'. Three documents are being released together under the 'Manual' title.

The PA Manual itself summarises a large amount of technical detail about the science and technology of PA and how it can be applied in practice by graingrowers; it includes financial spreadsheets that can be used by growers and advisers to see whether expenditure on PA is likely to be a sound investment for them or their clients.

The second report, 'Undertaking your own on-farm experiments: how PA can help', explains how growers can use PA to lay out and harvest their own trials of new varieties or different rates of fertilizer or other inputs. This is another major potential benefit of PA in allowing growers to test the value of new products or knowledge to their individual situation, and thus to fine tune their cropping program.

The third document, 'Standards for ElectroMagnetic Induction mapping for the grains industry', arose from concerns about the variable quality and usefulness of the EM survey that is becoming a common practice within the industry to map variation in soil characteristics. It proposes a set of standards for good practice in undertaking and reporting EM surveys, and will help growers to ensure they receive value for money from expenditure on such surveys.

The three documents are complementary, and have numerous active links so that they can be jointly searched for information on particular topics. They also contain active text hyperlinks and references that take the reader direct to websites that provide additional information about topics of special interest. The product has also been set-up so that sections, pages, diagrams and images can be easily printed, or saved for later modification and use in other PA education and training materials.

The GRDC intends to update and re-issue the PA Manual following the completion of its PA research initiative in late 2007.

Digging Down With EM38

David Lamb *(School of Biological, Biomedical & Molecular Sciences, UNE)*

dlamb@une.edu.au

Abstract

Electromagnetic (EM) soil survey technologies currently rival yield mapping as the 'icon' of Precision Agriculture. EM units provide a measure of apparent conductivity (ECa) of underlying soil that is integrated over the entire sensing depth of the instrument. To date, and wisely so, apparent conductivity (ECa) maps of paddocks are primarily used to direct

subsequent field sampling to ascertain the nature of variability in ECa as linked to physical or chemical attributes. The 'ground-truthed' data are then used to support a range of activities including ascertaining the contribution of soil-related factors to spatial variations in crop yield or quality, optimising irrigation systems and so on. However, an understanding of the depth-related response function of EM units and how the magnetic fields generated by these units interact with their surroundings, offers the opportunity to (i) extract useful 'hidden' information contained in the single integrated ECa value, as well as (ii) allow the deployment of units in typically unfavourable conditions (eg close to objects such as fencelines and grapevine trellising). This presentation will provide a non-threatening outline of the underlying basics of EM units as well as overview two aspects of work that is being conducted at UNE: (i) using multi-height EM38 to estimate depth profile of volumetric water content, and (ii) developing a correction protocol for EM data acquired in the presence of nearby fences or grapevine trellising.

Use Of Geophysical Survey To Estimate Plant Available Soil Water Storage Capacity, Yield And Environmental Performance Across Paddocks

Mike T F Wong, Yvette Oliver, Michael Robertson, Kathy Wittwer *(CSIRO, WA)*

Mike.wong@csiro.au

Abstract

Field measurements and extrapolations of the data by APSIM modelling to cover a range of soil and season types show that plant available soil water storage capacity (PAWC) is an important determinant of both spatial and seasonal variations in crop yield in our Mediterranean-type environment. The PAWC of a soil is determined by its clay content and the volume explored by roots. Both electromagnetic (EM38) and gamma-emission surveys can sense clay contents but not root depth. This creates the need for local calibration in each paddock. In the absence of interference, EM38 and gamma-emission surveys they are well correlated with PAWC measured across a paddock. Salt increases the apparent soil electrical conductivity (EC_a) measured by EM38 surveys out of proportion to clay content. This typically occurs in the low-lying discharge areas of the landscape and the increases in EC_a are not matched by increased gamma-emission. On the other hand, superficial rocks and gravels increase gamma-emission out of proportion to clay content. When the rock or gravel layer is overlaid by sand, the gamma-emission is attenuated according to the depth of sand and provides a means of scaling PAWC to take account of soil depth.

APSIM-derived correlations between PAWC and yield, drainage and nitrate leaching provide estimates of yield and environmental performance across paddocks. Yield and environmental response across the paddock can be evaluated to assess the effect of various season and management scenarios to improve paddock management.

Getting More From Gamma Radiometrics

Alex. McBratney, Raphael Viscarra Rossel, James Taylor, Henry Taylor*, Michael Short
*(ACPA, University of Sydney; * current address Auscott Ltd, Oxley Highway, Warren)*

Alex.McBratney@usyd.edu.au

Abstract

The development of proximal soil sensors to collect fine-scale soil information for precision agriculture is crucial because conventional soil sampling and laboratory analyses are time-consuming and expensive. The principal proximal sensors in use are the electromagnetic induction (e.g., EM38) and direct electrical conductivity devices e.g., Veris 3100) Here we look at the possibility of calibrating hyperspectral γ-ray energy spectra to predict various surface and sub-surface soil properties. The spectra were collected with a proximal, on-the-go γ-ray spectrometer. We surveyed various fields in New South Wales (and some in Scotland) and collected hyperspectral γ-ray data consisting of 256 energy bands (rather than the three regions of interest [K, U, Th] conventionally used in gamma radiomertric analysis) at many thousands of sites in each field. Bootstrap aggregation with partial least squares regression (or bagging-PLSR) was used to calibrate the γ-ray spectra of each field for predictions of selected soil properties.

However, significant amounts of pre-processing were necessary to expose the correlations between the γ-ray spectra and the soil data. We first filtered the spectra spatially using local kriging then further de-noised, normalised and detrended them. The resulting bagging-PLSR models of each field were tested using leave-one-out cross-validation. Bootstrap aggregation-PLSR or bagging-PLSR provided robust predictions of clay, coarse sand and Fe contents in the 0–15 cm soil layer and pH and coarse sand contents in the 15–50 cm soil layer. Furthermore, bagging-PLSR provided us with a measure of the uncertainty of predictions. This study is apparently the first to use a multivariate calibration technique with on-the-go proximal γ-ray spectrometry. Proximally sensed γ-ray spectrometry proved to be a useful tool for predicting soil properties in different soil landscapes. The gamma radiometric response seems to be less sensitive to soil moisture variation than electrical conductivity which offers interesting possibilities of using both techniques together.

References

Viscarra Rossel, R.A., Taylor, H.J. & McBratney. A.B., 2006 Multivariate calibration of hyperspectral γ-ray energy spectra for proximal soil sensing European Journal of Soil Science (in press).

