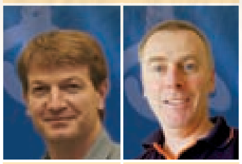
Photo: Ben Jones, Mallee Focus

Greater interest: *Rising fertiliser costs have contributed to an increased uptake of variable rate fertiliser application and the potential use of EM38 soil mapping data for paddock zoning.*

Key role for EM38 soil mapping in the mallee

Scientists have been working with grain growers, farm advisers and extension officers in the vast dryland mallee of southern Australia to develop electromagnetic soil mapping as a practical, more widely used farm management tool.

AUTHORS



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FOR CSIRO SUSTAINABLE ECOSYSTEMS

At a glance

- Electromagnetic soil mapping is well suited to the low-rainfall mallee environment. It is now being widely used to map soil variation important to yield potential and fertiliser management.
- Researchers have shown fertiliser inputs can be reduced and average paddock gross margins increased by zoning mallee paddocks according to the potential yield responses of different soil types.
- A key focus of this work now is on developing tools and packages to further facilitate cost-effective use of electromagnetic soil mapping and improved input strategies based on soil and season type.

Electromagnetic (EM38) soil mapping offers grain growers in the extensive dryland mallee of Victoria, New South Wales and South Australia a relatively low cost and reliable option for zoning paddocks according to soil type and potential yield responses.

By using this information in combination with precision agriculture technologies, growers can reduce their use of inputs such as fertilisers, and increase their average paddock gross margins.

This is the key finding of a three-year research project, known as Reaping Rewards, in which scientists have been working with grain growers, farm consultants and extension officers to develop EM38 soil mapping as a practical farm management tool.

Background to the research

The mallee covers about five million hectares of farmland with an average annual rainfall of 350 millimetres or less. It stretches from Hay, NSW, in the east, across the northwest corner of Victoria, to Murray Bridge, SA, in the west. The main agricultural activities in the mallee are the cropping of various cereals and pulses, and livestock production.

The Mallee Sustainable Farming (MSF) group is a farmer-driven organisation promoting the development and adoption of profitable and sustainable farming systems throughout the mallee.

During 2005, MSF initiated the Reaping Rewards project, which involved a series of paddock trials, field testing and computer modelling simulations to demonstrate the reliability and effectiveness of EM technology for soil mapping and support its more widespread use as a practical, on-farm management tool.

Project stakeholders (grain growers, farm consultants, extension officers and scientists) agreed that to achieve this aim, there needed to be a much greater validation of the ability of EM38 technology to cost-effectively map important soil characteristics and lead to profitable variable rate management of zones.

Photo: Ben Jones, Mallee Focus

Variable rate: *About 35 percent of farmers in the Victorian mallee have used variable rate fertiliser on identified zones within paddocks — a much higher proportion than most other cropping areas of Australia, where the average is about 20%.*

EM38 soil mapping

EM38 soil mapping measures the apparent electrical conductivity (ECa) of soil. Factors such as soil moisture content, salt levels and soil texture affect the concentration of conductive materials and influence this measure.

ECa measurements are usually obtained through a high-resolution EM38 survey, which typically involves an all-terrain vehicle equipped with an electromagnetic sensor and data recorder traversing the survey paddock. When combined with targeted soil testing, data from such surveys can often be used to map soil properties such as plant available soil water storage capacity (PAWC), clay content and soil depth.

Although it is necessary to analyse soil core samples to calibrate and validate EM38 measurements, EM38 mapping is particularly useful in the mallee as it usually correlates well with important soil characteristics that are associated with crop yield potential, such as common salt-related subsoil constraints that reduce plant available water.

Past research has shown EM38 maps on typical mallee soils reliably identify important and relatively 'fixed' soil characteristics related to yield.

So on mallee soils, EM38 maps can be used as a stable base layer for developing paddock zones that support the application of precision agriculture and variable rate technologies.

Greater interest in this technology

Dramatic increases in fertiliser prices during recent years, coinciding with some relatively poor seasons, have greatly increased the need for more carefully allocated and cost-effective fertiliser use.

During the same period, the technology and services that make precision agriculture and variable rate technologies feasible have become cheaper and more readily available to farmers. For example, EM38 mapping services are now available for less than $5 per hectare — making it relatively easy and inexpensive for growers to obtain more detailed spatial information about the soils in their paddocks.

