The estimation of soil sodicity and pH using NIR spectroscopy has potential for precision agriculture

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Introduction

To improve the response to applied soil inputs in agriculture, low cost soil analysis is needed so they can be applied variably to optimise crop response and input use efficiency. Near infrared spectroscopy (NIRS) is accepted worldwide for the analysis of many constituents in various plant tissues, providing fast, economical and safe analysis with accurate results (Batten, 1998). Implementation of precision farming requires extensive information on soil properties and conventional laboratory systems are costly in generating the necessary data.

Material and Methods

Over 500 soil samples from the 0 to 10 cm depth interval covering southern NSW ricegrowing areas were used in this research. Soil samples were air dried after collection before being passed through a jaw crusher to pass a 2mm sieve. Commercial Pivot laboratory analysis including pH, CEC, Ca, Mg, Na, %OC and ESP were determined for these soils. NIR scans of these soils were made with a NIRsystems 6500 scanning spectrophotometer, obtaining spectra at 2 nm intervals between the 400 and 2500 nm wavelengths.

The soils were ranked from lowest to highest for each soil property and a subset consisting of every fourth sample removed. The Partial Least Squares (PLS) regression procedure was used to determine the best correlation (i.e. calibration) between the chemical reference data and spectral data for the remaining samples. The subset samples were used as validation sets to determine the predictive ability of the calibrations.

Results and Discussion

The calibration with the best predictive ability has the highest r^2 and the lowest Standard Error of Performance (SEP) of the prediction set. Table 1 presents results for a range of soil properties. The best predictive ability was obtained for CEC, followed closely by exchangeable Ca and Mg, pH and Ca:Mg ratio (Table 1). Exchangeable Na, ESP and OC were also predicted to a useful level of accuracy.

Table 1. Chemical characteristics, calibration and prediction results for soil properties

Variable	Range	No. Calib Samples	Calib. R^2	SEC	No. Pred Samples	Pred. r^2	SEP
pH	3.8-7.3	417	0.83	0.30	138	0.80	0.32
CEC, cmol(+)/kg	2.7-33.6	422	0.88	2.19	139	0.90	1.88
Exch. Ca, cmol(+)/kg	0.9-21.0	422	0.87	1.23	139	0.86	1.26
Exch. Mg, cmol(+)/kg	0.5-13.2	419	0.91	0.88	139	0.85	1.05
Exch. Na, cmol(+)/kg	0.04-3.9	413	0.69	0.45	137	0.64	0.48
% ESP	0.1-24.0	414	0.69	2.55	135	0.68	2.69
Ca:Mg ratio	0.4-3.5	414	0.87	0.21	136	0.79	0.26
% Organic C	0.6-3.0	270	0.62	0.26	90	0.66	0.25

The aim in precision agriculture is to divide a field into a number of management zones. In creating management zones a slight decrease in individual sample accuracy would be far outweighed by the speed and cost efficiency of NIRS analysis enabling a range of chemical properties to be determined for many samples within an individual field. Figure 1 illustrates the accuracy of the NIRS soil property predictions.

In irrigated agricultural systems lower soil pH can result in poor plant growth and reduced yield. The predictive ability of NIRS for pH is very good and would be suitable for commercial use. The highly accurate prediction of CEC by NIRS is extremely useful as the conventional laboratory test for CEC is expensive but it is necessary to know the soils CEC in order to calculate the amount of lime needed to bring the soil pH up to an acceptable level (Fenton, 1999).

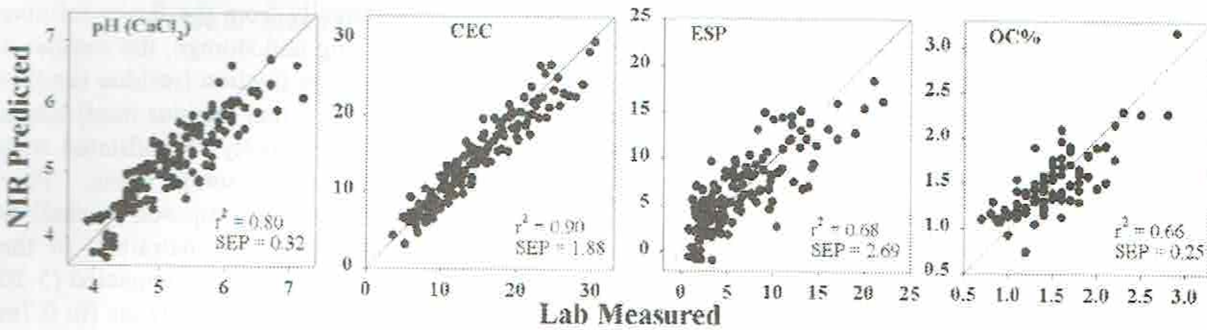

Figure 1. NIRS predictions of pH, CEC, ESP and OC plotted against laboratory values

ESP was not predicted with a high level of accuracy but is still a useful calibration. In the ricegrowing areas of Western Murray Valley in southern New South Wales surface soil sodicity can be highly variable within a field and is a significant problem in rice establishment (Beale 1998). Although applying gypsum can reduce the problem, gypsum increases potential recharge to the watertable by increasing infiltration (Slavich and Petterson 1992) so a method which assists in determining where to apply gypsum would be useful.

Conclusion

The results achieved by NIRS soil analysis using a large number of soils, from many soil types and with a separate validation set, gives us confidence that for the Riverine Plain soils of southern New South Wales, it is suitable for use in precision agriculture. The accuracy of the pH and CEC calibrations makes them particularly useful for the determination of soil acidity across a field and the estimation of lime rates necessary to bring the soil pH back to an acceptable level. Although the ESP predictions are not as accurate, they are suitable for assessing within field variability of surface soil sodicity, allowing variable rate applications of gypsum.

References

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