SOIL MAPPING AND MODELING ON TWENTY-FIVE INGREDIENTS USING A REAL-TIME SOIL SENSOR

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ABSTRACT

We obtained Twenty five calibration models based on Vis-NIR (305 - 1700 nm) underground soil reflectance spectra collected using a Real-time soil sensor with a differential global positioning system, in order to create each ingredient soil maps. The investigated soil ingredients were moisture content (MC), soil organic matter (SOM), pH, electrical conductivity (EC), cation exchange capacity (CEC), total carbon (C-t), ammonium nitrogen (N-a), hot water exchangeable nitrogen (N-h), nitrate nitrogen (N-n), total nitrogen (N-t), exchangeable potassium (K_2O), exchangeable calcium (CaO), exchangeable magnesium (MgO), hot water soluble soil boron (B), soluble copper (Cu), exchangeable manganese (Mn), soluble zinc (Zn), available phosphate (P-a), C/N ratio (CN), MgO/K2O ratio (MgO K_2O^{-1}), CaO/MgO ratio (CaO MgO^{-1}), lime saturation degree (LSP), base saturation degree (BSP), bulk density (BD) and phosphate absorption coefficient (PAC).

Twenty five soil maps were drawn using ArcGIS software.

Keywords: Real-time soil sensor, Vis-NIR spectroscopy, PLSR, soil map

INTRODUCTION

In precision farming, rapid, non-destructive, cost-effective and convenient soil analysis techniques are needed for soil management decision, crop quality control using manure, fertilizer and compost, and variable-rate input for soil variability in an agricultural field. In particular, it is required that multiple soil parameters are estimated by one measurement data. The visible and near infrared spectroscopy is one of the promising techniques that measure rapidly multiple soil parameters.

The aims of this study is to obtain twenty five calibration models using PLSR based on Vis-NIR spectra data collected by a Real-time soil sensor (RTSS).

MATERIALS AND METHODS

Experimental Field and RTSS

The experiment was conducted on 2 fields (Field A: 303×146 m, Field B: 303×148.8 m, Fig.1) after crop harvesting in 2007, 2008 and 2009, Hokkaido Japan. An outline of RTSS is shown in Fig.2.

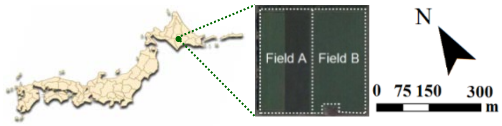

Fig. 1. Experimental fields

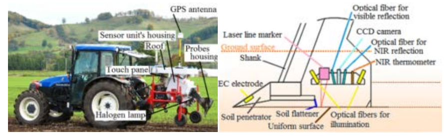

Fig. 2. RTSS

Multivariate Analysis

A total of 334 data of pretreated with 2nd derivative were used as the calibration dataset for full-cross validation. As shown in Fig. 3, original soil absorbance data (a) were converted to (b). Twenty-five soil ingredients calibration models were developed using the PLSR technique.

(a) (b)

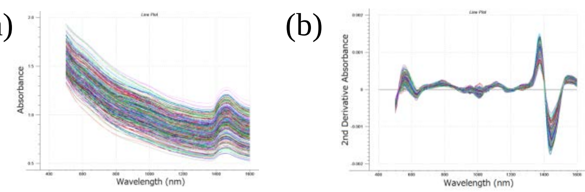

Fig.3 Original soil absorbance (a), Pretreated soil absorbance (b)

RESULTS

Table 1 shows the accuracy of twenty five calibration models. These obtained results, outliers were removed until the correlation coefficient of 0.8 or more using residual sample variance information in the Unscrambler software.

Table 1. The result of PLSR on twenty five calibration models.

Property	Unit	Wavelength (nm)	PT	PC	N				Property	Unit	Wavelength (nm)	PT	PC	N			
						R^2_{val}	$RMSE_{val}$	RPD_{val}							R^2_{val}	$RMSE_{val}$	RPD_{val}
MC	% weight	500 - 1600	2nd-D	7	334	0.84	2.26	2.52	Cu	ppm	500 - 1600	2nd-D	7	276	0.64	0.21	1.67
SOM	% weight	500 - 1600	2nd-D	7	334	0.71	0.58	13.47	Zn	ppm	500 - 1600	2nd-D	5	302	0.64	0.47	1.67
EC	mS cm^{-1}	500 - 1600	2nd-D	7	322	0.65	0.02	1.69	Mn	ppm	500 - 1600	2nd-D	7	211	0.64	2.20	1.67
pH	—	500 - 1600	2nd-D	5	280	0.65	0.24	1.68	B	ppm	500 - 1600	2nd-D	7	315	0.64	0.16	1.67
P-a	mg $100g^{-1}$	500 - 1600	2nd-D	6	325	0.78	9.18	2.12	N-h	mg $100g^{-1}$	500 - 1600	2nd-D	7	334	0.74	0.97	1.94
K_2O	mg $100g^{-1}$	500 - 1600	2nd-D	7	265	0.64	2.51	1.67	N-t	%	500 - 1600	2nd-D	7	334	0.80	0.01	2.22
MgO	mg $100g^{-1}$	500 - 1600	2nd-D	11	281	0.64	2.85	1.67	N-n	mg $100g^{-1}$	500 - 1600	2nd-D	7	279	0.80	0.26	2.25
CaO	mg $100g^{-1}$	500 - 1600	2nd-D	11	258	0.64	20.94	1.67	N-a	mg $100g^{-1}$	500 - 1600	2nd-D	7	334	0.69	0.28	1.79
MgO K_2O^{-1}	equivalent ratio	500 - 1600	2nd-D	7	322	0.65	0.50	1.68	C-t	%	500 - 1600	2nd-D	7	334	0.82	0.19	2.36
CaO MgO^{-1}	equivalent ratio	500 - 1600	2nd-D	7	243	0.64	0.85	1.67	CN	%	500 - 1600	2nd-D	10	334	0.71	0.46	1.85
LSP	%	500 - 1600	2nd-D	12	275	0.64	4.81	1.67	PAC	—	500 - 1600	2nd-D	7	334	0.79	70.07	2.20
BSP	%	500 - 1600	2nd-D	8	254	0.64	5.19	1.67	CEC	me $100g^{-1}$	500 - 1600	2nd-D	7	334	0.74	1.80	1.95
									BD	—	500 - 1600	2nd-D	7	334	0.73	0.04	1.93

PT: Pretreatment, PC: Principal component, N: Number of samples
R_{val}: Correlation coefficient of validation, R^2_{val}: Coefficient of determination of validation
$S.D._{Val}$: Standard deviation of validation, $RMSE_{val}$: Root mean square error of validation
RPD_{Val}: Residual prediction deviation of validation, ($RPD_{Val} = S.D._{Val} / RMSE_{val}$)

CONCLUSIONS

Accuracy of each twenty five calibration models using a Real-time soil sensor were obtained more than 0.64 (R^2_{val}).