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FarmLink Research Report 2019

Towards best practice site-specific mapping, prevention and treatment of subsurface acidity in southern NSW

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Trial Site Location Barmedman, Boree Creek, Cowra, Grenfell, Grong Grong, Harden, Henty, Illabo, Lockhart, Marrar, Methul, Quandialla, Tallimba, The Rock, Wagga Wagga, Young

Introduction

A recent focus on subsurface acidity research in southern NSW has highlighted that current minimum tillage farming practices including lime top dressing without incorporation are failing to prevent soil acidification occurring throughout the profile, particularly at 5-15 cm. At the same time, extensive topsoil pH mapping has demonstrated that high levels of within-paddock pH variability are common in our region, resulting in increasing adoption of Variable Rate (VR) liming practices.

To date however, there has been very little research examining patterns of pH variability in the subsurface, leading to a large gap in knowledge around the most effective, affordable and practical methods of data collection to both map and treat the subsurface layers.

This project seeks to address these shortcomings through a large (2,692 ha) survey of 42 paddocks throughout the FarmLink region across a range of soil types, rainfall zones and management histories. The project will involve assessing correlations between the pH + Aluminium percentage of 360 strategically placed 0-5 cm, 5-10 cm, 10-15 cm, 15-20 cm cores and a number of potential proxy data layers including ECa (via EM38) and 0-10 cm soil pH, CEC and texture.

Data collection for this project commenced in December 2019 and will continue through until March 2020. The current report outlines the background/rationale of the project and research methodologies. 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 - SAV19

Funding Partner

Australian Government

National Landcare Programme

Background

Soil acidity is a major limiter of crop productivity and a significant global agricultural soil degradation issue. The gross value of agricultural productivity lost due to soil acidity in Australia is estimated to be $1,585 million per annum and $378 million in NSW alone (NLWRA, 2002; Khairo & Li, 2018).

The current treatment of soil acidity in NSW is based predominantly on recommendations arising from research undertaken as part of the NSW Government Acid Soil Action (ASA) program (1997-2003). These recommendations were based on a surface application of lime to treat the 0-10 cm layer via a presumed incorporation to a traditional cultivation depth of 10 cm.

With considerable changes to farming practices over the previous two decades including widespread adoption of minimum or no-till systems, it has become apparent that these amelioration practices are no longer effectively treating soil acidity throughout the profile. Instead, the phenomena of pH stratification or 'subsurface' acidity has been identified in many paddocks (Figure 1).

pH stratification in no-till systems is the result of a number of combined processes, including: 1) surface applications of lime without incorporation; 2) acidifying fertilisers banded below the soil surface, particularly ammonia-based products such as MAP, which is widely used as starter phosphorus; and 3) uptake of alkali (OH-) from the soil by plant roots and removal or redistribution to the soil surface through plant litter and dung (Paul *et al*., 2003).

In recent times, the issue of pH stratification has been highlighted due to the increasing interest of growers in southern NSW to develop profitable pulse options. One recent study of 55 sites surveyed across the High Rainfall Zones of Victoria, South Australia and NSW found that only 17% possessed a pH_{Ca} of >5.2 through the entire 0-20 cm zone, with 59% returning a pH_{Ca} of <4.8 at 5-15 cm depth, despite 51 of the 55 paddocks having a history of liming (Burns and Norton, 2018). This suggests that the process of subsurface acidification may be more widespread in our broadacre cropping areas than previously realised.

At the same time, cheaper soil analysis and advances in sensor and variable rate (VR) technologies have led to a broader uptake of site-specific liming in the FarmLink region. Methods such as grid soil sampling and Veris® on-the-go pH sensors have demonstrated that lateral within-paddock variability of the topsoil pH is relatively common; driven by both inherent (background) soil variability and past management practices (e.g. removal of fences).

To date however, there has been very little work that has looked at both vertical (i.e. down profile) and horizontal (i.e. across paddock) pH variability concurrently. As a result, there is a substantial knowledge gap around the patterns of pH variability in the subsurface and the best data collection and interpretation methods for growers and advisors to use when creating site-specific liming plans.

While segmented soil sampling (e.g. 0-5 cm, 5-10 cm, 10-15 cm, 15-20 cm) provides excellent information at the location of the sample, it is unsuitable to perform in high densities (e.g. grid sampling) due to its highly manual/time consuming and costly nature.

For this reason, it is more likely that an economically viable solution to quantifying the spatial variability of subsurface acidity may come in the form of a proxy data layer that is ground-truthed using strategically placed segmented soil tests.

