

# Comparison of near infrared spectroscopy and standard analysis of turf soil profiles

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## Introduction

The evaluation of soil profiles in turf is important due to the possibility of layers formation. Layers can be caused by an accumulation of organic matter such as thatch or thatch-like derivative or can result from soil textural and structural differences. They can be voluntarily put in place like in a golf green construction situation, for example where a layered soil profile, based on an adequate particle size distribution will improve water availability for the turfgrass community. However, mismanagement of a turf stand results in an undesired and inefficient layered profile leading to water movement restriction, poor aeration and limitation of nutrient availability.

Nowadays, the characterization of soil profiles is done through the use of standard soil laboratory analysis which is money and time consuming. Our study compared the effectiveness of near infrared (NIR) spectroscopy with standard analytical methods in characterizing turf soil profiles. NIR spectroscopy is widely use for forage analysis and is receiving more and more interest from soil scientists.<sup>1-3</sup>

## Materials and methods

### Field samples

Samples representative of different soil textural classes were taken from several Pennsylvania golf courses and from Penn State University turfgrass research centers. An important soil profile variation was provided due to samples coming from fairways, greens and tees of native and modified soils. Fresh samples were vertically scanned, with a scanning NIR monochromator, each 1.25 cm to characterize the profile by layers. A rectangular device was used to present the sample to the scanning unit. A total of 92 samples resulting in 325 layers were scanned.

Immediately following the scanning process, a subsample was taken from each sample for moisture and organic matter content evaluation. A guiding unit was used to insure that the subsample was coming from the same area hit by the scanning window. The moisture content was evaluated by drying the sample at 135°C for 12 hours and the OM obtained by ashing at 600°C for 2 hours.

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The select program from the “Infrasoft” software used in the study identified 100 samples that needed to be evaluated for further laboratory analysis due to their important spectral differences. The samples were first ashed at 350°C for 30 hours to reduce the OM content. The pipette method was then used to determine the particle size distribution.

#### Artificial mixtures

The ability of NIR spectroscopy to predict artificial mixtures of pure sands, silts, clays and organic matters was evaluated. Feldspar and quartz sands and silts, kaolinite and montmorillonite clays and reed sedge and Canadian sphagnum OM were used as the pure sources. The mixtures were made on a weight basis containing different percentages of each constituent. A spinning cup device was used for the scanning process.

## Results and discussion

Table 1 shows the results of the field sample calibration. The values obtained from the calibration were not as accurate as expected for the future utility of this technique. A side study

**Table 1. Accuracy of NIR calibration for field soil samples.**

Constituent	$n^a$	SECV <sup>b</sup>	1-VR <sup>c</sup>
			%
Sand	110	18.03	0.69
Silt	110	14.92	0.67
Clay	110	5.98	0.66
OM	110	5.1	0.56

<sup>a</sup>Number of samples selected by global and neighborhood “H”.

<sup>b</sup>Standard error of cross-validation and estimate of accuracy.

<sup>c</sup>Percentage of variation in the reference method values explained by NIR.

**Table 2. Accuracy of NIR calibration for artificial soil mixtures.**

Constituent	$n^a$	SECV <sup>b</sup>	1-VR <sup>c</sup>
			%
Sand	129	13.57	0.87
Silt	129	9.42	0.92
Clay	129	8.00	0.94
OM	129	7.70	0.95

<sup>a</sup>Number of samples selected by global and neighborhood “H”.

<sup>b</sup>Standard error of cross-validation and estimate of accuracy.

<sup>c</sup>Percentage of variation in the reference method values explained by NIR.

