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FarmLink Research Report 2019

Utilising new technologies to better understand and manage within-paddock nitrogen variability

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Trial Site Location Ardlethan, Girral, Rannock, Temora, Thuddungra

Introduction

Despite significant technological advances in sensors and machinery capabilities over the past 20 years, adoption of precision (site-specific) nitrogen management in Australia remains low. While cost is often cited as a key barrier, the lack of agronomically sound and easily implemented Variable Rate (VR) N methodologies has generally presented a greater impediment to growers and advisors as they look to move into this space. This has been driven by a lack of large (paddock) scale research into levels of nitrogen variability in our broadacre cropping systems and the most effective ways to map and manage such variability.

In addition to optimising on-farm input use efficiencies, better tools for N management are required to avoid environmental impacts of excess N supply including nitrate leaching resulting in the acceleration of soil acidification, transport of N to inland waterways and increased N2O emissions.

This project seeks to evaluate the efficacy of a number of VR nitrogen approaches across 511.4ha of broadacre cropping area over five paddocks within the FarmLink district. Soil nitrogen concentrations as determined through intensive deep N grid soil sampling (0-30 cm/30-60 cm) will be compared to a number of data layers including grain yield, grain protein concentration (GPC), NDVI and apparent electrical conductivity (EC_a) to assess varying approaches for informing site-specific nitrogen management. Phase two of the project will involve grower participants designing 'best-bet' VR nitrogen applications for the 2020 season based on the numerous data layers collected.

Data collection for this project commenced in November 2019 and is ongoing at the time of report writing. The current report outlines the background/rationale for the project and its progress to date. Project results will be presented throughout 2020 via FarmLink communications and in the 2020 research report.

Project Partners

FarmLink change • adapt • prosper

precision agriculture

Project code - 4-BA9KC2G

Funding Partner

Australian Government

National Landcare Programme

Background

Nitrogen is a key input in broadacre cropping systems, representing a significant proportion of total input costs and influencing grain yield and quality more than any other factor after moisture availability across the majority of broadacre cropping area in Australia.

Despite the key role nitrogen plays in rainfed broadacre cropping, the decision support tools used by growers and advisors to inform nitrogen application rates are varied and often based on generalisations. A recent survey conducted by the Northern Grower Alliance (2018) of 100 agronomists and advisors indicated that the most common factors guiding N application rates were: yield and protein target for the next crop, soil moisture availability and/or seasonal forecast and agronomist/consultant advice.

In southern NSW, anecdotal evidence suggests that less than 20% of growers use any form of annual soil testing to help formulate their nitrogen input strategy. Where growers are soil testing, current common practice is to take 4-8 deep soil cores (0-60 cm or 0-30 cm/30-60 cm) within a paddock at around the time of sowing, which are bulked together to return one result.

Within the FarmLink region, where moderate to high levels of within-paddock spatial variability are common for key yield drivers including soil type, soil constraints, plant available water capacity (PAWC) and frost potential, it is logical to assume that substantial variability of within-paddock soil nitrogen levels also occur.

While this would be intuitive to most growers, the lack of understanding regarding patterns of nitrogen variability and lack of clear guidance/recommendations in terms of the best methods to map and manage nitrogen variability has meant that uptake of precision (site-specific) N management is still low. This represents a significant constraint and missed opportunity as we move into an era where an increasing number of growers are equipped with the technology and capability to implement Variable Rate (VR) applications.

Where VR nitrogen is occurring, one method being employed is a management zone approach. This involves dividing the paddock into smaller subunits most commonly based on either productivity (e.g. using yield data or NDVI) or soil type (e.g. using EC_a or aerial imagery). Soil sampling is then undertaken to quantify soil nitrogen levels within each zone, which are assumed to be more or less homogenous. While this is generally considered an improvement on whole paddock sampling, very little work has been done locally to evaluate the efficacy of these methods and compare different zoning approaches.

A second strategy is to use in-season imagery (e.g. Normalised Difference Vegetation Index, NDVI) to develop VR nitrogen maps based on crop vigour. The advantage of these approaches is they give guidance on crop N requirements in real time. The limitation however is that poor crop growth may not necessarily be due to N nutrition, therefore considerable ground-truthing and agronomic interpretation is required for successful implementation.

