

Near-infrared reflectance spectroscopy for estimating soil characteristics useful in the diagnosis of soil fertility

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[Introduction] Improving fertility diagnosis and overcoming limitations of the conventional methods in soil analysis are the main justifications of our study. We investigated the ability of the near-infrared reflectance spectroscopy to predict four soil characteristics: total organic carbon (TOC) content, total nitrogen (TN) content, clay content and cation-exchange capacity (CEC) of soil samples representative of the Walloon region (Southern Belgium).

[Materials and Methods] The various steps of a methodology for routine application of the NIRS technique were optimized by comparative evaluations of performance and variability and selection of the most appropriate options. More than 1,100 soil samples representative of the diversity in the Walloon Region were analyzed. The above mentioned parameters, on air-dried samples, sieved at 2 mm, were measured following standard procedures (Springer-Klee, Kjeldhal, chain hydrometer, and Metson methods respectively) and by NIRS.

Before NIRS measurements, a sample presentation procedure was defined and used for both calibration stage and routine work. In the chemometric approach, several spectra pre-treatments were compared and partial least square (PLS) global and local calibration were applied in order to select the most accurate model. A study of the repeatability and reproducibility of the NIRS technique was also conducted to be compared to reference analysis methods.

[Results and Discussion] The PLS local calibrations showed very encouraging results for all the characteristics: on average for crop soil samples, the variation coefficient of prediction (CV_p) was around 15 % for TOC content, 7 % for TN content, and 10 % for clay content and CEC (Table 1). These prediction accuracies allow the use of NIRS within the framework of fertility evaluation and routine work. The repeatability and reproducibility studies showed that NIRS technique is nearly as reliable as reference procedures with repeatability coefficients of 4.5, 4.3, 9.7, and 6.9 % for the TOC, TN and clay content, and CEC respectively (Table 2).

Table 1. Results of the PLS local calibration

Soil properties	SEP	CV _p (%)
TOC (g 100g ⁻¹)	0.13	15.3 %
TN (g kg ⁻¹)	0.08	7.1 %
Clay (%)	1.8	9.6 %
CEC (cmol(+) kg ⁻¹)	1.1	9.1 %

SEP : standard error of prediction

CV_p : ratio of the SEP (standard error of prediction) to the validation sample set mean, expressed in %

Table 2. Results of the repeatability and intra-laboratory reproducibility studies for TOC, TN and clay content, and for CEC

Soil properties	s _r	r (%)	s _R	R (%)
TOC (g 100g ⁻¹)	0.001	4.5 %	0.008	10.6 %
TN (g kg ⁻¹)	0.002	4.3 %	0.005	7.3 %
Clay (%)	0.83	9.7 %	1.82	21.3 %
CEC (cmol(+) kg ⁻¹)	0.19	6.9 %	0.81	14.1 %

s_r : standard error of repeatability

r (%) : repeatability error

s_R : standard error of reproducibility

R (%) : reproducibility error