Grid soil mapping to manage variability across multiple soil properties

Dr Kirsten Barlow and Matt Kelly
Precision Agriculture Pty Ltd

Key points

- Soil sampling to understand in-paddock variations of pH, exchangeable cations and phosphorus (P) provides growers with an understanding of key soil constraints and their distribution, supporting more targeted amelioration strategies.
- For a case study property near Tocumwal, Victoria the variable-rate application (VRA) of lime, gypsum, phosphorus and potentially magnesium (Mg) was well supported by soil test results.
- Measurement of pH, exchangeable cations and phosphorus parameters across 280 paddocks showed a generally poor correlation between these components suggesting different management zones are required to address different soil constraints.

Background

Soil constraints, such as acidity, sodicity and nutrient availability, are a significant challenge across the Riverine Plains area. While ameliorating these constraints by applying lime, gypsum and fertiliser accounts for a significant portion of annual on-farm expenditure, a strong evidence base, combined with the capability for variable rate applications (VRA), can improve the return on investment (ROI).

Grower knowledge, historic yield and satellite data can all provide a valuable insight into in-paddock variation for both crop and pasture production. However, this variation is driven by multiple factors including, soil type, available water, available nutrients, the effects of soil constraints and previous yields and management. Grid soil sampling is a proven sampling strategy to identify and allow for targeted amelioration of soil constraints across a paddock.

Aim

This project investigated the use of grid soil mapping to measure a variety of soil chemistry properties, specifically soil pH, exchangeable cations and soil phosphorus (P), and explored the potential relationships between different soil characteristics across individual paddocks.

Method

Grid soil mapping is the process of collecting soil samples on a standard grid to quantify the spatial variability across a paddock. The process of grid soil mapping used in this study involved:

- digitising the paddock boundary and developing a sampling grid of 1–2ha in size
- collecting GPS-referenced surface soil (0–10cm) samples
- submitting soil samples to an accredited laboratory for analysis, including pH_{CaCl_2}, exchangeable cations and phosphorus (Colwell P).

Data was collected and analysed from an irrigated mixed farming enterprise near Tocumwal, NSW along with 12 months of commercial soil grid mapping data collected from 280 paddocks (10–200ha in size) by Precision Agriculture Pty Ltd during 2018. This data was collected from paddocks across SA, Vic, Tas and NSW, with approximately 60 of the paddocks located within the Riverine Plains area.

Figure 1 outlines the 320ha property near Tocumwal, which was mapped on a 2ha grid.

Results

i) Soil pH

Soil acidity affects 50% of Australia's agricultural land and can significantly limit both crop and pasture production, restrict crop choice, and, when untreated can reduce the health of the soil resource. During 2018 Precision Agriculture collected almost 10,000 soil samples across the Riverine Plains region. Of these samples, 40% had a pH <4.8 (moderately to highly acidic) and 47% had a pH of between 4.8 and 5.4 (slightly acidic), which indicates the scale of the problem across the region.

The average soil pH was 5.2 across the Tocumwal case study paddock (Figure 2), with 190ha having a pH <5.2, which places these soils into the slightly — highly acidic categories.

Calculating the variable rate strategy for this property involved setting a target pH of 5.8 in order to increase crop choice (including pulses and a move to potential summer crops such as maize). To achieve a target of pH 5.8, an average lime rate of 2.0t/ha was required, with a VRA ranging from 0–4.5t/ha across the paddock.