Taylor, H.J., 2005 The use of ground-based gamma radiometry for the prediction of soil properties and comparison with other proximal soil sensors. Unpublished BScAgr thesis, Faculty of Agriculture, Food & Natural Resources, The University of Sydney.

Acknowledgments

This work was supported by an Australian Research Council Discovery grant on ‘Digital Soil Mapping” and the GRDC’s SIP09 Program.

Pasture Measurement: The First Step Towards Precision Dairying.

Ian Yule[1], Bill Fulkerson [2], Hayden Lawrence[1] and Robert Murray[1] ([1] *NZCPA, Massey University, New Zealand; [2] University of Sydney, Camden)*

I.J.Yule@massey.ac.nz

Abstract

Just like their cropping counterparts, dairy farmers require a method of measuring yield. A number of methods have been used to do this over the last thirty years, most notably, the Rising Plate Meter, originally the Massey Grass Meter (Holmes 1974). Other pedestrian carried methods, such as the conductance probes, have also been developed. All previous methods had the limitation of sampling speed which reduced their use; other issues included crop moisture conditions and inconsistency between operators. Although dairy farmers realised the importance of feed budgeting and a number of relatively sophisticated software packages were developed, their use was limited because of the quality of pasture measurement data going into the system.

For feed budgeting to be successful, good information on pasture growth must be available within a time scale that is consistent with the management practices of the farm. Research suggests a 10 to 15% improvement in the utilisation of pasture is possible through accurate feed budgeting. In New Zealand a 10 % increase in utilisation is worth over $560M NZD per annum to the dairy industry. It is also apparent that one of the critical factors in managing pasture is the residual level left after grazing, too little and cows will not be fed sufficiently, too much and grass is wasted and quality of pasture will ultimately suffer. When budgeting for a herd of 300 cows, accurate measurement of pasture is essential in order to calculate the amount of feed offered to the cows.

The lack of a fast, accurate, pasture measurement system was identified as the main limiting factor in the development of precision pasture management. After reviewing available methods, it was decided that a proximal method would be best suited to New Zealand conditions. The final outcome was a commercially available, ATV based pasture meter which is marketed by C-Dax Systems Ltd through a commercial agreement with Massey University. The unit can measure pasture cover at 20 km per hour. The trailed unit takes 200 measurements per second, these measurements are averaged and either recorded into the system or matched with a GPS location for mapping purposes. Three tiers are being made available to the market and are packaged with P-Plus feed budgeting software from Farmworks PFS Ltd, the third commercial partner.

The unit has been tested in New Zealand and Australia on a number of pasture crops. It has consistently out-performed the rising plate meter in terms of accuracy. Pasture tends to be variable and the large number of measurements taken increases the consistency of measurement, when sufficient samples are taken it is possible to create a pasture yield map. With this system, farmers can now develop greater confidence in their feed budgeting in order to provide better utilisation of pasture and allocated feeds. The system also provides the basis of a precision measurement system that can be applied to pastural agriculture.

Using "Weedseeker" Spot Spraying Technology in Cropping Systems

David Brownhill *(Crop Optics Australia)*

www.cropoptics.com.au

Background

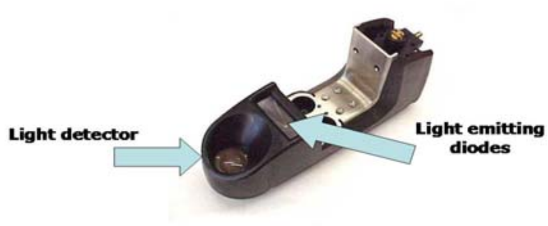
Crop and weed sensing technology has existed as a research tool in Australia since 1984. The concept was originally developed by researcher Warwick Felton at the DPI Tamworth. The reliable application of the concept in agriculture has only recently been possible with the commercial release of 'Weedseeker' and "Greenseeker" selective application equipment by US based company N-Tech Industries.

Selective spot spraying technology was commercialised in the USA seven years ago and has found wide commercial application around the globe in all types of agricultural environments. Sensors can be used to selectively apply herbicides, insecticides, fertilizers and fungicides to plants in a wide range of agricultural situations including cotton, broad-acre, horticulture and viticulture. Merrilong Pastoral Company at Spring Ridge in northern NSW imported the first 64 Weedseeker sensors for broad acre use into Australia in 2002 using matching grant money provided by AFFA under the "Farm Innovation Program".

Anywhere a product can be targeted to the plant and not bare soil, the weedseeker can provide large savings and big environmental benefits.

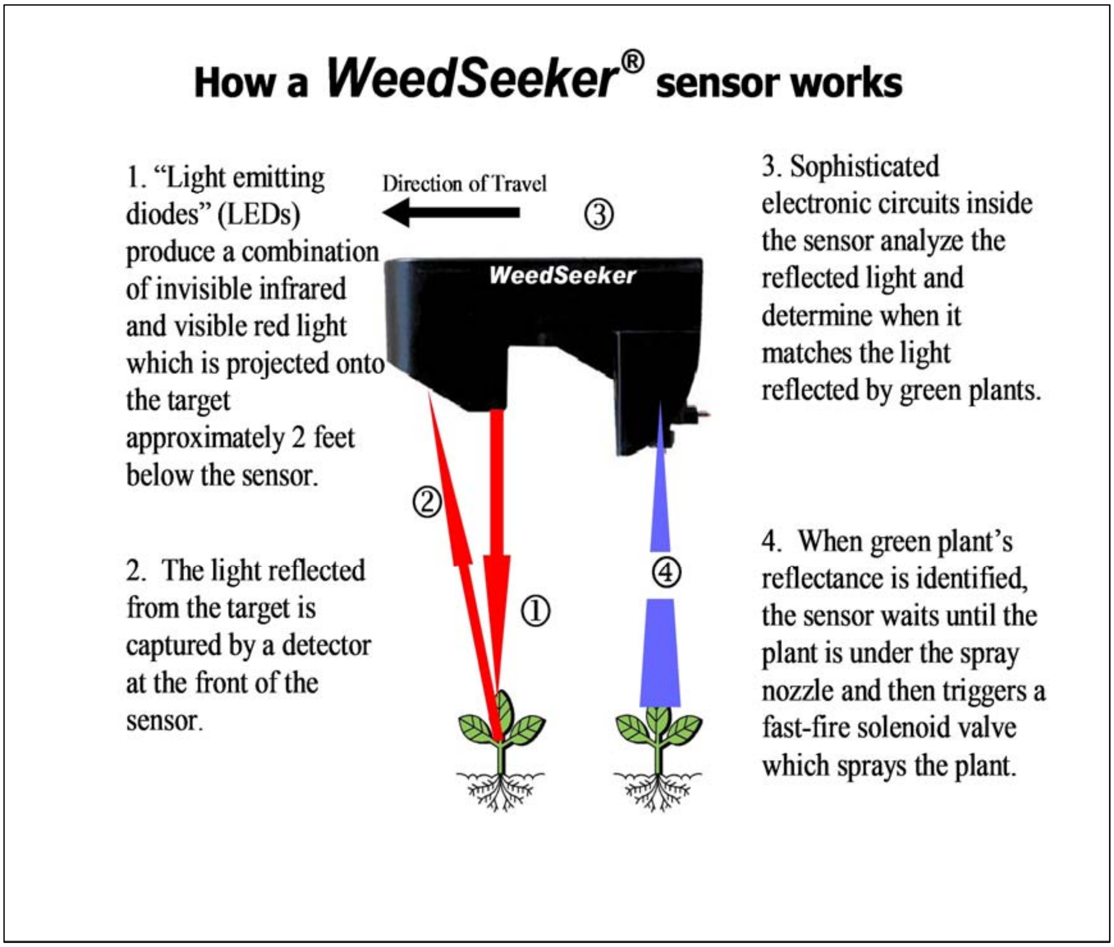
DPI research in Northern NSW has shown that average weed cover in fallow paddocks is as low as 20% of the paddock area. This means that often 80% of the herbicide applied falls on bare soil and is wasted. This is inefficient, expensive and environmentally unstainable. There are now 13 commercial spray-rigs across NSW and Qld operated by both farmers and contractors achieving large reductions in fallow herbicide use and savings of 80% and better.

