SOIL SURVEY AND ELECTROMAGNETIC INDUCTION – A MARLBOROUGH VINEYARD CASE STUDY

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Abstract

Differences in soil texture, soil nutrient status, available moisture and soil drainage, among other soil properties, contribute to the variability in fruit quality and yield within a vineyard. Accurate mapping of this variability could lead to an improved soil and vine sampling and management process, hence to a more uniform grape quality. Generally, maps derived from traditional soil surveys do not adequately account for the spatial variability of soils, making interpretation and soil management difficult. A geographic information system, a real-time kinematic differential global-positioning system and an electro-magnetic sensor, together with field work, are used to assess a soil survey in a ninety eight hectare vineyard in the Marlborough Region, New Zealand. Apparent electroconductivity (EC_a) surveys were made during both dry (March) and wetter (September) soil conditions. Percentage and depth of gravel, gley horizons, soil bulk density, total available water content, chemical properties and depth to water table were all either measured in the field or estimated. Extremes in soil texture are found to correspond to high or low EC_a values. The deep and shallow EC_a survey made in March depicts soils with a high and a low percentage of coarse gravels. The deep EC_a survey made in March also depicts deep soils with particles finer than 2 mm deeper in the profile. The highest and lowest total available water content estimates were also associated with highest and lowest EC_a values. The EC_a survey made in September apparently responds to water tables within 120 cm below the surface. Furthermore, from the contour survey made with the differential global-positioning system, a series of hollows and ridges are detected. A tendency for lower fertility on the ridges is observed. Nevertheless, it is not possible to accurately define soil variability from the EC_a surveys. Although the information generated by the electro-magnetic sensor is useful, both field observations and the topographic survey are the main influences defining and mapping the five soil-geomorphic units identified in this project. The implications of the results for soil management are discussed. Suggestions for improving future trials using the electro-magnetic sensor for soil variability assessment and potential future research are also given. Finally, a lack of correspondence between potassium concentrations in soils and plants is investigated. A high potassium concentration in the water used for irrigation is found to be the possible cause of such results.

Keywords: precision viticulture, soil electroconductivity, electromagnetic induction, soil properties, soil survey, GIS.

A mi hermano y hermana,
mamá y papá,
abuelos y abuelas,
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CHAPTER 1

General Introduction

1.1 Viticulture in the Marlborough Region

Viticulture and wine production in New Zealand have been increasing during the last twenty years. According to the Wine Institute of New Zealand (2003), the number of wineries increased from 131 to 398 between 1990 and 2003. In the same period, the producing vineyard area increased from 4,880 to 14,802 ha. The wine industry in New Zealand is decisively export orientated, with a growth from 8 million litres to 23 million litres exported in the last 10 years, representing NZ$ 246.4 millions FOB (free on board).

Marlborough winegrowing area has grown rapidly and is now New Zealand's largest and best-known one, with over 5,000 ha of established grapes (more than forty percent of the total New Zealand grape producing area), which produces half of the total New Zealand grape production. The worldwide interest in Marlborough wines, particularly Sauvignon Blanc and Chardonnay (and more recently Pinot Noir and Riesling), has resulted in a rate of development of about 1,200 ha per year of new vineyards (Wine Institute of New Zealand (2003).

The region's environmental conditions have been crucial to such development. The typical free-draining, alluvial loams with gravelly sub-soils provide optimum growing conditions. High annual sunshine-hours (2450), cool climate during the hottest month (average 18°C), with cool nights and limited rainfall (642mm/year), allow a slow ripening process that contributes to the high quality of Marlborough wines.

1.2 Soils, viticulture and precision technologies

Differences in soil properties, soil nutrient status and available moisture contribute to the variability in fruit quality, ripening and yield within a vineyard. An understanding of this variability and the relationships between manageable soil properties, grape yield and fruit quality could support more accurate soil and vine sampling and management.

The development of new technologies has revolutionised the way in which soil information can be obtained more efficiently. Non-contact sensors based on electromagnetic induction technology have been shown to provide an effective basis

for delineating interrelated physical, chemical and biological soil attributes (Johnson *et al.*, 2001a).

One of these technologies is the Geonics electro-magnetic (EM38) sensor, which measures soil's apparent bulk electrical conductivity (EC_a). With the data generated by the EM38, soil-sampling sites can be strategically selected and a targeted soil sample to calibrate the instrument can be taken (Bramley & Proffit, 2000). Once a relationship is established between EC_a measures and one or more soil attributes, accurate maps showing the variability of different soil properties can be produced (Doerge, 2001).

Adopting precision viticulture technologies like the EM38 and site-specific concepts, can lead to more accurate soil surveys and improved management opportunities (Lamb & Bramley, 2000). For example, the use of EM sensors, together with other precision viticulture tools, boosts the opportunity to harvest depending on quality specifications, to make a more effective use of inputs, reduce environmental risk, enhance sustainability and optimize the use of natural resources (Lamb & Bramley, 2000; Bramley & Proffit, 2000; Wolkowski, 2000).

1.3 Research importance, aims and objectives of the project

A winery expansion scheme is being carried out at Rarangi in the Marlborough region, where 600 hectares are being planted. Soil properties are well known to influence vineyard performance, so an understanding of the soil's variability within the vineyard and the relationships that exist among the soil properties and the vines is required to adopt a site – specific vineyard management that could improve the grape production process.

A lack of in-depth knowledge of the spatial variability of soil properties within the Rarangi vineyard planted mainly in 2001, is limiting the successful adoption of site-specific concepts and technology. Another unresolved question in the vineyard is the relatively high potassium concentrations found in plant samples. These values are higher than expected, being poorly correlated with the exchangeable potassium levels in the soils.

EM38 measurements have the potential for mapping some soil properties differences, and some previous work has been done in New Zealand (Pitcher-Cambell, 2002; Hedley *et al.*, 2002). However, the proposed area to be studied is different to the majority of previous similar surveys. The large proportion of gravel and stones and slight soil differences within the area of study constitute an extra challenge for both the interpretation of EM38 readings and the vineyard management. Hence, the growing wine industry in New Zealand will benefit from an increase in our knowledge and

understanding of the relationship between soil properties and the electrical conductivity of the soils. A successful survey in this study would not only be helpful in assessing the likelihood of the vineyard response to targeted management, but would also promote the use of tools like the EM38, which promise a more accurate, quicker and cheaper method of mapping soil variability than the traditional manner.

The main aim of this study is to use precision technologies (EM38, high-accuracy real-time kinematic differential global-positioning system (RTK - DGPS)) and geographic information systems (GIS)) to produce accurate maps showing the distribution of main soil properties. A second aim of this project is to investigate possible reasons for the high potassium levels found in vines despite the low levels in soils.

To achieve these aims, this project had the following objectives:

1) Carry out a detailed topographic and electromagnetic survey of the 98 ha of vineyard using the EM38 and RTK - DGPS, and map the variability found.

2) Identify and survey soil properties that are most important for the vines performance with a view to assessing the feasibility of crop response to targeted management.

3) Compare the EC_a data with the detailed soils information collected in the traditional manner and interpret the electrical conductivity variability in terms of those characteristics identified in the previous above mentioned exercise.

4) Map the soil types and the variability of specific soil properties within the study area, implementing a geographic information system.

5) Determine the nutrient status of the soils.

6) Investigate the potassium (K) availability of the soils and possible causes for the high values found in plant samples compared with the low K values in the soils.