These factors have contributed to a significant increase in interest in zoning paddocks and variable rate fertiliser application. Estimates from consultants offering commercial EM38 mapping services suggest the area of cropping land EM38 mapped in the Victorian mallee alone has increased from about 20,000ha during 2006 to 120,000ha during 2008.

Paddock trials and modelling

During the 2006 and 2007 seasons, the research team carried out a number of paddock trials aimed at developing cost-effective methods to define zones on mallee soils and evaluating the profitability of variable rate fertiliser application.

Given the difficulties of evaluating fertiliser strategies using data from just two seasons, which, as it turned out, were very dry, Anthony Whitbread from CSIRO Sustainable Ecosystems ran a series of wheat crop yield simulations using APSIM to evaluate variable rate profitability over a longer term and wider range of seasons. (APSIM is a computer modelling tool that uses data such as soil, fertiliser, rainfall and weather records to predict crop performance. It allows users to see how different combinations of inputs will impact on potential crop yield.)

The simulations used soil data from paddocks across the Victorian, SA and NSW mallee. Results from Carwarp, Victoria are shown here as an example. Each paddock was classified as having low, medium or high EM soil readings. (The areas of each soil class were 65ha, 32ha and 24ha respectively, see Figure 1.) Yield performance in each of these soil zones was simulated using weather records from the past 50 seasons. It was assumed wheat was sown between April 25 and July 15, with sowing triggered by 10mm of rainfall over five days and at least 10mm of available soil water in the profile.

What the paddocks trials showed

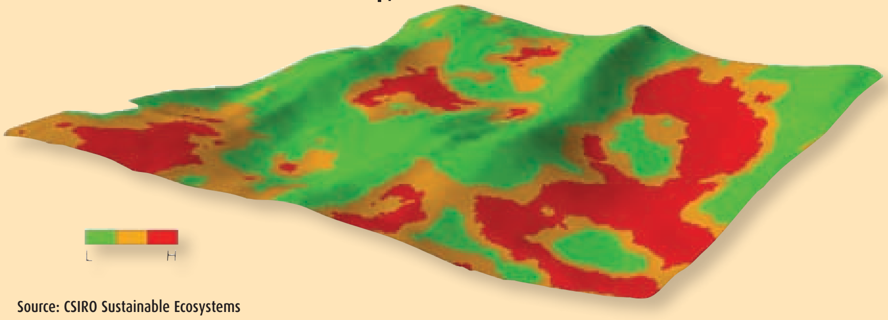
During 2006, average barley yields were 0.6 tonnes per hectare in the low EM zones and 0.2t/ha in the high EM zones at Carwarp. The following season, average wheat yields at Carwarp were 1.3t/ha in the low EM zones and 0.8t/ha in the high EM zones.

Both seasons were very dry, with almost no spring rainfall during the finish of the crops. During such seasons, the soil characteristics that are typically mapped by EM surveys (texture and salts) significantly influence yield.

The dry seasons meant there was little response to fertiliser during the trials, particularly on the heavier (high EM) soils. This lack of fertiliser response in the higher EM zones showed the potential to increase gross margins by greatly reducing nitrogen input on these zones.

Indeed, the dry season and the presence of relatively high starting nitrogen and phosphorus levels during 2007 meant that zero fertiliser was the most profitable option on all EM-based zones. (At Carwarp, the nitrogen levels at sowing were high:

FIGURE 1 EM-based zones at Carwarp, Victoria



Source: CSIRO Sustainable Ecosystems

148; 262 and 346 kilograms per hectare (0–110cm) for the low, medium and high EM zones respectively. The corresponding phosphorus levels (0–10cm) were 28, 27 and 41 milligrams per kilogram.)

The research team extrapolated fertiliser responses from the replicated strips at Carwarp during 2007 out to the whole paddock scale.

They found shifting from 64kg/ha flat rate application to zero on the high EM zone and 64kg/ha on rest of paddock would have increased the average whole paddock gross margin by $16/ha.

Shifting to zero on the high EM zone, 64kg/ha on the medium EM zone and 111kg/ha on the low EM zone would have resulted in an $2/ha increase in paddock gross margins. (Based on a return of $300/t of grain; fertiliser costs of $1100/t; and non-fertiliser variable costs of $100/ha.)