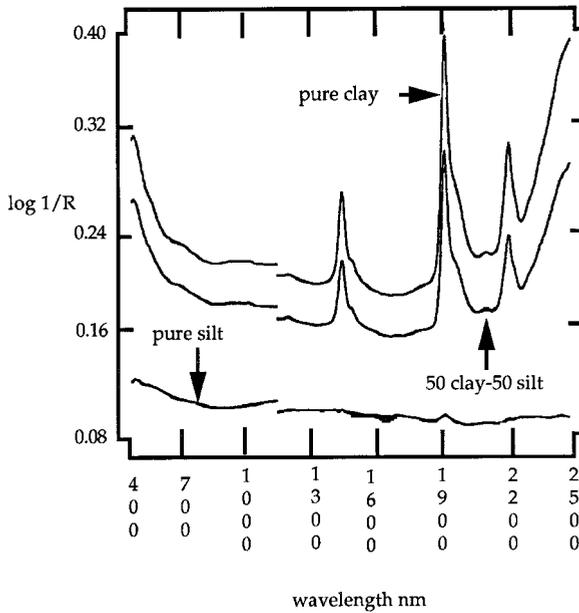


Figure 1. NIR spectra of pure clay, pure silt and 50% clay-50% silt mixture.

was thus conducted in which the ability of NIR to predict sand, silt, clay, and OM in artificial mixtures was evaluated. Table 2 provides the results of the calibration.

NIR predictions were more accurate on artificial mixtures than on field samples. These results were expected, since in the artificial mixtures the constituents were isolated from other biotic and abiotic factors influencing the predictions in the field samples. However, non-linearity was detected between NIR and the reference values in the artificial mixtures. When studying the spectra of a 50% silt-50% clay mixture for example, the spectrum looked more like a pure clay spectrum than a 50% silt spectrum-50% clay spectrum (Figure 1). This non-linearity, due to visibility differences among the pure constituents, is believed to be associated with the different particle surface area for each constituent.

A transformation model was developed to correct for the non-linearity problem observed. The following models were used to identify proportionality and visibility factors associated with the pure constituents (example based on a silt-clay mixture):

$$\text{lab mixture spectrum} = P_1 * \text{Pure silt spectrum} + P_2 * \text{Pure clay spectrum}$$

where  $P_i$  are the proportionality factors. The  $P_i$  were estimated with regression and used in the next model to identify a visibility factor associated to each constituent.

$$\text{New Silt} = P_1 = 100 * V_1 * \text{Silt} / V_1 * \text{Silt} + V_2 * \text{Sand} + V_3 * \text{Clay} + V_4 * \text{OM}$$

where the  $V_i$  are the visibility factors and Silt, Sand, Clay and OM are the laboratory weights. An iterative procedure was used to estimate the  $V_i$ .

The results of the calibration on the transformed data for the artificial mixtures are shown in Table 3. The transformation of the data slightly improved the accuracy of the NIR calibration. The transformation was then applied to the laboratory data of the field samples (Table 4).

Table 3. Accuracy of NIR calibration for artificial soil mixtures after transformation of the laboratory data.

Constituent	$n^a$	$SECV^b$	$I-VR^c$
		%	
Sand	129	10.84	0.92
Silt	129	5.56	0.97
Clay	129	7.19	0.95
OM	129	7.46	0.96

<sup>a</sup>Number of samples selected by global and neighborhood “H”.

<sup>b</sup>Standard error of cross-validation and estimate of accuracy.

<sup>c</sup>Percentage of variation in the reference method values explained by NIR.

Table 4. Accuracy of NIR calibration for field soil samples after transformation of the laboratory data.

Constituent	$n^a$	$SECV^b$	$I-VR^c$
		%	
Sand	110	10.41	0.61
Silt	110	11.28	0.65
Clay	110	8.08	0.53
OM	110	6.59	0.78

<sup>a</sup>Number of samples selected by global and neighborhood “H”.

<sup>b</sup>Standard error of cross-validation and estimate of accuracy.

<sup>c</sup>Percentage of variation in the reference method values explained by NIR.

The OM was the only constituent improved following the transformation of the data. The lack of improvement on the field samples suggest that more studies are needed to clarify the non-linearity observed.

## Conclusion

The transformation of the data improved the ability of NIR to predict artificial soil mixtures but did not improve the overall predictions of the field samples. The use of NIR to characterize turf soil profiles is promising. Further studies are being conducted to better understand the non-linearity problem.

## References

1. R.C. Dalal, and R.J. Henry, *Soil Sci. Soc. Am. J.* **50**, 120 (1986).
2. K.A. Sudduth and J.W. Hummel, *Transactions of the ASAE* **36(6)**, 1571 (1993).
3. E. Ben-Dor and A. Banin, *Soil Sci. Soc. Am. J.* **59**, 364 (1995).