Two-layer multiple soil-property mapping measured with a real-time soil sensor

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Abstract.

We obtained calibration models for 32 soil properties based on Vis-NIR (350 - 1700 nm) underground soil diffuse reflectance spectra collected using a real-time soil sensor (SAS3000) with a DGPS system, in order to generate soil property maps. We have previously demonstrated one-layer soil maps for soil management decision making by growers; however, for effective crop management, growers often wish to obtain complex layer information for their fields. Thus, in the present study, we measured two-layer soil depth on the same field, using tram lines and the SAS3000 sensor. The two layers selected by the grower were 0.15 m and 0.30 m. Guidance on soil management methods was also requested by the grower, and this will be a future task.

Keywords.

Two-layer soil map, Soil sensor, Vis-NIR spectroscopy, PLSR.

INTRODUCTION

In precision agriculture, rapid, non-destructive, cost-effective, and convenient soil analysis techniques are needed for efficient soil management; as well as crop quality control using fertilizer, manure and compost; and variable-rate input for soil variability in a given field (Viscarra Rossel et al. 2006). Many growers wish to know the soil variability in the top and deeper soil layers. However, it is difficult to obtain such knowledge using chemical analysis methods alone. Vis-NIR spectroscopy is an effective measurement method for simultaneously estimating numerous soil properties (Adamchuk et al. 2004; Kodaira and Shibusawa 2013). In this study, we measured two-layer soil spectra data using an SAS3000 soil sensor.

MATERIALS AND METHODS

Experimental Site and Settings

The experimental site was a commercial upland field in Saitama Prefecture, Japan. The field (0.09 ha: 45 m×20 m) consisted of taro plants (*Colocasia antiquorum* Schott), with crop rotation (Fig 1). The soil depth of the two studied layers, as selected by the grower, was 0.15 m and 0.30 m, respectively. First, soil spectra data for the depth of 0.15 m was obtained using the SAS3000 sensor; and then similar data was obtained for the soil depth of 0.30 m, using the same sensor and a 0.15 m tramline (Fig 2). The soil sensing speed was set at 0.28 m/sec.

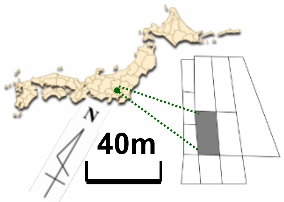

Fig 1. Site location.

Fig 2. SAS3000 and setting of soil depth.

RESULTS

A total of 100 soil samples and related spectra data were collected, to generate 32 estimated calibration models using second-derivative and partial least-squares regression (Table 1). The models included moisture content, soil organic matter, pH, electrical conductivity, cation exchange capacity, total carbon, ammonium nitrogen, hot water exchangeable nitrogen, nitrate nitrogen, total nitrogen, potassium, calcium, magnesium, boron, copper, manganese, zinc, available phosphate, C/N ratio, MgO/K2O ratio, CaO/MgO ratio, lime saturation degree, base saturation degree, phosphate absorption coefficient, sodium, available silicate, free iron oxide, exchange acidity, dry density, sand, silt, and clay. Figure 3 shows the resulting two-layer soil maps for 32 soil properties.

Table 1. Accuracy of 32 calibration models.

