VARIABLE RATE NITROGEN IN PRACTICE

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KEY POINTS

There is no one size fits all approach to Variable Rate Nitrogen

Look for proven strategies that are supported by science and focused on measuring Nitrogen in the soil profile.

Choose an approach that reflects your system, budget and Nitrogen management strategies.

Aim

This paper investigates three different evidence-based approaches for variable rate nitrogen management. Investigating some of the pros and cons of the different methods and presenting a couple of local case studies.

Introduction

Nitrogen (N) is essential for plant growth and crop production. It is critical in cereals for setting yield potential in the early stages of growth, while the availability of soil nitrogen at grain fill, along with soil moisture, is the key determinant of grain protein. Under-application of N is the main reason for the 'yield gap' between potential and actual yields in Australia. On the other hand, current fertiliser prices and the potential environmental impacts make over-application of N equally undesirable.

The importance of the N decision is matched only by its complexity. There are three key factors that explain why determining an optimal nitrogen application rate can be so challenging:

- Variability in N supply: Nitrogen is an extremely mobile nutrient and the amount that is available to plants can change substantially both within and between seasons. Nitrogen moves easily down the soil profile and has multiple loss pathways. Mineralisation – the natural process by which soil organic matter is converted to available N – also accounts for a large proportion of N supply but will vary depending on soil type, temperature, and moisture.

- Variability in N uptake: The amount of N required by plants (and potential yield) is also largely dependent on seasonal conditions. The right amount of N for a poor season is very different to the right amount of N in a great season, and this is impossible to know in advance.

- Spatial Variability: because of the previous factors, and differences in soil types, topography, crop yields and animal movement, N varies significantly within a single paddock. The optimal N rate in one part of the paddock is often very different to that in another.

Variable Rate Applications (VRA), where different N rates are applied to different parts of a paddock can help balance out the variability in N supply.

However, a variable rate N strategy is still based on the strategic decisions around the impacts of seasonal conditions, crop demand, yield estimates and grain quality. The complexity of N decisions means that there isn't one best approach to variable rate N.

This paper introduces three different evidence-based VRA N strategies (figure 1) with associated case studies that illustrate how they can be applied in the real world. These include grid soil sampling to directly measure the variability and the development of robust management zones (using EM38 or yield-protein data) combined with strategic soil sampling.

Grid soil sampling

Grid-based soil sampling involves taking multiple soil samples in a grid pattern across an individual paddock. Unlike conventional soil sampling, where all samples are bulked together to provide an average for the whole paddock, the samples from each grid square are analysed separately. This allows for fertiliser to be varied at the same resolution as the grid itself – normally a 2 ha in medium to high rainfall zones. Whilst grid-sampling for soils is commonly used across Australia, it's application to N management is less common.

The primary benefit of this approach to VRA N is that a) it involves high frequency direct measurement of N, rather than just measuring a proxy or attempting to predict its distribution, and b) a single round of grid sampling can test for multiple soil characteristics simultaneously. Consequently, this approach is often considered by growers who already use a grid-based approach to manage other inputs (such as lime, gypsum, or phosphorus).

Whilst high frequency soil sampling provides the most accurate measurement of N it is also relatively expensive and is rarely used beyond a 30cm soil depth. These constraints can mean that a multi-year VRA N strategy based on grid soil sampling is challenging. Nevertheless, grid-based N sampling is probably the most accurate method of determining a soil N baseline.

