

Near infrared spectroscopy for prediction of N-mineralisation in arable soils

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Introduction

Considerable amounts of soil N can be mineralised and, thus, made available for plant uptake during the growing season. Large differences within fields are often encountered and it is now becoming possible to adjust applied fertilizer rates to these variations. This accentuates the need for fast and economical methods that can predict N-mineralisation.

The main source of N in soils is N-containing compounds in the organic matter. Near infrared (NIR) spectroscopy has successfully been used to predict organic matter contents in soils and different types of organic matter have also been distinguished. This indicates that NIR could be used for the prediction of N-mineralisation in arable soils.

The objective of this investigation was to compare the ability of the NIR technique with the commonly used analysis of NO₃ and NH₄ in predicting the soil N-supplying capacity measured as N uptake.

Materials and methods

Fifty-four 24 m² plots, without N-fertilization, in two nearby winter wheat field on a farm in south-western Sweden, were sampled in 1998.

Soil samples were taken from the surface layer (0–30 cm), dried, homogenised and analysed with a Bran+Leubbe InfaAlyzer 500. A total of 234 bands, between 1500 and 2500 nm, were recorded and the data were autoscaled. These wavelengths had earlier been found to be the most useful for N-mineralisation studies. The contents of NO₃ and NH₄ of undried samples were also analysed.

Partial least squares (PLS) models were constructed for the prediction of N uptake using cross-validation, or with data from one field as the calibration set and data from the other as a test set. In addition, data collected in the same manner from one of the fields in 1997 was used for calibration and the data from 1998 for validation.

Results and discussion

Within-field differences in N-mineralisation were considerable, with a range between 16 and 117 kg N per hectare. In all cases, NO₃ had less predictive ability than NIR data and NH₄ data were not useful at all.

Cross-validated NIR models for Field 1 gave better predictions ($r = 0.85$, $SEP = 15.1$) than for Field 2 ($r = 0.54$, $SEP = 17.6$), despite the lower number of samples.

A cross-validated PLS model, with NIR data from both fields, gave a model with intermediate predictive ability compared with the models for each separate field ($r = 0.69$, $SEP = 17.3$). This shows that samples from all parts of the region which the model covers should also be included in the calibration set.

It was not possible to predict N-uptake in one field with models from the other field. This indicates that large differences in the types of soil organic matter, even within small regions, exist. A principal component analysis plot also indicates that there are differences in the spectral data from the two fields. However, if data from 1997 were used for the model construction of Field 1, a validation on samples taken in 1998 gave very promising results ($r = 0.88$, $SEP = 14.3$). This indicates that the N is delivered in a similar manner each year from a particular type of organic matter.

Conclusions

- NIR data was more efficient than soil NO_3 or NH_4 to predict the N-uptake of unfertilised plots
 - Models constructed with data collected one year could be used to predict the N-uptake the next year
 - Calibration samples should be taken from all parts of a region for which a model is used
- Soil analysis with NIR may be used as a tool to make more precise within-field N-applications.