Properties	Unit	N	F	Range of calibration database	RMSE$_{val}$	R$^2_{val}$	Properties	Unit	N	F	Range of calibration database	RMSE$_{val}$	R$^2_{val}$
1 N-t	%	98	9	0.20 — 0.50	0.026	0.82	17 BSP	%	74	7	48.40 — 109.72	6.364	0.82
2 N-h	mg 100g^{-1}	82	8	4.78 — 12.24	0.843	0.83	18 CSP	%	81	8	39.12 — 102.92	6.602	0.84
3 N-n	mg 100g^{-1}	50	3	0.20 — 1.09	0.148	0.65	19 Mg/K	E.R.^{*1}	74	9	1.56 — 4.22	0.293	0.84
4 N-a	mg 100g^{-1}	61	6	2.43 — 5.83	0.371	0.82	20 Ca/Mg	E.R.^{*1}	93	10	3.56 — 21.02	2.230	0.83
5 P-a	mg 100g^{-1}	68	3	0.62 — 54.35	5.141	0.83	21 CEC	me 100g^{-1}	87	8	29.06 — 48.97	2.077	0.83
6 K	mg 100g^{-1}	86	6	22.09 — 109.78	9.979	0.83	22 DD	—	72	7	0.83 — 1.00	0.015	0.83
7 Ca	mg 100g^{-1}	96	8	255.00 — 1295.00	111.55	0.82	23 S	%	80	5	27.33 — 44.91	1.616	0.83
8 Mg	mg 100g^{-1}	79	4	0.82 — 98.48	8.241	0.82	24 SL	%	58	4	30.05 — 40.03	0.901	0.83
9 Na	mg 100g^{-1}	88	4	1.54 — 5.02	0.407	0.83	25 CL	%	72	6	21.73 — 35.47	1.080	0.82
10 Zn	ppm	77	6	4.86 — 19.00	1.487	0.82	26 MC	%	77	8	35.44 — 51.80	1.172	0.83
11 Mn	ppm	98	7	17.64 — 92.46	8.19	0.83	27 SOM	%	84	6	15.52 — 20.80	0.635	0.82
12 B	ppm	50	1	0.31 — 0.44	0.016	0.78	28 HR	%	90	9	4.37 — 10.00	0.393	0.90
13 Cu	ppm	93	8	0.18 — 2.70	0.290	0.82	29 Fe	%	50	2	4.14 — 4.60	0.107	0.37
14 pH	—	90	7	5.87 — 7.23	0.142	0.84	30 SiO	mg 100g^{-1}	95	8	80.73 — 196.00	13.243	0.84
15 EC	mS cm^{-1}	57	5	0.08 — 0.22	0.012	0.83	31 C/N	%	91	8	10.56 — 13.62	0.285	0.83
16 PAC	—	89	10	1540.0 — 2359.0	65.40	0.83	32 C-t	%	99	10	2.54 — 6.56	0.319	0.85

*1 E.R.: Equivalent Ratio, N: Number of samples, F: Factor of PLSR, $RMSE_{val}$: Root mean square error of validation, R^2_{val}: Coefficient of determination of validation