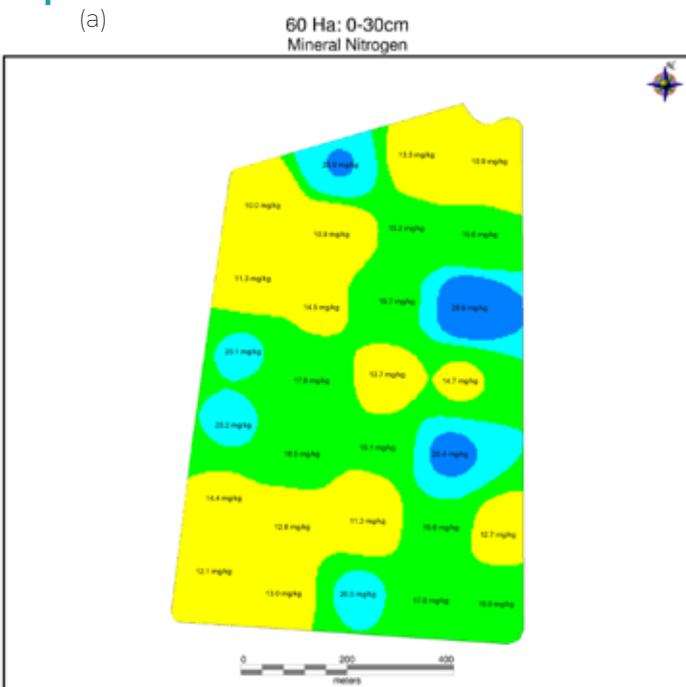**Case Study 1 – Grid based N management**

In Case Study 1 grid soil mapping was undertaken across the paddock on a 2-ha grid, using a 0-10cm soil depth, with the samples analysed for nitrate, ammonium, and carbon. While this was shallow compared to the 30 to 60cm depth more commonly used for nitrogen management, the agronomist was focused on the variability in surface nitrogen and potential mineralisation,