Components of the Sensor Head



The **WeedSeeker®** sensor has a built in light source consisting of light emitting diodes (LED's). It uses both visible and infrared LED's. The light detector measures the reflectance of the ground over which it travels.

Weedseeker Operation



Weedseeker Applications

1) Broad-acre fallow spraying
2) Shielded spraying in row crops
3) Application of fungicides, insecticides and fertiliser in horticultural crops
4) Spot spraying on irrigation channels
5) Viticulture and tree crops
6) Industrial uses including weeds on roads, railways, airports etc

Hugh Ball's Weedseeker on a Hayes linkage boom

Peter Farrell's Weedseeker on a Goldacres self-propelled sprayer

Weedseeker Benefits

1) ***Reduce Herbicide Costs*** - Australian and USA research has shown savings in herbicide use in cotton, soybeans and fallows commonly in the range 50-80 %. Commercial use of the weedseeker systems in the northern cropping area over the last four years have resulted in actual reductions in fallow herbicide use of 90 %.

2) ***Herbicide Resistance*** - The emergence of hard to kill fallow weeds such as fleabane, peachvine, milkthistle, roundup ready cotton and marshmallow has become an increasing issue in the northern cropping region. Australia was one of the first countries in the world to discover resistance in annual rye grass (Lolium sp) to the common fallow herbicide Glyphosate. The weedseeker allows us to use mixtures of different herbicide groups, which may be currently too expensive to apply in a blanket application. This will prolong the life of existing herbicides and reduce resistance in weed populations greatly improving sustainability of cropping systems.

3) ***Reduction in Herbicide Drift*** - When we only spray the weeds and not the paddock the total pesticide released by the boom is substantially lower. The risk of herbicide drifting onto non-target areas and the surrounding environment is reduced.

4) ***Increased Adoption of No-till*** - Reduced tillage cropping systems can provide environmental benefits in terms of reducing soil erosion by wind and water. The system is more profitable but the input costs are high due to the increased herbicide use. Reducing herbicide use would improve returns further and allow more farmers to adopt the system to the benefit of the whole agricultural landscape.

5) ***Environmental*** - reducing pesticide load in the environment benefits the whole community

Examples of Herbicide Savings

Jamie Grant - Dalby QLD		**Peter Farrell- Moree NSW**	
Field Area - 246 hectares		**Field Area -** 120 hectares	
Weeds - Peachvine, milkthistle, fleabane, volunteer cotton		**Weeds -** Volunteer cotton 30 cm high	
Herbicide-2.6 L/ha Rup + 4 L/ha Surpass		**Herbicide-** 1 L/ha Starane + 1 L/ha MCPA	
Actual Area Sprayed-11.88 ha (4.5%)		**Actual Area Sprayed-**18 ha (15%)	
Cost of Blanket Spray	$7840	**Cost of Blanket Spray**	$3360
Cost with Weedseeker	$353	**Cost with Weedseeker**	$504
Herbicide Saving/Field	$7487	**Herbicide Saving/Field**	$2856
Herbicide Saving/ha	$30.43	**Herbicide Saving/ha**	$23.80

Further Information: Greg Giblett 0428 667752 Agronomist
Dan Moloney 0428 664318 Sales Manager
Dave Brownhill 0427 473725 Director

Hypercpectral And Thermal Technologies For Assessing Nitrogen And Water Status In Wheat

Glenn Fitzgerald *(DPI VIC)*, **Garry O'Leary** *(CSIRO)*, **Robert Belford** *(DPI VIC)*, **Adam Tilling** *(RMIT)*, **Daniel Rodriguez** *(APSRU),* **Lene Christensen** *(NGB, Sweden)*, **Mohammad Abuzar** *(DPI VIC)*, **Tom Clarke** *(ALARC)*

glenn.fitzgerald@dpi.vic.gov.au

Abstract

Nitrogen (N) is one of the most expensive inputs for rainfed wheat systems in Australia. Since plant N uptake requires a sufficient supply of soil available water, targeting N inputs at the proper growth stage and in areas of a paddock with sufficient water supply would provide the greatest potential for improving N use efficiency and crop yield and quality.

Remote sensing of thermal and spectral properties of canopies can provide rapid, non-destructive assessment of crop water and nitrogen stresses. One of the major challenges to the practical use of remote sensing is the "mixed pixel" phenomenon, where the spectral or thermal information for the plant target is mixed with soil reflectance. We demonstrate approaches for detection of N and water stress that can separate these signals at the canopy level.

Results from thermal and multispectral measurements of wheat crops in two cropping systems, Horsham, Victoria, Australia and Phoenix, Arizona, USA are presented using a Canopy Chlorophyll Content Index (CCCI) for assessing N stress, and temperature relationships to measure water status. Under irrigated wheat systems in Phoenix, temperature relationships between mixed canopy and foliage temperatures showed similar relationships to those for dryland wheat in Horsham. The CCCI led to good relationship with chlorophyll and N at both locations early enough for potential mid-season N fertiliser recommendations.