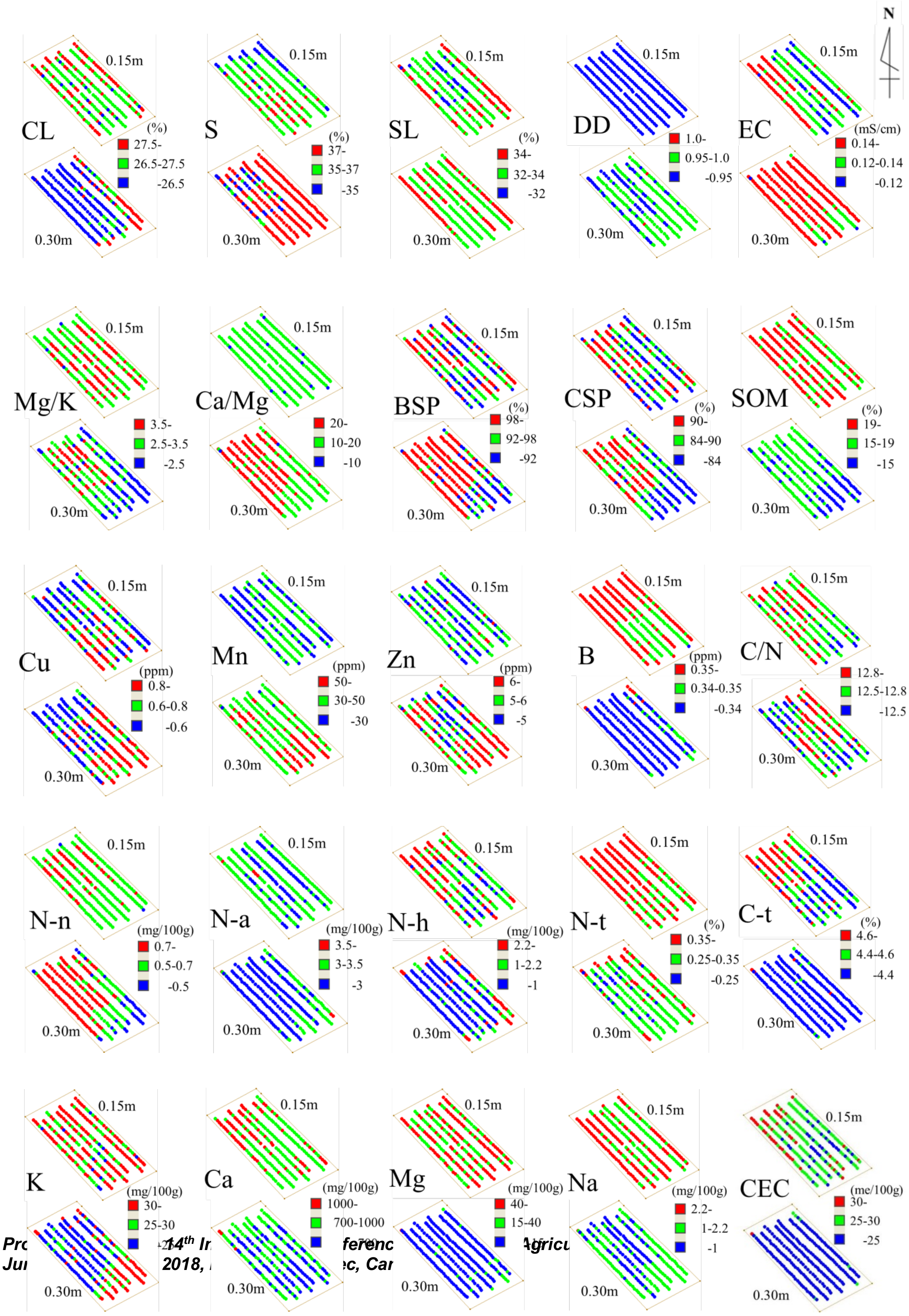

Fig 3 (1). Two-layer soil maps for 32 soil properties

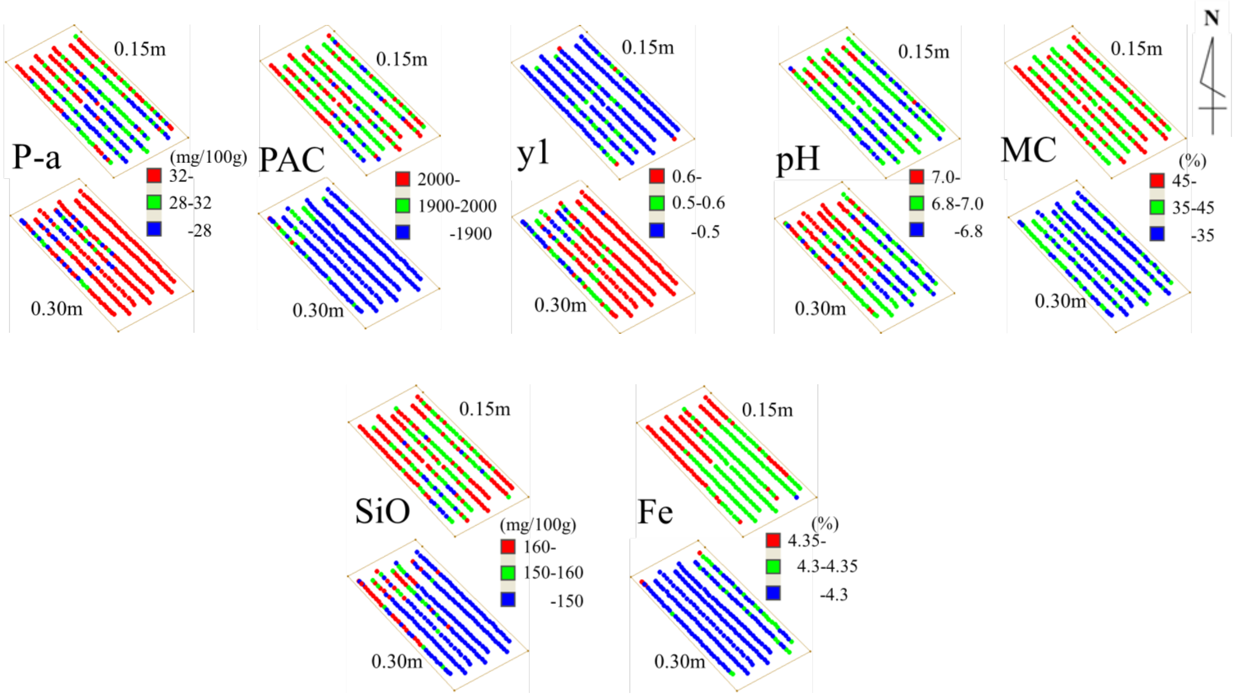

Fig 3 (2). Two-layer soil maps for 32 soil properties

Discussion and Conclusion

The results revealed that the distribution varied with the depth of the soil. In addition, the grower wished to know how to manage variable-rate input in the field, and we consider this a future task.

Acknowledgements

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