Figure 1: Three tested pathways into a variable rate nitrogen strategy
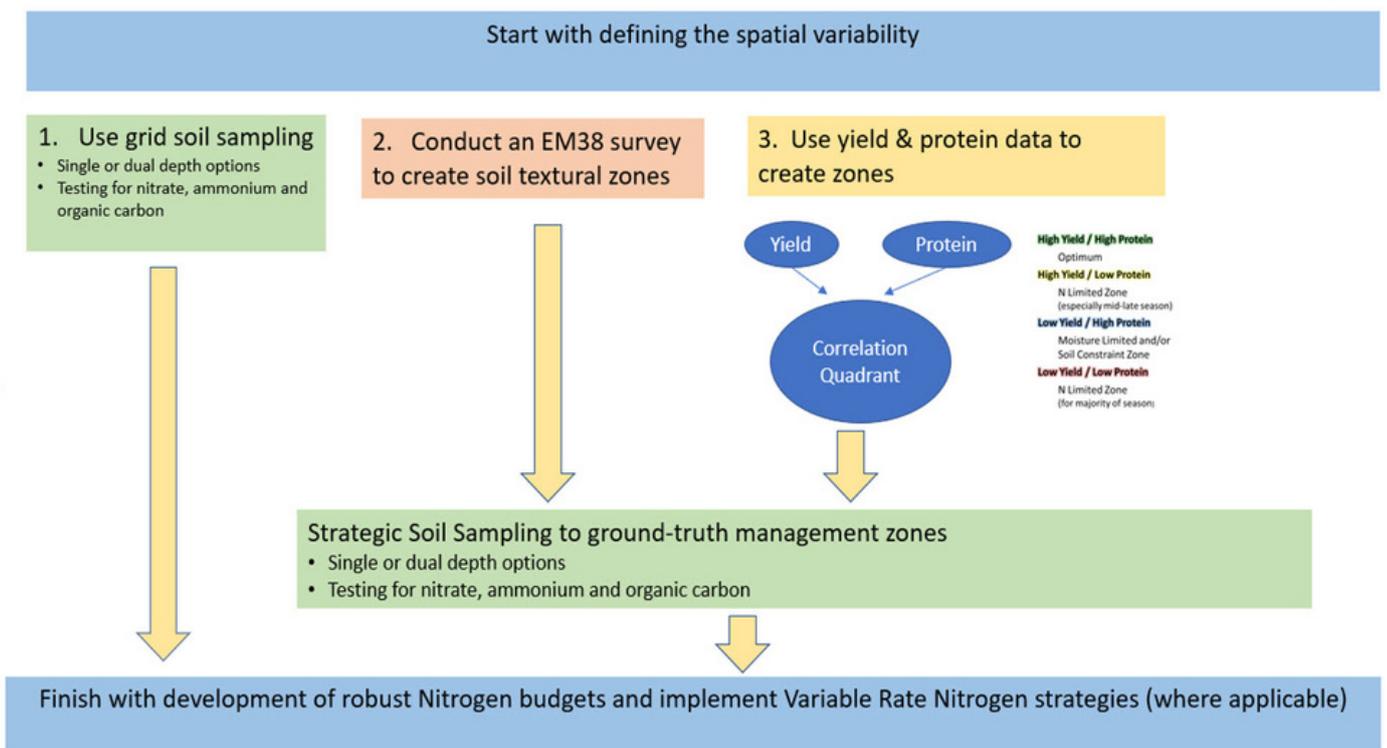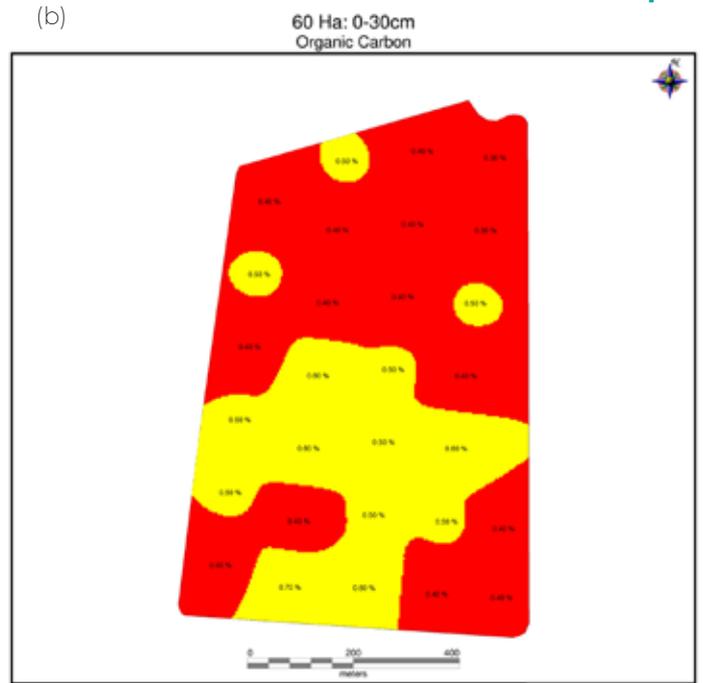
with many years of deep N analysis to support his understanding of the soil profile. As seen in Figure 2, there was significant variability across the paddock with total mineral nitrogen (ammonium plus nitrate) ranging from 10 – 29 mg/kg while organic carbon ranged from 0.25– 0.74 %. In combination with the agronomist's knowledge of the soil profile this was used to develop a VRA N strategy for the paddock with N rates ranging from 0 to 175 kg/ha of Urea. These were applied as a late season application following earlier blanket Urea spreading. The farmer and agronomist were happy with the results and will use a similar strategy this year, however final yield response to the strategy could not be accurately assessed as the paddock was heavily frosted.
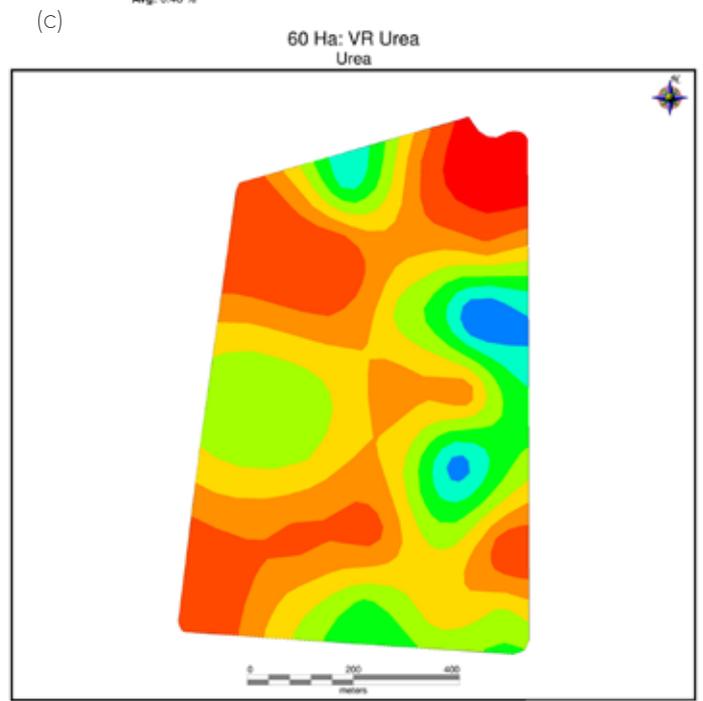
Figure 2: Grid soil mapping (0-10cm soil depth on a 2ha grid) with results for (a) total mineral nitrogen (mg/kg), (b) organic carbon (%), and (c) the VRA N fertiliser strategy developed for in-season urea following previous blanker applications.