In recent times, the commercial availability of 'on-the-go' grain analysers has provided an alternative data layer with considerable potential for informing VR nitrogen inputs. One such instrument is the CropScan 3000H, manufactured by Australian company Next Instruments Pty Ltd (https://www.nextinstruments.net/). These units are mounted on-board the harvester and collect georeferenced moisture, protein and oil percentages in real time using Near Infrared Spectroscopy (NIRS), the same technology used at grain receival points throughout Australia. The result is a high-resolution map of grain quality attributes (typically 20-40 points/ha, provided yield is sufficient). For a full description of the CropScan 3000H see Appendix 1.

The potential to use this information to improve nitrogen management lies in two main areas. Firstly, to identify areas within the paddock of surplus or deficient soil nitrogen, and secondly to use the data for site-specific N budgeting, i.e. tracking how much nitrogen has moved off-farm and using this information to inform nitrogen input decisions (Taylor & Whelan 2007).

The idea of using grain protein concentration (GPC) as a post-harvest indicator of N nutrition adequacy for wheat yields was described by Goos *et al.* in

1982. They determined that N responsiveness diminished above a critical GPC level of 11.5% for dryland winter wheat in Colorado, USA. In Australia, early work from Russell (1963) in South Australia suggested that yield responses were most likely when grain protein was <11.4%. An analysis of more recent trials in South Australia and Victoria indicates that this general conclusion still appears valid (G. McDonald, published in Unkovich *et al*., 2020). This review found that when GPC was <11.5%, over 70% of trials analysed had an N response, while when GPC was >11.5%, only 32% of the trials had an N response, which was either only marginally positive or in some cases was negative (i.e., yield constraining).

Whilst it has been shown that both varietal and climatic conditions can influence critical grain protein concentrations (Fowler, 2003), a simplified 'rule of thumb' interpretation of this work is that wheat with <11.5% grain protein has had insufficient nitrogen to optimise yield, whereas wheat with >11.5% grain protein has had surplus nitrogen which has been used to increase protein, often with no economic gain.

While this information cannot be used for in-season nitrogen management, it can potentially be used to identify N deficient areas which can be addressed through increased nitrogen rates in subsequent seasons (e.g. Long *et al*. 2005). It can also be used to identify areas for follow up investigation where nitrogen supply has been adequate (i.e. GPC >11.5%) and yield has been poor. These areas are likely constrained by another issue (e.g. pH, salinity, etc.), which may result in N inputs being scaled back in subsequent seasons.

The second approach to using high resolution grain quality parameters is through an N budgeting system, whereby nitrogen removal for wheat and other grains is calculated using a N% to GPC conversion factor of 5.7; Unkovich *et al*. 2020). Rearranged, this can be expressed as

These maps give growers an understanding of the level of nitrogen that has been exported off-farm and the spatial variability of these patterns. In doing so they open up the possibility of more accurate gross margin mapping and the implementation of nitrogen 'replacement' strategies (providing N levels are adequate initially).

Despite the theoretical possibility of these approaches, in reality nitrogen management in Australian cropping systems is highly complex, being confounded by interactions with other variable factors including water availability, soil N supply (mineralisation) and soil constraints.

A need therefore exists for research to compare and contrast the many various approaches to site-specific nitrogen, to determine not only the most scientifically valid methods but also strategies that are cost-effective and practical for growers and advisors. This study will do so by working with five growers in the FarmLink region examining nitrogen variability and potential management approaches over 511.4 ha.

The key objectives of the project are to:

- Quantify the level of intra-paddock variability of soil nitrogen concentrations within five paddocks in the FarmLink district through intensive (grid) deep N sampling
- Examine correlations between soil nitrogen and other data layers including EC_a, NDVI and grain protein/oil concentration to assess their suitability to inform site specific nitrogen management
- Work with growers and advisors to develop 'best bet' VR N applications using the numerous data layers collected, plus assess their success/impact through follow up soil sampling and analysis of grain yield and grain quality layers

N Removal (kg/ha) = Grain Protein (%) x Grain Yield (kg/ha) x 0.00175 (Engel *et al*., 1999)

Methodology

Grain Yield and Grain Quality Data Collection

During the 2019 season, eight FarmLink members with CropScan 3000H on-board grain analysers fitted on their harvesters were engaged to be part of the project. Where available, historic grain yield, protein and oil data was collected and analysed to identify paddocks favourable for the study. Suitable paddocks consisted of those cropped to wheat, barley or canola in 2019 and 2020, those having good paddock histories and those with some level of expected variability in soil nitrogen levels. Growers also had to be equipped and willing to implement VR nitrogen treatments in the 2020 season.

