PRECISE SURVEYING OF SOIL PRODUCTIVITY INDICATORS USING ON-THE-GO SOIL SENSORS

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Introduction

Current soil sampling methods, such as conventional and hectare grid sampling, do not provide a cost effective way in which to gather G.P.S. referenced data at an adequate frequency.

Various on-the-go soil sensing methods have been attempted to try and combat this. One such method is the Veris Mobile Sensor Platform (MSP-3). This method combines the mapping of soil texture via electrical conductivity (EC), organic matter (OM) percentage, using near infra-red light reflectance and soil pH levels, using ion-selective electrodes, along with topography data.

The concept of direct measurement of soil pH, texture (via EC) and OM, all geospatially referenced, has allowed for a substantial increase in measurement density.

In this paper, we discuss various case studies and investigate:

1. Variable rate lime prescription rates, generated from on-the-go pH measurements and how it can result in the improved prediction of liming requirements compared to the conventional and grid sampling methods.
2. Mapping soil texture via EC and using GPS references to provide dense data coverage to delineate soil boundaries more accurately than currently available data and existing soil maps, including S-Map.
3. Acquiring precise topographical measurements simultaneously to and geo-referenced proximal soil sensor readings. Topography and landscape position frequently exert a significant influence on soil properties and productivity.

Background

Continuous Soil Sensing involves the use of mobile soils sensors that measure soil characteristics on-the-go while recording these results with GPS co-ordinates to allow the data to be displayed and analysed using geospatial platforms. Soil characteristics display X-Y-Z variability, which is variation by surface location on the paddock, but also with depth in the soil profile. This characteristic allows for the 3-D mapping of soil characteristics in a paddock.

The most commonly measured soil characteristics is soil electrical conductivity (EC), which is an indicator of soil texture. By using different electrical voltage and currents and sensors spacing, it is possible to measure EC at different depths in the soil profile.

Since the 1990's visual sensors have been used on on-the-go soils sensors to measure soil colour, and from this estimate soil carbon content. The most commonly used unit for soil carbon estimation utilises near-infrared sensor technology.

In 2002 Purdue University patented technology for an on-the-go soils sensor to collect a soil sample while underway, and then lift this sample against a pH probe, thereby measuring soil pH on a geospatial level. Veris Technologies based in Salinas, Kansas developed this technology and released a commercial on-the-go soil pH mapping platform in 2003.

pH Variability

International research has found that soil pH varies by up to 3 units in distances of 130 metres in most transects through sample paddocks. In some sections, soil pH varied about 2 pH units over a 13 m distance. New Zealand work has found pH readings varying by 2 or more units in a single paddock.

By analysing soil pH variability it has been concluded that samples would have to be drawn every 30m or less to adequately assess the spatial variation of soil pH. Sampling at this intensity would require approximately 11 times as many soil samples as the commonly used 1 hectare grid.

Possible Applications

The most common use of the information obtained from on-the-go soil sensing units is to develop variable rate irrigation prescriptions. Less water can be applied more regularly to coarser textured soils to minimise drainage through the soil profile, while less regular applications can be made to finer textured soils.

We believe that the use of geospatial measurement of soil pH offers profitable returns by applying lime variably across the paddock.

Variable rate seeding is used to plant higher populations on finer soils with better soil moisture storage, and lower populations in coarser, more drought prone areas. Modern maize planters are also able to plant two different hybrids in a paddock, thereby planting higher producing hybrids in the finer textured parts of the paddock, and more defensive hybrid choices in coarser areas of the paddock.

For this study we used a Veris MSP-3 unit from Veris Technologies, Salinas, Kansas. This unit makes about 200 measurements per hectare for soil EC and OM, and approximately 20 measurements for pH per hectare. The table below outlines the properties and characteristics the unit measures, and the measurement systems and units used.