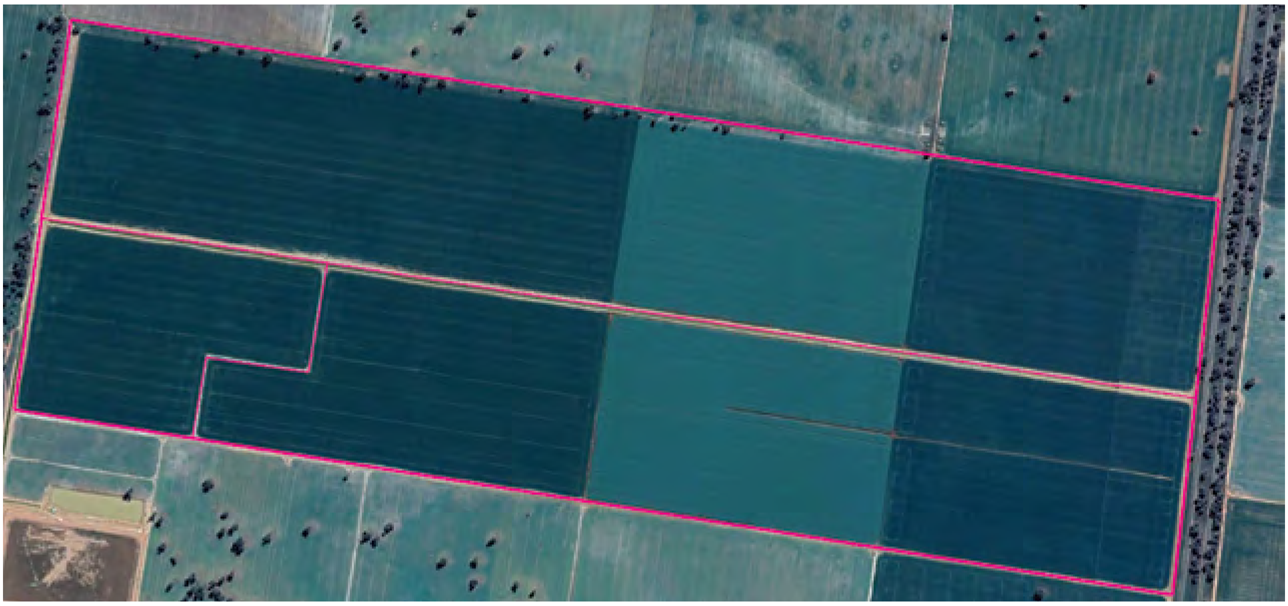

FIGURE 1 Satellite image of the Precision Agriculture case study property near Tocumwal, NSW (August 2018)

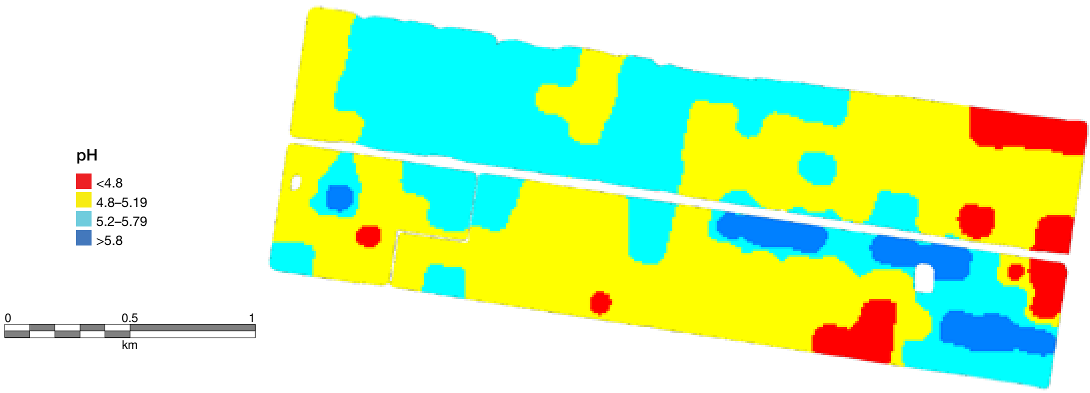

FIGURE 2 Grid-mapped soil pH_{CaCl2} data (0–10cm)

A blanket application of 2.0t/ha lime across the paddock was estimated to result in a range of soil pH from 5.1–7.3.

ii) Phosphorus

Soil phosphorus levels depend on a range of factors including previous management history and natural variation. Soil phosphorus (Colwell P) was measured on the case study property and the grid soil sampling results (Figure 3a) reveal the variation in phosphorus soil test values, with an average Colwell P of 77 mg/kg, and a range of 38–140mg/kg.