All harvesters were late model CaseIH machines running Pro700 displays. Growers performed grain yield monitor calibrations as per standard procedures outlined by the manufacturer. Prior to harvest (November 2019), Mat Clancy of Next Instruments performed calibrations on all CropScan 3000H grain analyser units using a single set of certified reference samples for wheat, barley and canola (Figure 1). In-cabin software was also updated, and a general check-up performed on each unit.

Due to the exceptionally dry (decile 1) seasonal conditions experienced in 2019, a number of pre-selected paddocks were unsuitable for the study due to either being cut for hay or tracking for very low yields and/or very high protein concentrations. It was therefore decided to delay selection of paddocks until after harvest when data could be assessed for quality.

Upon the completion of harvest, yield and grain quality data were collected from harvesters and imported into Trimble Ag Desktop software (Farmworks). Potential paddocks were assessed for their suitability for the project. Five paddocks were selected located at Ardlethan, Girral, Rannock, Temora and Thuddungra. All paddocks were cereals in 2018 (four wheat, one barley) and all were harvested using a single harvester. Yield and grain quality data was cleaned by removing erroneous data points, outliers and overlapping passes on headlands/obstacles. Yield data was reconciled where actual tonnages were available.

Figure 1: Mat Clancy (Next Instruments) performing a calibration on the CropScan 3000H unit at Ardlethan using reference standards of known protein percentage.

Grid Sample Plan Design

Guidance line files were obtained for each paddock so grid soil sampling plans could be designed to match the orientation (heading) and location of nitrogen application passes. Grid sampling cells were designed at 108 m x 108 m for four out of five growers who top-dress fertiliser at 36 m width (i.e. three spreader passes) resulting in a 1.17 ha grid (Figure 2). Grid cells were designed at 120 m x 120 m (five spreader passes; 1.44 ha grid) for the remaining grower, who top-dresses at 24 m width. Headland areas and any other major obstacles were excluded from sampling plans. Two paddocks were considerably bigger than the budgeted area therefore only part of the paddock was included. The total area encompassed in the study was 511.4 ha (425 samples) across the five paddocks.

EM38 Data Collection and EC_a Management Zone Design

EM38 and elevation ground surveying was conducted during January 2020 using a Geonics EM38 unit operated in the vertical dipole, spatially logged via RTK corrected GPS. Soil EC_a in milliSiemens per meter (mS/m) was collected on an 18 m swath for the 108 m x 108 m grid and a 24 m swath for the 120 m x 120 m grid. Swaths were orientated to align with the grid sampling plan.

Data was cleaned, calibrated and interpolated via kriging in ESRI ArcGIS. EM38 and elevation layers were interpreted alongside historic aerial imagery and farmer knowledge to manually create soil type based management zones, a common practice used by a number of local agronomists and precision agriculture service providers. Strategic soil sampling plans were designed for three zones of each paddock consisting of four individual GPS locations (points) per zone.

Soil Sampling

Soil sampling was delayed due to the exceptionally dry (hard) ground conditions experienced in late 2019 and into January 2020. Following a substantial rain event in mid-February soil sampling has commenced and is ongoing at the time of reporting.

Grid soil sampling consists of five individual subsamples taken within each cell, segmented into 0-30 cm and 30-60 cm depth and bulked. Grid samples will be analysed for nitrate (NO_3), ammonium (NH_4) and MIR texture (sand/silt/clay%). Strategic (zone based) samples will also be collected at 0-30 cm/30-60 cm however individual cores will not be bulked but rather analysed individually to assess within-zone variability. Analysis will consist of NO_3, NH_4, MIR texture, pH ($CaCl_2$), Electrical Conductivity (1:5), Chloride and Cation Exchange Capacity (Ammonium Acetate). All soil analysis will occur at APAL Agricultural Laboratory in Adelaide.