By combining canopy-level thermal and spectral properties, varying water and N status can potentially be identified, eventually permitting targeted N applications to those parts of a field where N can be used most efficiently by the crop.

The Use Of Yield Prophet In Zonal Management Decision Making

Dale Grey *(DPI VIC)*

Dale.Grey@dpi.vic.gov.au

Abstract

This paper presents data from a paddock at Telford near Yarrawonga in NE Victoria (500mm average anual rainfall). Paddock 44 has been part of a Precision Agriculture project conducted by the Riverine Plains farming system group and funded by the GRDC in conjunction with the Australian Centre for PA in Sydney. Intensive monitoring has occurred over the last 6 years which has enabled the delineating of the paddock into three zones. We have called these High, Medium and Low as characterised by their electromagnetic reading and these correspond to areas of the paddock with a deep clay soil (vertisol), a duplex loam over clay and a duplex loam over fractured siltstone rock respectively. For the last three years DPI has been monitoring this paddock as part of their monitor paddock project.

In 2005 we undertook to classify each of the three zones with enough information to enter it into the Yield Prophet model (YP). YP is an interface that uses the APSIM model of crop growth developed by the Queensland DPI and F. The crop grown this season was spring barley sown in June. Throughout the season a number of runs were conducted that modelled differences in growth and potential yield of these three areas. Due to a dry start to the season followed by a decile eight spring, potential yield rapidly increased towards the end of the season, making management decisions difficult. At the end of the season YP was overestimating the yield of the crop significantly but the trend in differences in the zones was quite accurate. The YP barley model has since been reparamatised making closer yield projections. In 2006 the paddock has been sown to canola, one of only two paddocks in Victoria to do so this season and we are helping to validate the canola part of the model.

Accurate soil characterisation is essential to get the model to run correctly, but we are confident that the differences being predicted between zones are believable and useful.

Data will be presented as to the information the model can provide to aid decision making on a paddock incorporating different zones.

Measuring Whole-Farm Crop Variability Using Pseudo Yield Mapping

Peter Fisher, Mohammad Abuzar *(DPI VIC)*

peter.fisher@dpi.vic.gov.au

Abstract

Crop yields vary both within paddocks (spatially), and across seasons (temporally). However, many growers are uncertain whether the level of variability on their property justifies significant capital investment in precision agriculture (PA) technology. The cost of PA equipment and concern over the cost-benefit of investing in it are the two major reasons why growers are cautious about adopting PA, according to a 2004 GRDC survey. Other growers may already be investing in PA technology, but would like to understand the nature of their paddock variability more rapidly than can be obtained by collecting annual yield maps.

To help inform growers of the economic importance of crop variability on their farm, a low cost analysis tool has been developed that provides an estimation of yield variability across an entire enterprise. The output from the tool is a yield map similar to that obtained from harvester-mounted yield monitors, but the yield variability is modelled from relationships rather than measured. This analysis is referred to as Pseudo Yield Mapping (PYM).

PYM uses historical satellite images available from Landsat satellites. The process relies on growers having recorded a detailed rotation history for each paddock and average paddock yields for as many seasons as possible. Using this information, Landsat images are selected for seasons that have similar crop types. This is important because the reflectance from a pulse or cereal crop can be very different and should not be analysed together. The satellite image data is used to create an NDVI map that represents the crop biomass, and a global standardisation is applied to ensure that major seasonal and spatial differences are retained and depicted on the final map. The final stage of the analysis is to develop the relationship between the remotely gathered biomass data and the actual average yield recorded by the grower for each crop. The result is an average pseudo yield map for each paddock on a property. The final whole-farm map consists of pixels of data averaged over all the years of available data for each major crop type.

The PYM approach has been tested on 12 paddocks in the southern Mallee. Results show the average yield at different locations across these paddocks varies from one tonne per hectare to 2.75t/ha. In the trial, the map produced by the PYM approach agreed closely with the comments of the farmer and showed that some paddocks were generally better yielding than others (Figure 1). It also showed that variability within each paddock fluctuates considerably. Some paddocks had very uniform production, while for others the average yield over time varied from one part of the paddock to another. PA tools such as variable rate technology would provide the greatest cost benefit in those paddocks with greatest variability.

The map of estimated yield variability can thus be used by growers and agronomy consultants to investigate the causes of yield differences and consider the most appropriate and economic remedies. This could include further soil testing or investment in PA technology.

PYM provides a further level of information than systems that zone a paddock into high, medium or low. This means that growers can identify paddock variability and prioritise the areas that will provide the best return from more precise agronomic management.

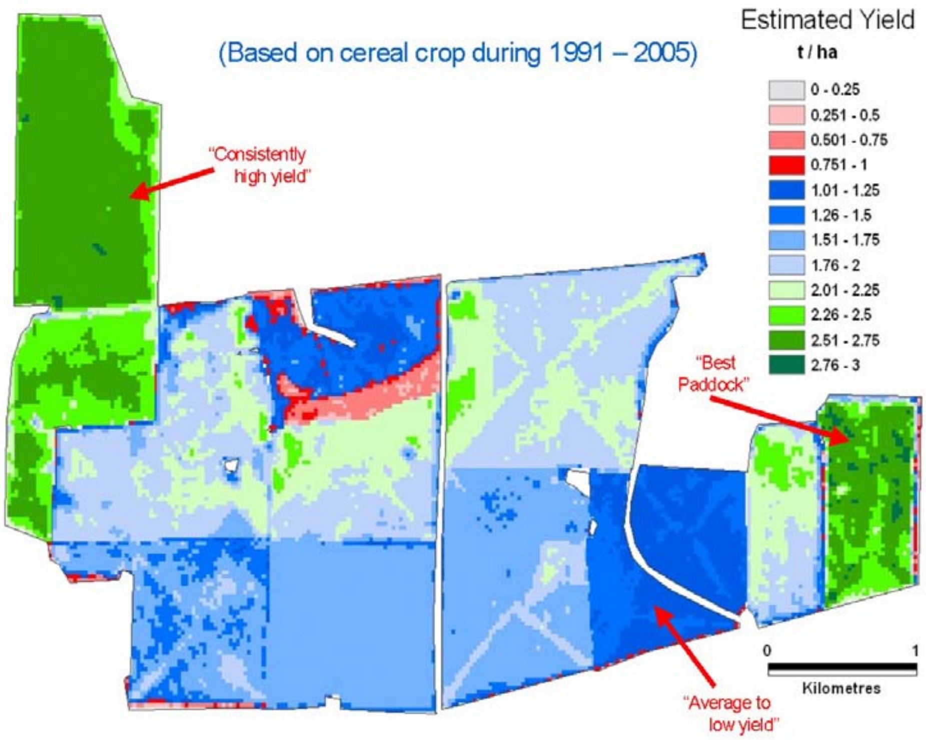


Figure 1. Map of estimated average yield developed from the Pseudo Yield Mapping approach (comments from grower in red).