(b)

(a)

(c)

EM38 Soil Management Zones

The use of soil type zones for VRA N has been one of the most enduring and reliable methods to date. This is driven by the strong relationship between soil texture and drivers of N availability and crop uptake. For example, heavier soils will generally provide greater N mineralisation and have lower losses of N to leaching. Soil texture also affects plant available water, which in water-limited environments will strongly affect crop N requirements.

One of the most accurate and established methods for mapping soil types is through an EM38 survey. The EM38 measures soil apparent electrical conductivity (ECa), which is influenced by soil texture (clay type and content), soil moisture, and salinity. Once the EM38 survey is completed strategic sampling is used to determine current N reserves and determine fertiliser requirements for the zone.

The primary weaknesses of the EM38 approach is that although soil type is a key driver of soil N other factors that influence crop variability (e.g. disease, weeds, prior management) are not always taken into account. This can lead to a degree of N variability which isn't measured or managed within the otherwise uniform zones.

Case Study 2 – EM38 Soil Management Zones

The case study paddock was mapped using an EM38-MK2 sensor on a 24m swath width (each pass of the paddock is 24m apart). The ECa data is collected as point data which is then converted into an EM38 map of the paddock (Figure 3a) and divided into 3 soil management zones (Figure 3b), defining areas of light, medium and heavy soils. Strategic soil sampling was conducted in June 2021 with 4 0-50cm soil samples collected within each management zones and composited to create a single analysis per zone (Figure 3c). The soil for nitrate and ammonium were summed together to give a soil mineral N within the profile. The mineral N concentrations ranged from 9.6 to 19 mg/kg between zones. Based on soil results and expected crop production a VRA N strategy was developed for in-season Urea applications (Figure 3d) following previous blanket applications.

Yield/Protein Management Zones

Finally, on-farm data including yield and protein data can provide a basis for defining nitrogen management zones. Caution should be used in the development of zones using yield data alone, as even when yield appears stable over multiple years (which isn't always the case), yield reflects

