Abstract
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 near-infrared reflectance (NIR) 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 NIR 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 analysed. The above-mentioned parameters, on air-dried samples, sieved at 2 mm, were measured following standard procedures (Springer-Klee, Kjeldahl, chain hydrometer, and Metson methods, respectively) and by NIR spectroscopy. Before NIR 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

Table 1. Results of the PLS local calibration.

Soil properties	*SEP*	CV_p (%)
TOC (g 100 g^{-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 %.

repeatability and reproducibility of the NIR technique was also conducted, to be compared to reference analysis methods.

Results and discussion

The PLS local (Foss – WinISI software) 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 NIR spectroscopy within the framework of fertility evaluation and routine work. The repeatability and reproducibility studies showed that NIR 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 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.