Development of an on-the-go soil sensing system for determinations of soil pH and lime requirement

R.A. Viscarra-Rossel[1], L. Thylén[2], Alex B. McBratney[1] and M. Gilbertsson[2]

[1]Australian Centre for Precision Agriculture, The University of Sydney, NSW 2006, Australia. Email: r.rossel@agec.usyd.edu.au
[2]Swedish Institute of Agricultural and Environmental Engineering (JTI), Uppsala, Sweden

Abstract

The implementation of precision agriculture (PA) at the farm or field level requires amongst other factors, the development of 'on-the-go' proximal sensing systems to collect the large amounts of soil information needed for crop management, with minimal labour, cost and effort. Research towards the development of 'on-the-go' proximal sensing systems to quantify soil variability and produce the information required for site-specific crop management (SSCM) is particularly important for the adoption of PA. The perceived advantages of such soil sensing systems are (i.) elimination of costly and tedious sampling and analysis, (ii.) efficient acquisition of fine spatial resolution continual data, (iii.) real-time availability of results and the possibility for their integration with other field operations, *e.g.* variable-rate resource applications, (iv.) minimal sample handling, *i.e.* no need for transport and storage, (v.) elimination of laboratory induced variability, (vi.) little expertise needed to operate the system after initial set-up.

This work describes the development of an 'on-the-go' proximal soil pH and lime requirement sensing system, and the methodology required to site-specifically manage acid agricultural soil. The proposed sensing system consists of the following sub-systems; (a.) a soil sampling component, (b.) a soil analytical and sensing component, (c.) data collection and measurement algorithms. The sensing system is controlled and automated using a control I/O system and custom designed software.

Soil is collected continuously from a working depth of 20 cm, sieved to a size fraction < 2mm and approximately 2 cm^3 of soil is measured and passed on to the soil analytical and sensing component. The soil analytical component comprises a batch-type mixing chamber with embedded pH Ion Sensitive Field Effect Transistor (ISFET) sensors and two inlets for: (i) chemical solution (lime requirement buffer/ 0.01M $CaCl_2$) and (ii) water. Two pumps are used to pump solution into the chamber. A small motor is used for mixing and a bottom opening valve is used to release waste. One cycle occurs in 4 + x seconds.

Laboratory testing of the system using soil samples form a single field showed that for determinations of soil pH in 0.01 M $CaCl_2$, when x = 6 seconds the root mean square error (RMSE) of pH measurements is 0.25 pH units. This accuracy is similar to that measured by Viscarra Rossel and Walter (2004) who used a pH ISFET for manual field measurements of soil pH. Determinations of lime requirement involve modelling the kinetics of the lime requirement buffer reactions to estimate reaction equilibrium times (e.g. Viscarra Rossel and McBratney, 2003). The estimated equilibrium pH_{buffer} values are then inputted into a lime requirement model for predictions of lime requirement. Results from laboratory testing of the system and algorithms using soil samples from a single field are shown in Figure 1.

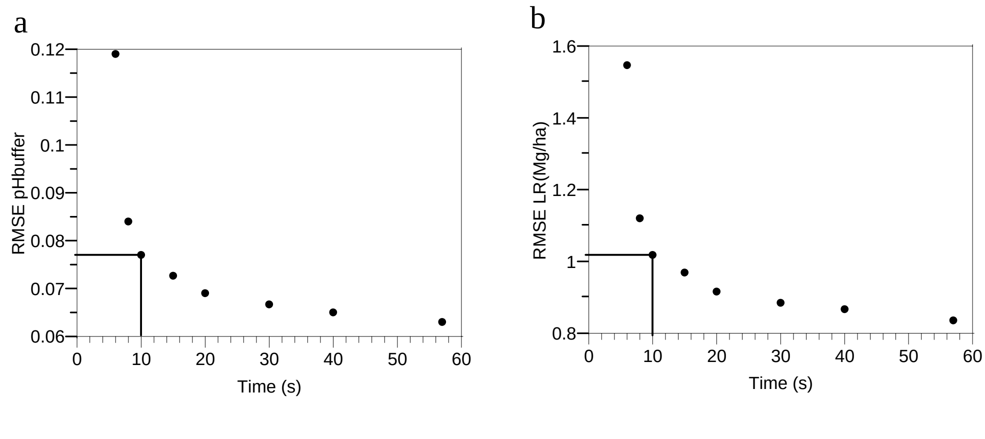

Figure 1. The RMSE of estimated (a.) equilibrium pH_{buffer} values and (b.) respective predictions of lime requirements at various times.

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For example, when x = 10 seconds the RMSE of the estimated equilibrium pH_{buffer} value is 0.077 pH_{buffer} units, corresponding to a lime requirement RMSE of 1.02 Mg/ha.

Although the analytical and sensing components as well as the data collection and measurement algorithms have so far only been evaluated in the laboratory, these preliminary results appear promising. During the first half of 2004 the various components of the sensing system will integrated and field trials will be performed.

References

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