Figure 3: Case Study 2 paddock showing (a) the EM38 map for the paddock which was used to build (b) 3 soil management zones and (c) a strategic soil sampling plan. The results from the strategic soil sampling was used to inform (d) the VRA N strategy for in season urea application.
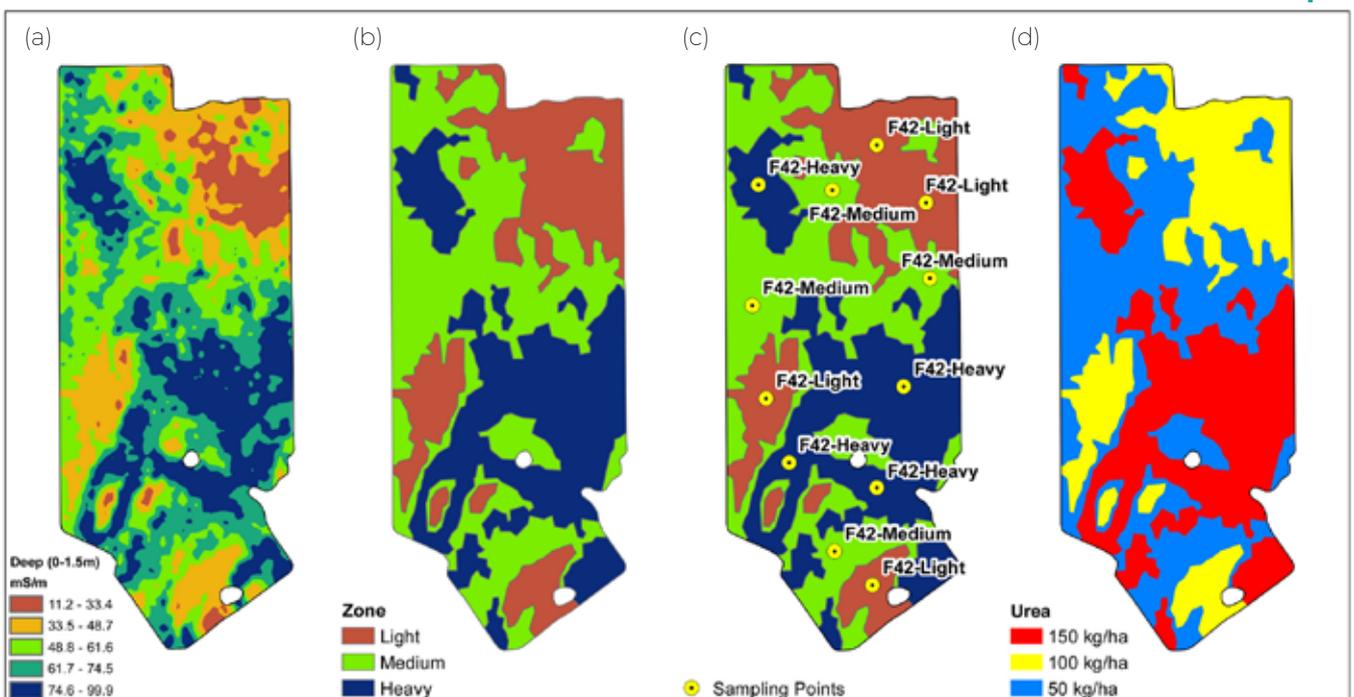
everything that affected the crop through the season: nutrition status and soil type, but also frost, weeds, disease, landscape, establishment and more. Therefore, differences in productivity may not equate to fertiliser responsiveness depending on whether N is the key soil constraint. Consequently, VRA N based only on yield maps will likely still lead to excessive applications in some areas and deficiencies in others.

However, combining yield with cereal grain protein maps from on-the-go harvester-mounted protein monitors is showing some real potential in the development of management zones for nitrogen. These layers can be used to develop 4 zones based on a distinction of high/low yield and high/low protein (Figure 1) with different constraints in different zones. For example, high yield:low protein is likely to be indicative of a N constraint, while low yield: high protein suggests a moisture or soil constraint other than N. These management zones can then be used as a basis for strategic soil sampling to measure the mineral N within the soil profile and formulate VRA N strategies. This approach was recently explored in a research project conducted by FarmLink and Precision Agriculture in southern NSW (Moffitt 2020), which highlighted the value of cereal protein data in this context.

Observations and comments

Mineral nitrogen can be highly variable between seasons but also within a paddock. Choosing a nitrogen management strategy that fits your farming system is the key to success.

The use of grid or zoning strategies for measuring soil N, does not have to lead to a VRA of Nitrogen. From experience a lot of the properties where they have used grid or soil management zones don't use a VR application or they save this for a late season application if required. However, they do start the season with an accurate knowledge of what is in their soils and can use this knowledge to ramp up or down their N strategy to manage production and risk throughout the season.

A good N strategy should be based on measured N within the soil profile. All three of the strategies presented here represent an evidence-based approach to defining and measuring the variability as the first step to optimising N management across the paddock.

References

E Moffitt (2020) Utilising new technology to better managed within paddock nitrogen variability and sustainably close the yield gap in southern NSW. Farmlink Research Report.

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