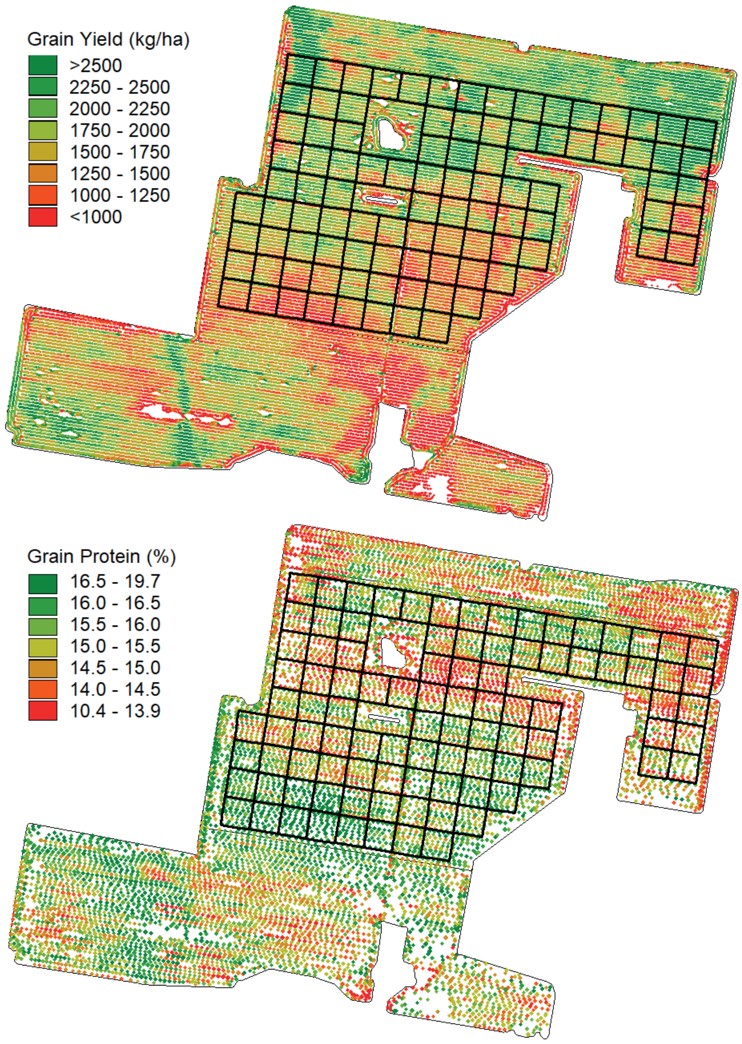


Figure 2: Deep N grid soil sampling plan overlain on 2019 wheat grain yield in kg/ha (top) and grain protein percentage (bottom) for the Thuddungra paddock. Grid sampling cells are 108m x 108m to match a 12m CTF system (3x 36m spreader passes).

Data Analysis

Regression analysis will be used to assess the relationship between soil nitrogen concentrations and a range of other parameters including 2019 grain yield, grain protein concentration, nitrogen removal, elevation and EC_a (via EM38).

2020 Season

During the 2020 season, growers will work with their advisors using all available information to develop 'best-bet' site-specific nitrogen input plans including 'average' strips and N rich strips. A follow up round of grid soil sampling immediately after harvest 2020 will assess the efficacy of variable rate approaches.

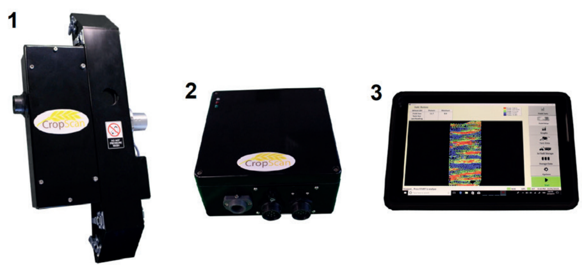
Results

Fieldwork for this project is ongoing. Results will be presented in FarmLink communications during 2020 and the 2020 Research Report.

Appendix

Description of CropScan 3000H

The unit consists of three components: 1) sampling head, 2) NIR spectrometer and 3) touch screen computer. The sampling head is mounted on the clean grain elevator, where it collects and isolates a grain sample within its chamber every 8-12 seconds (although at yields <2 t/ha cycle times are longer). A tungsten halogen lamp shines light through the stationary sample and into an optical fibre cable which transmits the light back to the NIR spectrometer located in the cabin. Protein, oil and moisture absorb NIR light at different frequencies and the NIR spectrometer uses a diode array detector and a spectrograph to separate the frequencies of light into the NIR spectrum. The in-cabin touch screen PC takes the NIR spectrum and applies calibration models to convert the spectral data into grain quality measurements. The cycle is repeated roughly 5 times per minute, with grain quality data georeferenced using location coordinates from the harvester's GPS. To reduce noise a rolling average is applied, although raw readings are also logged.



Appendix 1: Components of Cropscan 3000H grain analyser: 1) sampling head (mounted on clean grain elevator 2) NIR spectrometer (installed in-cabin and connected via fibre optic cable) and 3) in-cabin touch screen computer.

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