Even with a low-to-moderate phosphorus buffering index (PBI) (<280), the entire paddock had a Colwell P above the critical value of 38mg/kg for wheat, suggesting base phosphorus levels were adequate, so no capital rates of phosphorus were applied. However, a VRA replacement strategy would ensure the areas close to critical values are not run down to marginal levels, while also ensuring that phosphorus levels across the majority of the paddock are not increased.

iii) Exchangeable cations

Cation exchange capacity (CEC) provides a measure of the soil's ability to supply and hold important plant nutrients, including calcium (C), magnesium (Mg) and potassium (K) and also provides an indication of the soil's ability to buffer changes in soil pH. The CEC of the Tocumwal paddock was measured, with the area averaging 8.4cmol/kg, with a range of 4.5–19cmol/kg (Figure 3b).

Exchangeable potassium was 256mg/kg, with a range of 120–470mg/kg, exchangeable calcium was 1045mg/kg, with a range of 640–2090mg/kg and exchangeable magnesium was 231mg/kg ranging from

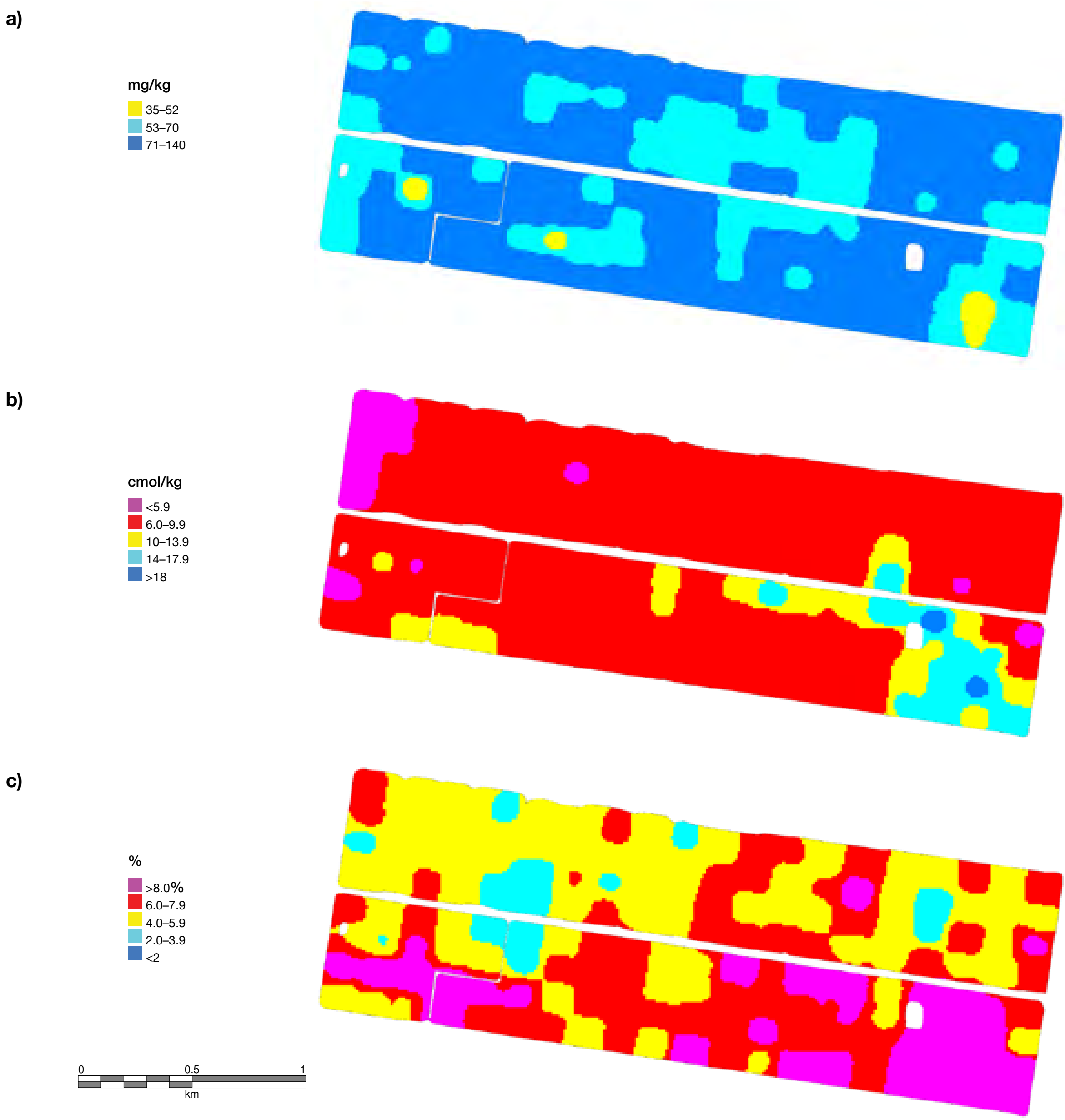

FIGURE 3 Grid mapped soil (a) phosphorus (mg/kg); (b) cation exchange capacity (CEC) (cmol/kg) and (c) exchangeable sodium percentage (ESP) (%) for a Precision Agriculture Pty Ltd 2018 case study paddock near Tocumwal, NSW

40–900mg/kg. In the context of wheat, the calcium and potassium levels were generally within or above the desired ranges. However, there were areas of the paddock where magnesium levels were low (<175mg/kg), suggesting the potential for VRA of magnesium to target these areas.

Exchangeable cations can also be used to calculate the exchangeable sodium percentage (ESP), with an ESP above 6% considered sodic. Sodicity impacts soil structure and can affect seedling emergence, root penetration, water infiltration, nutrient availability and soil aeration. For the case study property, the ESP averaged 6.6% and ranged from 2–18%, with just on half the paddock considered sodic (Figure 3c). VRA Gypsum would allow for the targeted amelioration of sodicity across the paddock, with gypsum concentrated on the most sodic areas of the paddock.

iv) Variation in multiple soil characteristics observed across 280 paddocks