New Products From John Deere – How To Influence The Process

Broughton Boydell *(John Deere)*

BoydellBroughton@JohnDeere.com

Ag Management Solutions - GreenStar products

John Deere Ag Management Solutions (AMS) is an advanced technology group that focuses on products and solutions that advance the excellence in agriculture. Our GreenStar™ System is designed to help customers make better management decisions, increase productivity, and provide value throughout the entire farming operation.

A Method Of Mapping Actual Fertiliser Distribution In The Field

Ian Yule, Hayden Lawrence and Robert Murray *(NZCPA, Massey University, New Zealand)*

I.J.Yule@massey.ac.nz

Abstract

Precision agriculture is based on the premise that field application of fertiliser is completely uniform. Internationally recognised testing methods tell us that we could expect a CV of at least 15 % for products containing N and 25 % for products without N. Using GIS and the positional information from the spreading operation, it was possible to calculate the actual CV achieved in the field.

In a study of ground spreading operations over 102 paddocks on 4 dairy farms, the typical field CV was found to be 37.9 %. Paddock shape was found to have an effect with irregular shaped paddocks having a higher application variation (40.8 %). The target application rate on all farms was 80 kg ha^{-1}, the actual application rate varied from 51.8 to 106.7 kg ha^{-1} of urea (46 % Nitrogen) fertiliser on individual paddocks. Variation due to driving accuracy and driving method was calculated to be 22.9 %, greater than the 15% calculated from a transverse test. The lowest calculated level of paddock variation on all farms was 20.8 % on a 2.94 ha regular shaped paddock. The highest calculated paddock variation (62.3%) was on a 0.80 ha irregular shaped paddock. This work was based on the assumption that transverse application variation due to speed fluctuations by the spreading vehicle was perfectly controlled by the on-board computer.

Field CV would increase if no speed to flow compensation control system was fitted to the spreader. The CV is also likely to increase with the presences of slope. Travelling across slopes can disturb the spread pattern, while up and down spreading changes the ratio of forward speed to engine speed (assuming a mechanical drive is used for the spinners) because of wheel slip and engine loading.

It was shown that by improving driving accuracy, considerable improvements in field CV could be achieved, an economic analysis is presented. For dairy farms in New Zealand using small paddocks (1 – 2 ha) it was estimated that an achievable field CV is between 25 and 30 %.

Similar methods were used for aircraft testing. Without the use of GPS guidance a test (over a 20 ha block) revealed a field CV of 90%. Flying the same block again with GPS guidance reduced the CV to 60%. A further large property 2,200 ha was flown and the CV derived from a GIS model. The result was an overall CV of 72%. The main reason for the high CV was the lack of a flow control system to adjust for fluctuations in aircraft speed.

Estimates of economic loss to the farmer were made and it was found that poor spreading was typically costing \$10 ha^{-1}, reducing fertiliser use by not spreading on unproductive areas had a further cost advantage of \$9 ha^{-1}. Adoption of variable rate application technology (VRAT) had the potential to yield an increased financial benefit of \$85 ha^{-1} (where perfect spreading is assumed). However, VRAT is not a realistic proposition unless accurate spreading can be achieved.

Using Variable-Rate Technology in Cotton Fields

Steve Madden *(Steve Madden Agriculture Pty Ltd)*

stevemadden@smag.com.au

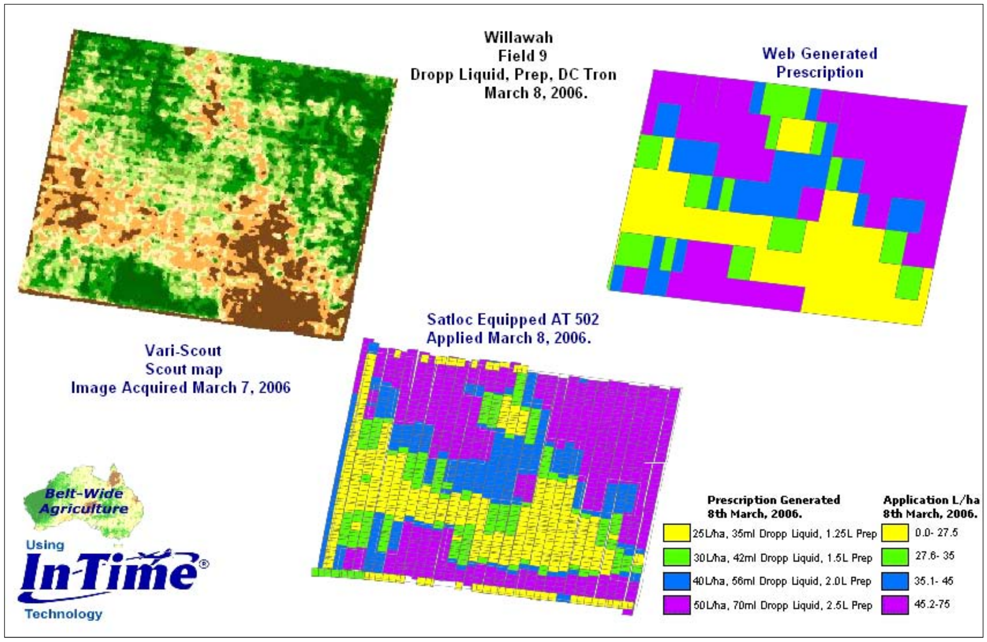
Background

50 fields of irrigated cotton in the Namoi Valley were defoliated this season using variable-rate technology provided by Belt-Wide Agriculture. Belt-Wide Agriculture is licensed by InTime Inc. to provide its technology to Australian agriculture. InTime is a company in Mississippi offering new and innovative precision farming services.

Biomass images obtained by aircraft at 12 000ft are processed into scout maps which are able to delineate management zones in crops. Agricultural consultants and agronomists are able to access 'scout maps' from the InTime website. Ground truthing the 'scout map' is performed using a handheld computer equipped with GPS capabilities and suitable software to make more informed decisions about crop treatments. Prescriptions for the application of variable-rate crop inputs are generated by the Intime website in minutes. Growers and applicators can easily download files for variable-rate equipped applicators.