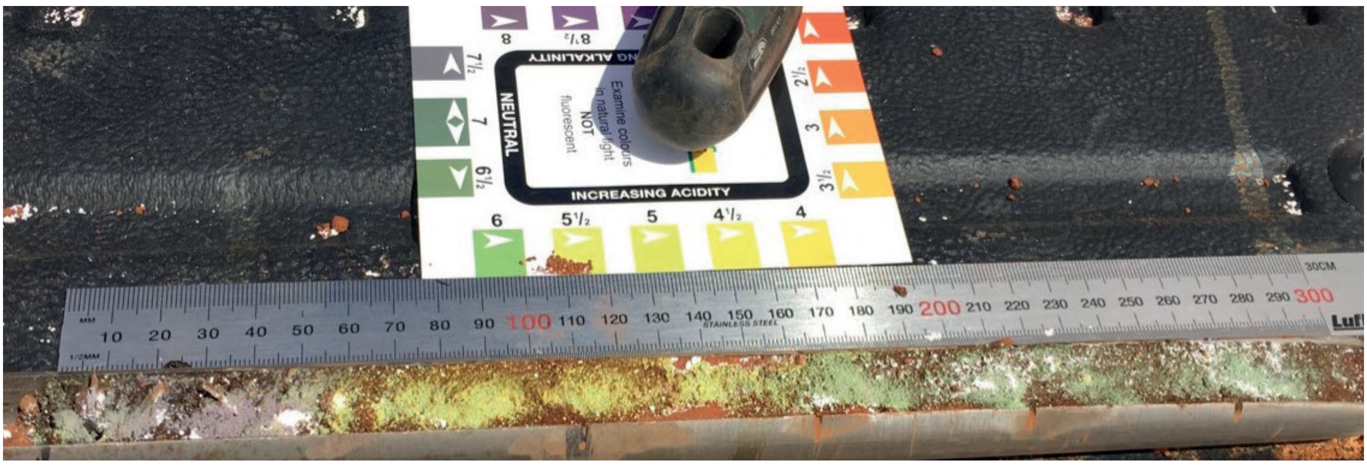

Figure 1: Spurr soil probe or 'digstick' core from surface (left) to 30 cm depth (right) treated with universal indicator/Barium Sulphate powder (legend in pH_{water}). A highly stratified profile is evident with an acidic band at 5-15 cm depth.

One potential option for this proxy layer is apparent Electrical Conductivity (EC_a), which can be measured using instruments such as a Geonics EM38. The rationale behind this theory is underpinned by the correlation between EC_a and a number of soil physical and chemical properties, including soil texture and Cation Exchange Capacity (CEC; Rhoades *et al*., 1976). As these properties are in most cases positively correlated with soil buffering capacity, it is hypothesised that areas of lower EC_a (i.e., lighter soils) will display more extreme subsurface acidification than those of higher EC_a (i.e. heavier soils). This process would be further reinforced by the tendency of lighter soils to leach nitrate ions at a higher rate than heavier soils, an acidifying process.

Extensive grid soil sampling of the topsoil (0-10 cm) has shown that this correlation does not always exist in the surface layer, most likely due to contrasting management practices and paddock histories. In the subsurface (10-20 cm) however, where physical disturbance is generally low, it is possible that this correlation remains.

A pilot study conducted as a joint project between FarmLink Research and Precision Agriculture in August 2018 on a 49 ha paddock at Ardlethan supported this hypothesis, with a correlation of $r^2 = 0.82$ and 0.81 existing between pH_{Ca} and EC_a at 10-15 cm and 15-20 cm respectively. The full results from this study can be found in the 2018 FarmLink Research Report.

Following on from this outcome, the current study aims to:

1. Survey a range of paddocks throughout the FarmLink region of different soil types, rainfall zones and management approaches to examine the extent and severity of pH stratification
2. Analyse the relationship between acidity (and Aluminium) levels in the subsurface (10-20 cm) and a number of other soil characteristics, including EC_a (via EM38), surface pH, texture (via MIR particle size analysis) and Cation Exchange Capacity (CEC)
3. Determine the potential to use one or more of these layers as a basis for targeted strategic segmented soil sampling to improve site-specific (VR) lime applications

Methodology

18 growers from across the FarmLink region each selected approximately 150 ha of broadacre cropping and/or pasture area to be included in the survey, constituting 42 individual paddocks and a total area of 2,692 ha.

Paddocks were selected on the basis that they had not previously received VR lime applications, had not been limed within the past two years, had detailed cropping/liming histories available and if possible, had some level of soil type variability. There was no emphasis on selecting paddocks at a particular stage of the liming rotation or paddocks considered to be acidic.