The 2018 grid soil mapping results for the 280 paddocks sampled across south eastern Australia, including the Riverine Plains region, demonstrated a high level of variability for pH, phosphorus, CEC and ESP. The average paddock pH ranged from 4.3–6.9, with 65% of the paddocks having an average pH of less than 5.2. Soil pH varied within paddocks by an average of 1.0 pH units (maximum –



minimum pH), with the greatest observed paddock variation being 3.2 pH units (pH 4.3–7.5). Assuming a target pH of 5.2, 90% of sampled paddocks had a measured minimum pH below 5.2 and therefore required lime in parts of the paddock. Conversely, 70% of paddocks had a maximum pH greater than 5.2, meaning no lime was required in these areas. These results show that pH variation occurs frequently within paddocks and highlights the potential for VRA lime in these paddocks. Similar variability was seen across the 280 paddocks for phosphorus, CEC and ESP, which also indicates that the potential for VRA phosphorus, magnesium, potassium and gypsum was significant.

Across the 280 paddocks mapped during 2018, the variability between the different soil properties was not correlated (consistent with the case study property), suggesting that variable rate management zones for acidity, sodicity and nutrient availability will differ. The major exception to this is the strong positive correlation (>0.7) across 70% of paddocks between pH and CEC, which reflects the role of exchangeable cations in buffering changes to soil pH, as well as the effect of pH on variable charge exchange sites in the soils.

Observations and comments

Understanding the variation in soil chemistry parameters across a paddock through grid sampling, as demonstrated by the results from the case study property, provides an understanding of the key soil constraints and their distribution, which can allow for more targeted amelioration strategies.

Results from the case study property, and the 2018 combined set of grid soil mapping data, show little to no correlation between the different soil attributes, with the exception of soil pH and CEC. This means different management zones are required to address different soil constraints.

Contact

Dr Kirsten Barlow Precision Agriculture Pty Ltd

T: 0437 374 947, 1800 773 247
E: k.barlow@precisionagriculture.com.au
W: www.precisionagriculture.com.au