Case Study One

The treatment below is a once over defoliation application by air. Higher rates of Prep and Dropp Liquid combined with higher volumes of water were applied to the highest biomass zones and lower rates to the lower biomass zones. The field was ready to pick fourteen days after application. For an investment of \$10/ha the grower saved \$28/ha through an application at \$13/ha and defoliant \$15/ha.



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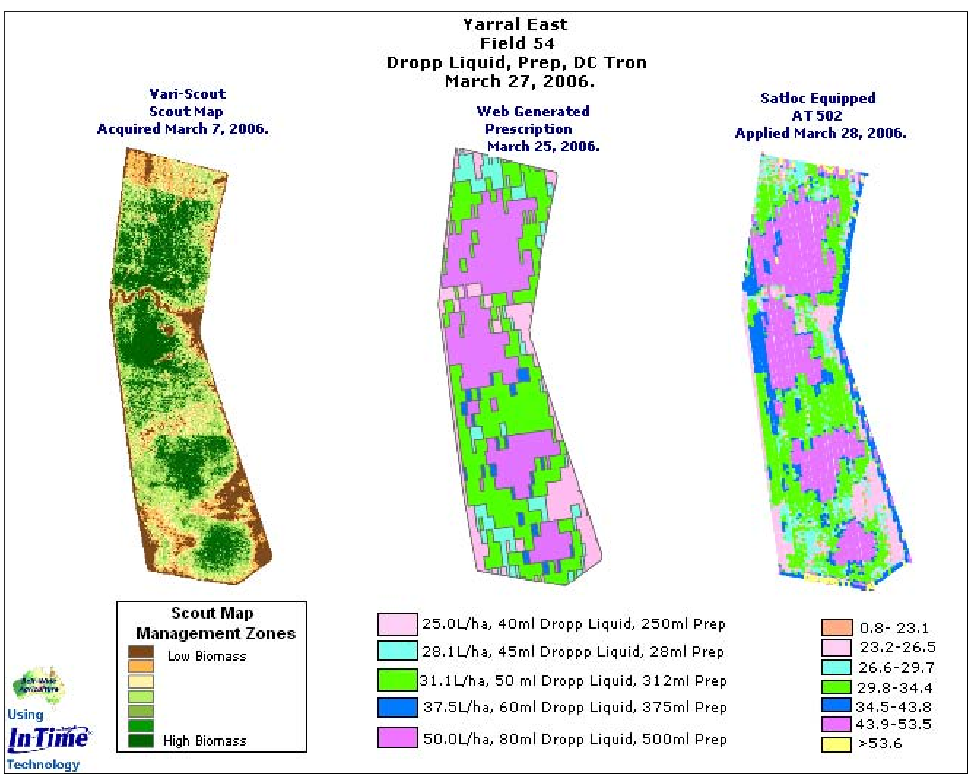
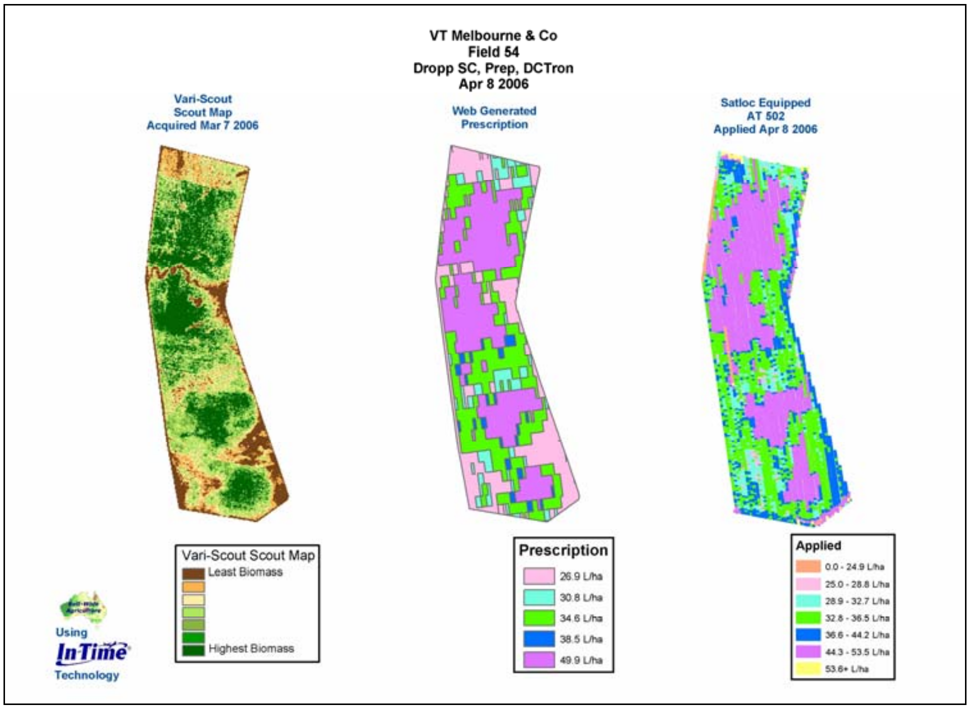
Case Study Two — two pass defoliation

A two pass defoliation application applied by variable-rate cost $49.25/ha in defoliant and resulted in savings of $9/ha in Dropp, Prep and DC Tron. Higher rates of water and defoliant were able to be applied to cotton with the highest biomass. The result was a quicker defoliation and boll opening of the higher biomass areas. The field was ready to be picked 5 days earlier than conventionally treated fields.





Addressing Variability In Soils

Ian Delmenico *(Crop-Rite Pty Ltd, Swan Hill)*

deli@bigpond.net.au

Take Home Messages

- ***Know and understand the variability***
- ***Understand the ability of a zone to supply stored moisture back to the crop***
- ***Information is critical to making the correct decision***
- ***Target inputs to biggest response and potential***
- ***Always focus on the bigger picture***

Identifying and understanding is the first step to addressing variability in soils

Looking at the bigger picture gives better direction than an isolated area. When focusing on an isolated paddock, it is hard to get an appreciation of trends. Adding other paddocks and farms into the picture often shows trends and patterns allowing better decision making to take place.

Variability can be caused in many ways and overlap with other variable factors. By identifying the type of variability we can then place them in 2 major categories: short-term and long-term.