Growers ranged in location from high to low rainfall zones and across a cross section of the soils present within the FarmLink region (Figure 2). There was also a combination of management histories in terms of cropping/pasture use, previous lime inputs, cultivation treatments and tyne vs. disc seeders.

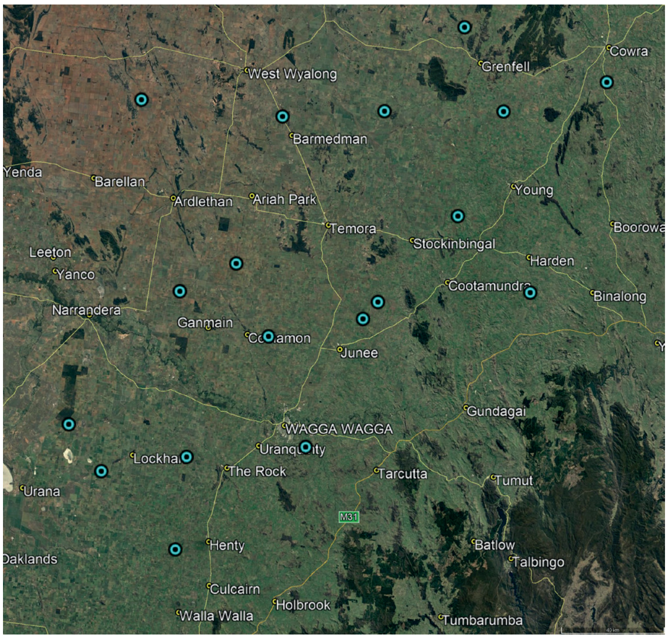

Figure 2: Location of the 18 grower participants and 42 paddocks included in the survey (blue circles

Data collection was broken into three phases, 0-10 cm grid soil mapping, EM38 surveying and strategic segmented sampling.

Grid Soil Mapping

0-10 cm grid soil mapping at a 2ha resolution was performed according to the standard methodology of commercial service provider Precision Agriculture during December 2019 – January 2020. All samples were collected with an Amity auger style drill mounted on a side-by-side ATV. Eight subsamples were collected per grid point on a diagonal angle to the direction of sowing over a 100m transect centred on the grid cell. Sampling plans were pre-designed using all available historic satellite imagery and grower knowledge to avoid previous fence lines and/or other obstacles. GPS guidance was used to locate soil samples in the paddock and sampling depth was checked prior to and regularly throughout sampling.

Analysis was performed by APAL agricultural laboratory for pH ($CaCl_2$), Cation Exchange Capacity (Ca, Mg, K, Na; Ammonium Acetate) and MIR Particle Size Analysis.

EM38 and Elevation

EM38 and elevation ground surveying was conducted during February 2020 using a Geonics EM38 unit operated in the vertical dipole, spatially logged via RTK corrected GPS. Soil ECa in milliSiemens per meter (mS/m) was recorded on a 3-4 m data spacing at a swath width of 24 m.

Strategic Sampling

Strategic soil sampling locations will be designed to span the range of EC_a, pH, CEC and MIR texture values within a paddock as determined by the initial rounds of data collection (EM38 mapping and 0-10 cm grid mapping).

Strategic sampling is planned for completion during February – March 2020. Approximately 20 segmented soil samples will be collected per grower, totalling 360 samples across 42 paddocks. An open sided Spurr soil probe or 'digstick' will be used to accurately sample to a depth of 20 cm, with this sample broken into 0-5 cm, 5-10 cm, 10-15 cm and 15-20 cm segments for analysis. Points will be located using GPS and sampled within a 10m radius of the GPS coordinate (eight sub-samples to be bulked).

Samples will be analysed at APAL agricultural laboratory for pH ($CaCl_2$), Cation Exchange Capacity (Ca, Mg, K, Na via Ammonium Acetate), Exchangeable Aluminium and acidity (KCl), Organic Carbon (W&B) and MIR Particle Size Analysis.

In addition to this sampling, a further 0-30 cm digstick sample will be taken for each point to be visually assessed using pH indicator and Barium Sulphate powder.

Stationary EC_a measurements (mS/m) will also be taken using a Geonics EM38 unit operated in the vertical dipole in two orientations at each segmented sample location (i.e., 16 measurements per point).

Data Analysis

Regression analysis will be used to examine the relationship between subsurface pH/Aluminium (10-20 cm) and a number of predictive variables; including EC_a as measured by EM38 and pH, CEC and texture at 0-10 cm.

Results

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

References

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