MONASH UNIVERSITY HONOURS PROJECT

RELATIONSHIP BETWEEN SURFACE SOIL PROPERTIES AND REMOTELY SENSED DATA (NDVI) IN NSW, AUSTRALIA.

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BACKGROUND:

Soil constraints such as acidity and nutrient availability are significantly reducing crop yields, limiting crop choice, and damaging the health of our soils when untreated. Lime and fertiliser are significant annual investments in the production system and farmers are increasingly looking for reliable evidence to justify such inputs. Grid soil sampling is a proven strategy, accurately identifying zones for targeted amelioration of surface soil across a paddock using Variable Rate (VR) lime and nutrient applications.

Grower knowledge, historic yield data and satellite imagery can provide useful insight to paddock variation, relating directly to crop biomass and production value. However, this variation results from a range of factors including surface and sub-surface soil properties, plant available water, weed burdens, pests, diseases and frost.

Increasingly, NDVI and yield maps are being used to formulate management zones for surface soil properties. This methodology is commonly advertised as cost effective and reliable in the identification of soil constraints. As part of her honours program, Brigette Snell of Monash University investigated the relationship between NDVI, yield data (where available) and surface soil properties. The project aimed to establish the scientific value of NDVI and yield data in development of practical management zones for surface soil characteristics in broadacre farming systems.

DATA:

28 paddocks from 6 properties across Central NSW were selected for the project. Paddocks were selected to capture regional variation. All paddocks were grid soil sampled post-harvest 2018. Testing analysed pH, Phosphorus (Colwell) and Exchangeable cations. Grid mapped data was then compared to a range of spatial data layers including:

- NDVI images from the Sentinel 2 satellite for August, September and October 2016-2019. Images were clipped to a buffer to reflect the grid map and the average values in each zone used for the analysis.
- Management zones developed from 4 years of late season (September) NDVI.

- Where available, yield data was obtained from property owners.
- Digital Elevation data and climate summaries were also considered in the analysis.

RESULTS:

Test results for pH, Phosphorus and Exchangeable cations showed high variability both within and between paddocks. The majority of paddocks exhibited one or more production limiting soil properties.

- Average pH in the paddocks ranged from 4.5 to 7.3 (average COV within paddocks = 5.2%).
- Average Colwell P ranged from 20 to 122 mg P/kg (average COV within paddocks = 28%).
- Average exchangeable Potassium ranged from 200 to 623 mg/kg (average COV within paddocks = 24%).

Similar to findings in Barlow et al. (2019), poor correlation existed between soil characteristics. In the instance of pH for example, areas where acidity was detected did not correlate with areas where phosphorus was limiting. A similar lack of correlation was found in the relationship between a majority of characteristics examined. This highlights the difficulty in creating management zones for different soil properties, as they do not align.

A changeable relationship between multiple years of NDVI and yield data was also observed. In most cases, the correlation between consecutive layers of NDVI was poor i.e. low NDVI areas were not located in similar spots year on year. This lack of any consistent trend was also observed in the provided yield data. It was noted that in a small number of paddocks (<10%), a consistent positive correlation was found between multiple years of NDVI.

In over 90% of paddocks, the variation in soil properties was not captured by the NDVI data. This emphasizes the large number of factors influencing crop and yield production which cannot be accurately identified with NDVI images. Key results were highlighted by the following case studies.

Case Study

Of the paddocks involved, this case study was considered indicative of wider trends. Further case studies and paddock data is available in the full research paper.

Grid mapping results found that soil pH along with Phosphorus and Magnesium availability could be limiting crop production in a number of areas in the paddock. Spring NDVI imagery varied from year to year (correlation coefficients of between -0.25 and 0.63) reflecting different crops, seasonal conditions and other biotic and abiotic factors. When the soil test results were compared to NDVI (2016-2019) over the 4 years, there was a variable correlation from negative to positive for all three soil test values.

Table 1: Results summary for Case Study.

	Mean	Minimum	Maximum	CoV	Correlation to NDVI	Zone 1	Zone 2	Zone 3
pH	4.8	4.4	5.4	5%	-0.33 to 0.43	4.9	4.8	4.7
Colwell P	33	10	93	56%	-0.29 to 0.58	31	31	37
Magnesium	127	69	294	39%	-0.48 to 0.40	140	111	132

No statistically significant differences were found between the soil test values in NDVI derived zones for any of the three potentially limiting soil properties. Typically, this would result in uniform lime application across the paddock, with low (uniform) rates of Phosphorus also likely to be applied. NDVI created management zones would not ameliorate the soil constraints and variability highlighted through the grid soil mapping results.