Short term variability - once identified these are the first to be corrected leading to elimination

Pests:	perennial weed, annual weeds, resistant weeds, vermin
Previous history:	removing internal fences, splitting of paddocks to differing crops
Rainfall pattern:	part of a paddock receiving the edge of a storm
Nutrition:	balance over- and under- supply
Top Soil Constraints:	sodicity, compaction

Long term variability - once identified these are able to be managed as production zones.

Sub-soil constraints:	salinity boron
Topography:	erosion, runoff
Texture:	sand, silt clay

To first identify variability we need the following :-

1.	*Previous history layers:*	rotations, channels, dams, banks etc
2.	*Weed layers:*	perennial, annual, resistant
3.	*Stable data layers:*	Em-38, topography
4.	*Variable data layers:*	yield maps, protein maps, moisture maps

All these layers can play a part in identifying or eliminating possible reasons associated with variability. EM-38 data layer (Fig.1) can help show subsoil variability in the form of salinity, which may not be visible on the surface, allowing zones to be produced. Within these zones the highest and lowest focal points can be located.

Soil sampling transect lines can be applied to areas that show the same characteristics.

Sampling can be carried out to ascertain nutrient levels and identify hostile levels. At this time compaction and moisture levels can be identified and recorded.

Segmenting samples (Table 1) enables us to examine what is available to the plant through the profile showing differing levels of nitrogen and other nutrients within zones and at depths. This allows us also see hostile sub soil concentrations resulting in informed decisions to be made, varying crop selection, seeding rates, fertilizer rates and timings.

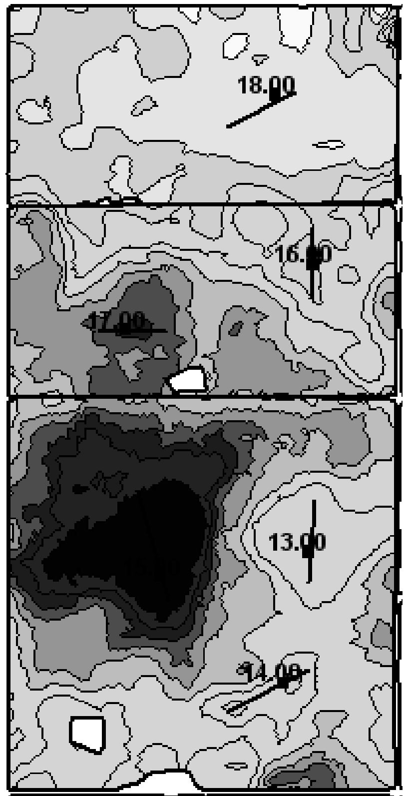


Figure 1. EM38 data layer

Table 1. Soil sample analysis results

		0-20cm			20-60cm					Soil Nitrogen			
Code	**O/C%**	**Nit-N**	**A-N**	**Sul**	**Nit-N**	**A-N**	**Sul**	**EC**	**Boron**	**Min**	**0-20**	**20-60**	**TA-N**
A-13	0.7	4	1	2.1	2	1	6.8	0.28	6.7	23	14	17	**54**
A-14	0.4	2	1	1.9	1	1	11	0.15	4.3	13	8	11	**33**
A-15	0.7	7	1	26.1	15	1	286	1.61	31.3	23	22	90	**135**
A-16	0.5	6	2	3.9	5	1	12.3	0.21	7.3	17	22	34	**73**
A-17	0.8	26	1	8.8	33	2	259	1.38	26.6	26	76	196	**298**
A-18	0.5	8	1	3	5	1	6.6	0.22	8.2	17	25	34	**75**

Communication

Communication between farmer and agronomist is critical to end result as the farmer has the most knowledge regarding visual data layers and history. The agronomist, (the person creating and applying the information to the zone) needs to be able to communicate with the VRA Systems. If this cannot be done in the most efficient for the farmer, then some of its effectiveness may be lost in the process.

Spatial Distribution Of Soilborne Disease Inoculum

John Heap and Alan McKay *(SARDI)*

heap.john@saugov.sa.gov.au

Summary

Soilborne diseases (eg take-all, rhizoctonia, CCN, and crown rot) cause large losses in Australian field crops, and often drive crop rotations. Research has demonstrated that spatial distribution of these diseases is correlated with variation in soil attributes, topography and patterns of plant growth. Differences in inoculum level are frequently found between PA production zones derived from both proximally-sensed and remotely-sensed data. Exploitation of zonal inoculum differences between PA zones has potential to improve the efficiency and reliability of soilborne disease sampling strategies, and offers the potential for differential disease management at the production zone and SSCM level. To define these zones tools are needed, so a range of data layers and zone models were evaluated.

Spatial data layers (c.30) were collected over five paddocks to determine which combinations of layers were most suitable for defining zones for disease inoculum measurement. Six models were used to generate zones for each paddock, and inoculum was measured for points on a grid over the paddock. The models used produced zones from:

a) Proximally-sensed data (yield, ECa, DEM).
b) Satellite NDVI data.
c) Custom disease zones (using correlation matrices and Forward Stepwise Multiple Linear Regression to choose layers - “Custom MLR”).
d) Biological layers (yield, NDVI, aerial photography, N-sensor).
e) Geological layers (ECa, DEM, slope, gamma-radiometric and magnetic).
f) ECa alone.

Zone models a) and b) were also compared over an additional eight paddocks. “Partition Index” (PI) was devised to compare the relative ability of each zone model to partition paddocks into zones with different inoculum levels. The PI takes into account differences between zone inoculum means and the whole paddock mean, as well as the size of each zone. Averaged over the five paddocks Proximal (a), Satellite (b) and Custom MLR (c) zone models were equal best. Biological (d) and Geological (e) models were equal but less useful, while ECa alone was least useful. Given the complexity of the interactions involved it appears difficult to predict the usefulness of specific models *a priori*. Use of custom MLR zones is probably unwarranted. Comparison of Proximal and Satellite models over 13 sites suggested that they were equally useful for the major diseases take-all, rhizoctonia and CCN. Satellite appeared better for crown rot, but Proximal was better for common root rot, *Pratylenchus neglectus*, and *Pratylenchus thornei.* Considered over all diseases, Proximal and Satellite were similarly useful. In summary, it is suggested that zones be derived from the cheapest available Proximal or Satellite data for disease inoculum sampling.

Planned future research includes: 1) investigation of zones with a biomass–yield gap; 2) Decision Framework prototypes; 3) paddock-scale VRT experiments; 4) inter-row sowing; and 5) on-farm validation of risk management and VRT strategies.

