

Nitrogen nutrient content analysis of soil with NIRONE™ Spectral Sensors

Introduction

Soil quality is a measure of the condition of soil to perform its necessary functions. Soil functions include providing nutrients and water to plants, filtering and cleaning water, regulating temperatures, recycling and storing nutrients and providing habitats for organisms. Sensors are a modern technology developed to help precision agriculture and farmers obtain faster and better results, assisting in the determination of various soil characteristics.

Nitrogen is one of the main soil macronutrients, elements which plants require in relatively large amounts. The rapid analysis of the nitrogen nutrient content in soil samples can easily yield important information, which can be used to evaluate the distribution of soil nutrients and future levels of fertilizing needs in different parts of a large agricultural field. One main advantage is targeting fertilization where it is needed the most, while cutting down on the amount of used fertilizers. Near-infrared (NIR) spectroscopy is a valuable tool when evaluating these parameters.

Real-time sensors enable fast collection and interpretation of data in many material sensing applications. With Spectral Engines' NIRONE™ solutions, these measurements and analysis can be carried outside of laboratories at a fraction of the cost of typical, much larger laboratory equipment.

Smart agriculture allows farmers to maximize their yields by using minimal resources such as water, fertilizers and seeds. By deploying sensors and mapping fields with their aid, farmers can understand their crops on a micro level, conserve resources and reduce their environmental impact. Providing this important data helps farmers monitor and optimize crops, as well as adapt to changing environmental factors.

The benefits of Spectral Engines' solutions are:

- Fast and accurate measurements
- Easy integration to all applications
- Real-time measurement data realized with compact spectral sensors
- Usage of true NIR wavelengths above the 1100 nm region which increase the sensitivity and selectivity of the measurement

USE CASE

We used NIRONE Sensor Evaluation Kits 1.7 and 2.2 to determine the level of added nitrogen (N) in soil samples. Nitrogen content can typically be measured in these ranges. One of the main challenges with soil samples is that they may contain a large amount of water, which will heavily occlude or mask the variation related to the nitrogen content. Because of this, completely drying the samples can be an important sample pre-treatment step before measuring spectra from the samples.

In this experiment, we used flower bed soil and nitrogen fertilizer. The finely ground nitrogen fertilizer was added to the soil samples in varying amounts.

We measured multiple spectra of each of the soil samples with NIRONE Sensor Evaluation Kit 1.7 and 2.2 sensors. The sensors were fitted with Spectral Engines 70mm Tube Optics. Tube optics help in keeping the sensor clean as well as keeps the measurement area wider. It is a good choice for measuring larger quantities of materials beneath the surface, for example when measuring bags or piles of grain, flour and soil.

After the measurements done with wet soil, the samples were oven dried. The samples were then measured again with the same setup.



Results and analysis

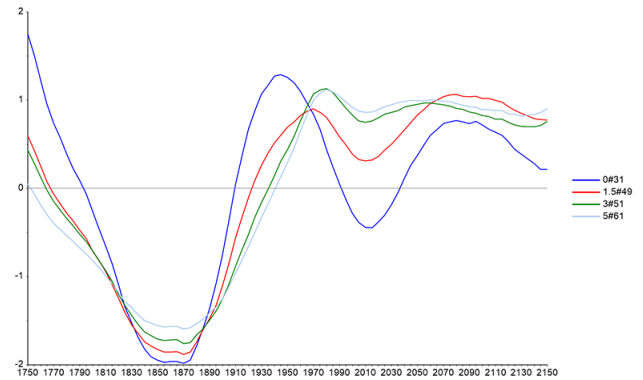
An analysis by using chemometrics was done on how well the sensor could predict the addition of a mass of nitrogen into the soil.

Analysis of the NIRONE 1.7 and 2.2 acquired data:

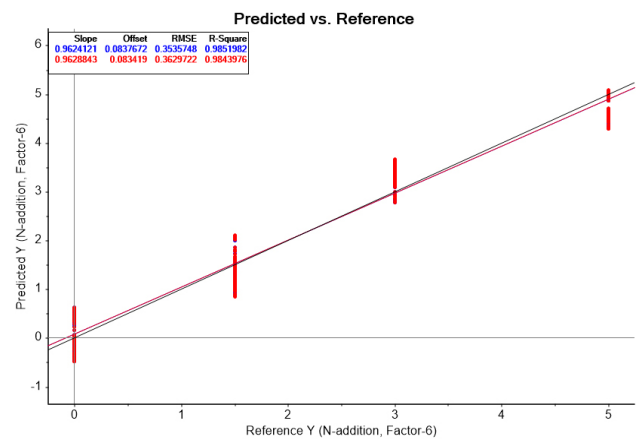
Sensor type	2sigma RMSECV, Wet samples	2sigma RMSECV, Dry samples
NIRONE 1.7	±0.97 g 5 Factors	±0.80 g 6 Factors
NIRONE 2.2	±0.90 g 5 Factors	±0.72 g 6 Factors

The total range for these samples was 0 to 5.0 grams of added nitrogen fertilizer per 100 grams of soil. The above RMSECV values are absolute errors of this range.

The trend was clear: drying the samples before spectral measurements offered multiple advantages to analysis, as these resulted in a lower measurement error. The absorption of nitrogen is more intense in the spectral range of 2.2 than in the range of 1.7.



Example spectra: spectra of dried soil samples with 2.2 sensor range (1750 to 2150 nm) after SNV pretreatment. *Standard normal variate (SNV) is an effective pre-treatment method for baseline correction.



Example Predicted vs Reference plot for 6 Factor PLS regression model of the 2.2 sensor, for the model generated using the dried soil spectra.

Conclusion

We demonstrated that the spectral range of 1.7 and 2.2 can be used to distinguish and evaluate the nitrogen nutrient content of a certain type of soil. The spectral range of 2.2 is slightly better for nitrogen measurements. These spectral ranges were ideal choices for the nitrogen analysis of soil. The spectral range of 1.7 is better for moisture measurements and 2.2 for example fat and oil measurements. The cost-effective price point and small size makes it possible to integrate Spectral Engines' NIRONE products into your smart farming solution or you can develop your own smart farming application.

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