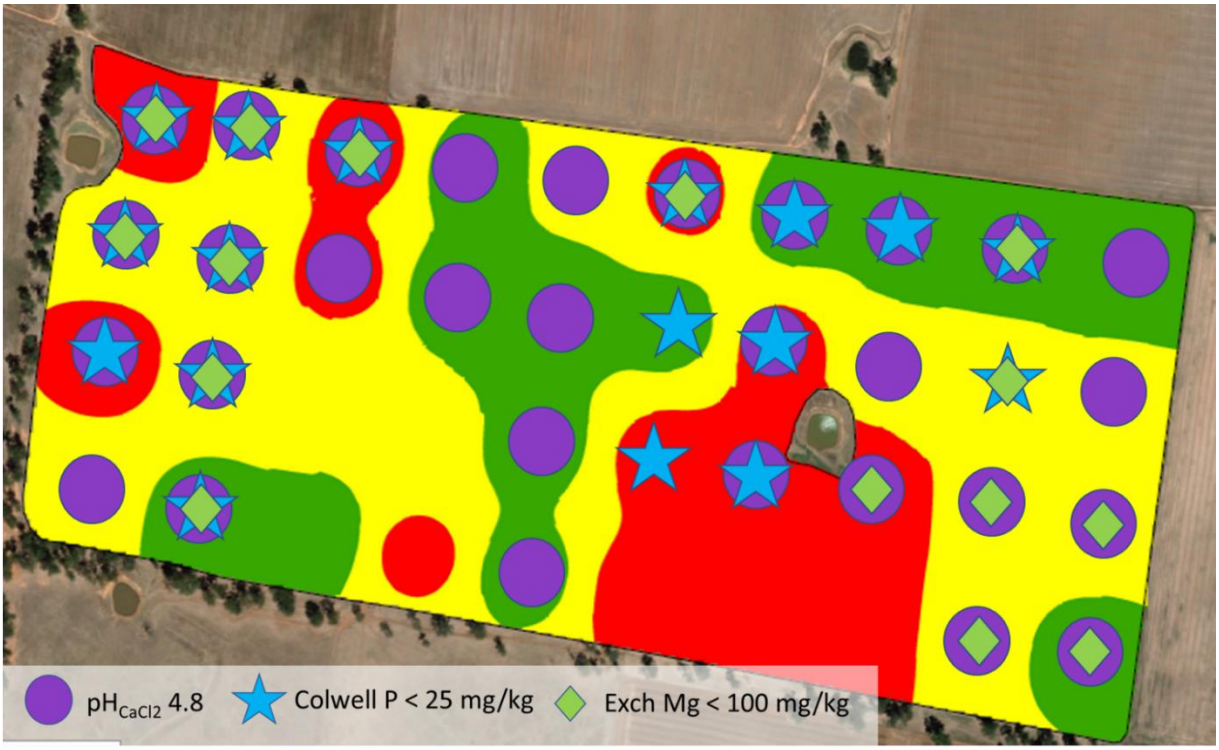

Figure 2: Distribution of zones (zone 1 = red, zone 2 = yellow, zone 3 = green) and limiting soil test properties for Case Study 2.

This case study was representative of a large portion of paddocks in the study. 25 of 28 paddocks showed no consistent correlations between NDVI and limiting soil properties. Across all 25 paddocks there were no significantly different soil test values between zones which matched low NDVI with low soil test properties.

CONCLUSIONS:

Precision Agriculture continue to use grid soil mapping for the identification and targeted management of surface soil characteristics. Based on many years of experience this process remains the 'gold standard.' Using proven soil science, developed to test key soil properties, this can accurately and repeatably identify soil constraints for targeted VR management.

NDVI and yield maps provide a measure of the variation in crop growth at a point in time along with a measure of total season production. The variation highlighted by these maps is the result of many factors including surface and sub-surface soil properties, soil type, elevation, management, pests, disease and frost.

This study has observed that in over 90% of paddocks within the data set, NDVI derived management zones did not identify soil constraints or provide insight to the factors creating paddock variation. In addition, the variation in soil properties within management zones (coefficient of variation) was similar to the variation across the full paddock.

Only a select number of paddocks in the study (<10%) were able to show that NDVI derived management zones could identify areas with significantly different surface soil properties and correlate low NDVI with soil constraints. Even when zoning worked, it still created an average soil property for each zone, thus limiting the ability to manage fluctuating soil test values.

The results have clearly shown that using NDVI and yield data as a basis for creating soil management zones does not work in broadacre cropping systems. These zones did not identify soil constraints and variation in surface soil characteristics in over 90% of paddocks in the study. Therefore, such an approach has limited relevance when developing VR solutions to address soil constraints. Grid soil mapping clearly provides the most accurate and reliable evidence base for VR management of surface soil properties.

REFERENCES:

Barlow K, Ie S, Fleay B (2019). Grid soil mapping to define the variability in multiple soil properties. In: Cells to Satellites. J Pratley Ed. Proceedings of the 19th Australian Society of Agronomy Conference,25-29 August 2019, Wagga Wagga, NSW, Australia. (http://www.agronomyaustraliaproceedings.org/).