Best-bet strategies for zones

The computer modelling showed that, on average, the low EM zone out-yielded the high EM zone by more than 60% during the 50 season types. During the 50 simulated seasons there were only seven 'flip-flop' years in which the high EM (high subsoil constraint) zone out-yielded the low EM zone — these were during years with high spring rainfall (soft finishes).

Reducing nitrogen inputs on the high EM zone by at least half compared with other zones was shown, on average, to be a profitable strategy involving reduced fertiliser costs.

The risk of not getting a profitable yield response from applying 15kg/ha nitrogen was shown to be twice as high in the high EM zone compared to the low EM zone.

The researchers assessed whether EM-based soil zones justified variable fertiliser strategies compared with uniform fertiliser applications over the range of 50 season types. To do this they used simple gross margin calculations based on simulated yields for a range of nitrogen rates applied to different zones at Carwarp, indicating possible average gross margin gains in each zone from spatially variable nitrogen rates (see Figure 2). Results show that using 30;15 and 0kg/ha N on the Low, Medium and High EM zones respectively could increase average paddock gross margin by more than $20/ha compared with a flat rate of 15kg nitrogen/ha.

Other factors and future directions

The results of this research support the argument that there is potential for increased gross margins by using variable nitrogen rates. There is also potential to reduce the risk associated with upfront fertiliser costs without reducing profitability.

EM mapping has been shown to be a practical and reliable tool to help to create the zones for variable rate on mallee soils. But EM mapping does not reduce the need for soil testing and monitoring nutrient levels and targeted soil testing in each zone should be part of any sustained variable rate fertiliser strategy.

Also, EM soil zones can be improved by incorporating farmer knowledge of other spatial factors likely to influence yield potential.

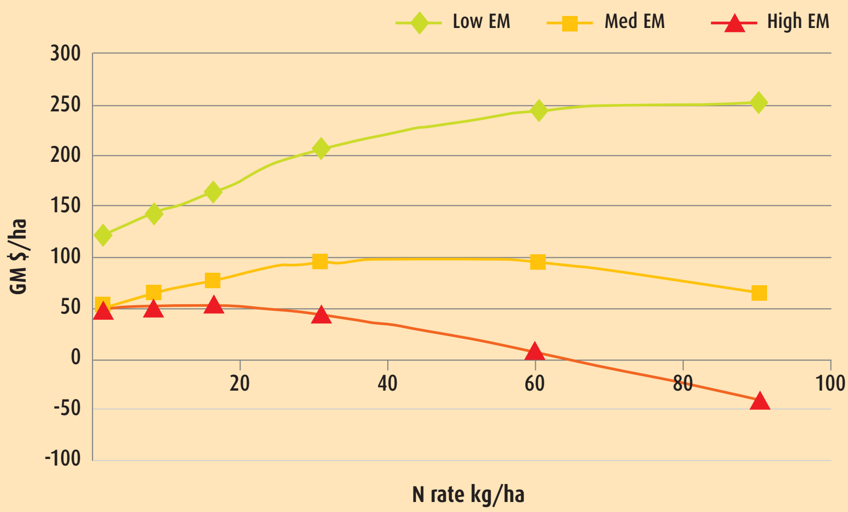
The simulations are an indication of whether differences in the optimal nitrogen strategy for each zone are likely rather than an indication of actual optimal nitrogen rates in an ongoing rotation. These results only reflect variable nitrogen application at seeding — greater benefits of variable rate could be expected when late season applications and other nutrients are considered.

Further work is being carried out to compare the effectiveness of EM-based spatial information with other sources such as elevation (for example, dune and swale-based zoning) and yield maps. Results so far show that EM-mapping can have a particular advantage over elevation-based zoning in identifying highly-constrained parts of the paddock where fertiliser inputs can be reduced with low risk. Tools and packages to further facilitate the reliable use of EM soil mapping and improved input strategies based on soil and season type are also being developed. FA

Photo: CSIRO Sustainable Ecosystems

Measuring up: *A researcher checks apparent soil electrical conductivity readings on a mallee paddock. EM soil surveys on typical mallee paddocks are now relatively cheap and effective at mapping soil characteristics that are important in determining yield potential.*

FIGURE 2 Simulated average Carwarp GMs over fifty season types; $250/t grain; $1.95/kgN; $100 non-fertiliser variable costs



Source: CSIRO Sustainable Ecosystems

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