Towards Autonomous Precision Implement Guidance

Jayantha Katupitiya, Ray Eaton, Tomonari Furukawa *(UNSW)*

J.Katupitiya@unsw.edu.au

Abstract

Time has come for the agricultural and horticultural industry to think about how to shape its future from the point of view of agricultural task execution. It was not long ago that many of us were skeptical about the unmanned shop floor. How could an entire factory be void of people, yet carry out all assigned tasks flawlessly! Even more daring is the Australian container handling facility operated entirely by unmanned machines. These are example situations in which the marrying of autonomous operation with precision manipulation has been successfully achieved.

Unlike the examples mentioned above, the agricultural industry faces the challenge of cultural shift if it is to achieve fully autonomous operation. Primarily this includes bringing in structure to farming operations. In the past, we may have ignored the accuracy of distance between plants, straightness of crop rows, depth of plantation, field leveling etc. To bring autonomous systems into unstructured environments and to claim success is almost impossible. The more structured the environment, the more successful the autonomous operations are.

This presentation is about autonomous systems that are destined to carry out precise agricultural operation through unmanned machines. We aim to experiment with methods that would precisely guide the dragged implements, which may finally lead to driven implements with distributed coordinated control.

We are currently preparing a John Deere tractor for autonomous operation and an implement is being designed for precision guidance. The tractor is equipped with automatic traction and steering control, twin GPS systems for position and orientation determination, inertial navigation system as a navigational aid during the absence of GPS and tilt sensors. It has an intricate safety sub-system and remote communication through a radio Ethernet. It also has an on-board long range modem communication system to communicate with a GPS base station for RTK operation.

Precision Agriculture Around The World – A Nuffield Experience

Mark Branson *(Clifton Farms, SA)*

marknola@bigpond.com

Summary

Australian farmers need to increase farm efficiencies to stay competitive in world grain markets. My Nuffield Scholarship "Using Conservation and Precision Agriculture to improve farm profits and the environment" took me to Europe, Canada, and USA where agriculture has been practiced for long periods of time under very different environments and farming systems. My aim was to look at these systems, new cropping technologies, and assess whether these applications maybe relevant to improve profitability and sustainability in Australian broadacre cropping.

Conservation agriculture is keeping a healthy, living soil that has the ability to breakdown plant residues into future nutrients, have a structure that is able to maximize water storage with reduced soil erosion, and active micro-organisms that are able to help in the breakdown of the plant residues plus aid in the adsorption of pesticides and other chemical wastes.
There are two aspects to conservation agriculture that I studied. The first being Carbon farming, involving no-till, stubble retention, and high carbon crop rotations, and the second being removing compaction from our soils by adopting no-till and controlled traffic systems.
Two trials that stood out on my trip were Jim Halford's long-term no-till trial at Indian Head Canada, and Dwane Beck's high Carbon rotation trial at Dakota Lakes research farm in USA. Both showed that by adopting conservation agriculture techniques you could dramatically improve the soil and the farms profits.

Precision agriculture (PA) is matching agronomy with paddock variability and has opened up a new level of management in broadacre cropping. It has come about by the advent of GPS technology where any position in a paddock can be repeatably logged.
In Australia the initial adoption phase of PA is looking at zonal management where areas of variation within the paddock are identified and used to form a management zone. Now there is series of on-the-go sensors that have been developed overseas that will aid in making precision agriculture easier and affordable.

There is the development of the Verris Mobile Sensor and an Austrailan developed Buffer pH sensor, which will be able to map pH and other soil attributes quickly and at a reasonable price. Plus an on-the-go grain protein sensor for protein mapping and nitrogen budgeting has been released by Zeltex, and was partly developed by the Australian Centre for Precision Agriculture.

I was most excited about the new remote sensing technology to be used primarily for post nitrogen applications, but can be used with plant growth regulators and fungicides. The sensors that have promise are the satellite package from EADS France called "Farmstar", numerous aerial imagery companies carrying Multi-spectral or Hyper-spectral sensors, and the on-the-go ground sensors, the improved Yarra N Sensor, N-Tech's GreenSeeker ®, and

the new Crop Circle sensor developed by Holland Scientific in the USA. These sensors have been shown to increase crop profits by Aus$28/ha to Aus$100/ha in overseas research, plus can lead to a third less nitrogen being leached into the environment. I see potential for these sensors to be used in Australian broadacre cropping systems, but application algorithms need to be developed and the economics need to be defined for Australian conditions.

Phosphorus is an element that if adequate, should be placed in the soil at the replacement rates derived from the previous years yield map. The ability to accurately budget nutrients is a vital step in making precision agriculture work in relation to applying fertilisers, and for this to occur one needs to determine what nutrients are able to come from the soils natural pool. This is something worldwide scientists are working on, and I found only one company that has worked on a scheme trying to predict the uptake of nutrients into the roots of plants. This work has been done by Western Ag. Innovations Inc. from Canada, and they use plant root simulation probes (PRS) to attract nutrient ions to the probe over a 24 hour period, and hence are able to tell what nutrients in the soil would be available to the plant in that time. Alongside of this is a computer model, developed by the company, which forecasts yield potential and demand from the crop, which when added to the PRS data is able to optimise profit from the fertiliser inputs.

Conservation and Precision agriculture have bright futures for Australian broadacre cropping farmers, and my report covers the reasons why they will help in improve farm efficiencies, as well as reasons why they are essential in preserving the environment.

8th International Conference on PA – An Assessment

James Taylor *(ACPA, University of Sydney)*

james.taylor@usyd.edu.au

Summary

The 8th International Conference for Precision Agriculture was held from July 23-26, 2006 in Minneapolis, Minnesota, U.S.A. Approximately 350 people from 27 countries (and 32 states in the U.S.A) attended over the 4 days with ~50% of these from industry organisations. There was only a small Australian contingent (5) that included two growers, two industry representatives and myself. While a wide variety of themes were covered at the conference the main emphasis was on Remote Sensing (particularly proximal sensing for nitrogen management) and Precision Management (including on-farm experimentation). These two topics encompassed nearly half the 160 oral and poster presentations. There were very little emphasis on environmental and conservation aspects of this technology, developments in crop quality sensors and applications of PA outside of broadacre crops e.g. viticulture, horticulture and livestock. The trade exhibition which accompanies the conference has always been a strong point of the International Conference on PA. This year there were 28 companies represented with a shift away from hardware manufactures to software providers. There were several Web-based data (primarily imagery) delivery companies as well as farm-based GIS software providers with stands at the conference.

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