Table 1. Soil Properties and Measurements System used by Veris MSP-3

Soil Property	Measurement system	Soil Characteristics	Unit
Physical	Electrical conductivity	Soil texture	Microsiemen (μs)
Biological	NIR spectroscopy	Soil organic matter	Percent (%)
Chemical	pH probes	Soil pH	pH units

Figure 1. Veris MSP3 Unit, showing components for individual measurements

Case Study

In order to assess the use of the Veris MSP-3 we undertook soil sensing on a subject paddock in South Canterbury. Using the Landcare Research S-map Soil Report system we found that the subject paddock is predominantly a moderately deep Templeton Silty Loam. However, this information is given with a low level of confidence. A recent soil test of the subject paddock gave a soil pH of 5.9, but with no indication of variability.

The image below shows the subject paddock, and the regions of soil pH in the paddock. This image was prepared using SMS AgLeader GIS software, and is based on individual readings from approximately 300 sampling sites that the Veris MSP-3 took pH readings from. Soil samples were taken at sites in the subject paddock and lab tested for pH, with the results then being used to calibrate the Veris MSP-3 pH data. Note the pH variation from 4.4 to 7 within the subject paddock.

Figure 1. Subject Paddock Soil pH Map

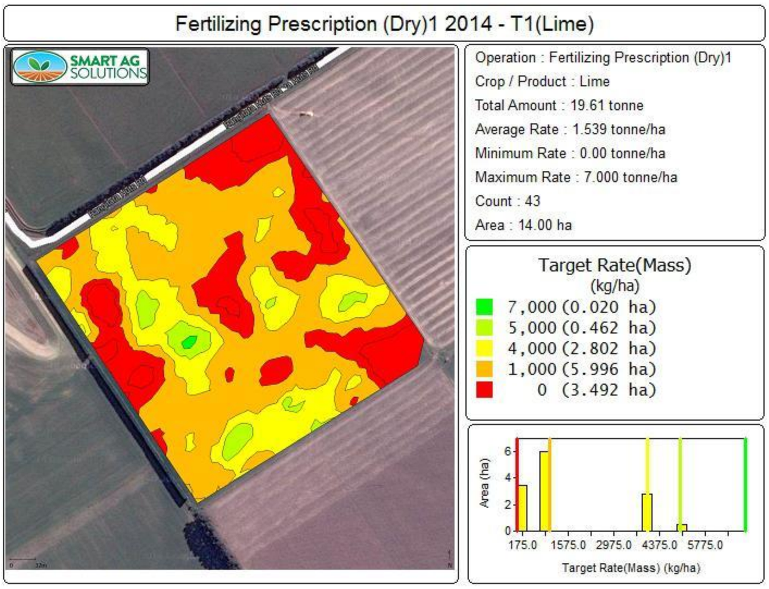

Figure 2. Subject Paddock Variable Rate Lime Recommendation

The subject paddock is 14 hectares, and has an average pH of 5.6 (Based on calibrated Veris MSP-3 measurements). Below we undertake financial analysis of the subject paddock:

Whole subject paddock to receive lime:

- Subject paddock pH = 5.6, therefore apply lime at 4t per hectare
- Total subject paddock to receive 56t lime @ $60 per tonne, a total of $3,360

Subject paddock mapped using Veris MSP3:

- Lime is to be applied at variable rates to portions of the paddock, as per the following:
    - 0.02ha @ 7t/ha
    - 0.46ha @ 5t/ha; 2.8ha@ 4t/ha
    - 5.9ha @ 1t/ha
    - 3.4ha no lime applied
- The total lime to be applied is 19.6 tonne at a cost of $1,176. There is the additional cost of Veris MSP3 mapping @ $72 / hectare, for a total of $1,008 for the whole subject paddock.
- The cost of mapping and lime is $2,184, therefore there is an immediate saving of $1,176 over applying lime to the whole paddock based on the pH obtained from the conventional soil test.
- The variable rate lime application resulted in a yield increase of 200 kg /ha, with the wheat price at $410/tonne resulting in an increase in income of $1,148.
- Therefore, by using the Veris MSP-3 on-the-go pH soil sensor there is potential to increase the profit margin by $2,324 in the subject 14 hectare paddock. This equates to $166 / hectare in a single crop, however the benefits will continue over multiple crops.

We believe that the use of on-the-go soil sensing systems can empower many farming decisions, and ultimately result in increased profits and/or more efficient input use.