ADÜ ZİRAAT DERG, 2017;14(2):29-31 — doi: 10.25308/aduziraat.310537 Araştırma / Research

Determination of Soil Organic Carbon Levels Using Near Infrared Spectroscopy (NIRS) in Saline Soils

Alper YORULMAZ[*1], ***Gönül AYDIN***[1], ***Levent ATATANIR***[1]

[1]*Adnan Menderes Üniversitesi, Ziraat Fakültesi, Toprak Bilimi ve Bitki Besleme Bölümü, AYDIN.*

Abstract: Due to the global climate change, salinity is in arid and semi–arid climates a major problem for the soils. In this connection it is very important to determine the organic carbon content in saline soils. This is aimed at the study that prediction of the organic carbon content in saline soils using NIRS and to evaluate the success of near infrared reflection spectroscopy (NIRS). NIRS device of 116 soil samples from different levels of soil salinity were collected between (350–2500 nm). Partial Least Square (PLS) regression analysis was used to conclude between the results obtained from the reflection values and traditional analyses methods at the laboratoary. NIRS calibrations were developed with modified partial least square regression and tested with independent validation samples. The best equations were obtained with the first derivative of the spectra without scatter corrections. The results obtained from the experiment concluded that soils of resource area texture, organic matter, $CaCO_3$ and salinity are affects on the reflection values. Good predictions were obtained for organic carbon contents in salt effected soils. According to the results obtained from the study, NIRS could be used as a practical and economic technique to predict organic carbon contents in salt effected soils.

Keywords: *NIRS technique, soil organic carbon, salt effected soils, soil salinity*

Tuzlu Topraklarda Toprak Organik Karbon Seviyelerinin NIRS (Near Infrared Spectroscopy) Kullanarak Belirlenmesi

Özet: *Tuzluluk, kurak/yarı kurak iklimlerde ve taban suyu varlığında büyük bir problem olabilmektedir. Bu bağlantı tuzlu topraklarda organik madde içeriğinin belirlenmesi için çok önemlidir. Bu çalışmanın amacı tuzlu topraklarda organik karbon içeriğinin NIRS (Near Infrared Reflectance Spectroscopy–Yakın kızılötesi yansıma spektroskopisi) ile tahmin edilebilirliğinin ortaya konulması amaçlanmıştır. Farklı seviyelerde tuz içeren 116 toprak örneğinde NIRS cihazı ile 350–2500 nm aralığında ölçülmüştür. Laboratuvarda yapılan geleneksel analiz yöntemlerine göre elde edilen değerler ile yansıma değerleri ölçülmüş ve en küçük kareler (PLS) regresyon analizi yapılmıştır. NIRS kalibrasyonları bağımsız değerlere sahip örnekler ile test edilmiş ve en küçük kareler regresyonuna göre modifiye edilerek geliştirilmiştir. En iyi eşitlikler dağılım düzeltmeleri olmadan spektrumların ilk türevi ile elde edilmiştir. Çalışmadan elde edilen bulgulara göre araştırma alanındaki toprakların bünye, organik madde, $CaCO_3$ ve tuzluluk değerlerinin yansıma değerlerini etkilediği sonucuna varmıştır. Tuzdan etkilenmiş topraklarda organik karbon içerikleri için iyi tahminler elde edilmiştir.*

Çalışmadan elde edilen sonuçlar değerlendirildiğinde NIRS spektroskopisinin, tuzdan etkilenmiş topraklarda organik karbon içeriğini tahmin etmek için hızlı ve ucuz bir yöntem olarak kullanılabileceği sonucuna varılmıştır.

Anahtar Kelimeler: *NIRS tekniği, toprak organik karbonu, tuzdan etkilenen topraklar, toprak tuzluluğu*

INTRODUCTION

New technologies to determine the soil properties, which affect the plant growth accurately and economically, have been developed. Near–infrared Spectroscopy (NIRS, 700–2500 nm), which was developed for that aim, is one of the techniques for obtaining inexpensive and rapid soil data for agricultural and environmental use.

Stevens *et al.* (2010) reported that visible (VIS) and near–infrared (NIR) spectroscopy is an environmentally friendly, inexpensive and fast technology. In addition, it can also obtain a large number of reflection data, in the land and the laboratory. VIS/NIR hyperspectral data was used for prediction of soil organic carbon (SOC) with different regression models such as multiple linear regression (MLR) (Vasques *et al.*, 2008), principal component regression (PCR) (Chang *et al.*, 2001) and partial least squares regression (PLSR) in past decades. The PLSR method built by Wold *et al.* in 1983 was agreed that successfully model for the prediction of SOC. Where in linear relations used both the chemical analysis and spectral data. On the other hand, the nonlinear results could be occurred due to different soil properties (Zhu *et al.*, 2007) and may be related to instruments (sensor sensitivity and lamp aging) (Ge *et al.*, 2011). The aim of this study that prediction of the organic carbon content in saline soils using NIRS and to evaluate the success of near infrared reflection spectroscopy (NIRS).

MATERIALS and METHODS

The Study Area

The study area were located in Söke/AYDIN (27°09'53" – 27°23'03"E, 37°28'40" – 37°43'09"N) (Figure 1). Söke Plain is located in the western part of Aydın/TURKEY with the average annual temperature of 17.6°C and the rainfall of 643.7 mm (Anonymous, 2002).

Soil Samples

The study area the dominant soil type is Entisol. A total of 116 samples were taken from the sampling points determined by the grid method. Approximately 2 kg soil samples were taken from each sampling point at a depth of 0–30 cm for later spectral measurements and SOC content analyses in laboratory (Figure 2).

Soil Organic Carbon (SOC) Contents Analysis and Spectral Readings

All soil samples collected from the study area were dried to bring the air–dried moisture content and purged small gravel and vegetative residues. 116 soil samples collected and then sieved by 2 mm (20 mesh grid sieve) stainless steel sieve. After the sieving soil spectral reflections were measured by Analytical Spectral Devices (ASD) FieldSpec®3 in the laboratory (Figure 3). Spectral reflections were measured between 350–2500 nm wavelengths within 1 nm increments (Figure 4) (Peng *et al.*, 2014). As a standart method Walkley–Black method (Walkley and Black, 1934) was used to determining of SOC contents of

[*]***Sorumlu Yazar:*** *a.yorulmaz.adu@gmail.com*
Geliş Tarihi: *4 Mayıs 2017*
Kabul Tarihi: *31 Ekim 2017*

Table 1. Statistical analysis results from Standard methods

	% Org. C and EC (dS/m), all the examples					
Parametre	**Min.**	**Max.**	**Mean**	**Stickiness**	**Skewness**	**Std.Dev.**
% Org. C.	0.27	2.50	1.19	-0.56	0.26	0.51
EC (dS/m)	0.68	30.00	4.09	3.80	4.48	3.80

soil samples. EC values were analyzed by the U.S. Salinity Lab method (U.S. Salinity Lab. Staff, 1954).

Preparation of Data Set

The spectral data of soils into a raw dataset were associated with the SOC content measurements by Partial Least Square Analysis (PLS). ViewSpec Pro software was used to transfer soil reflectance signals into excel format.

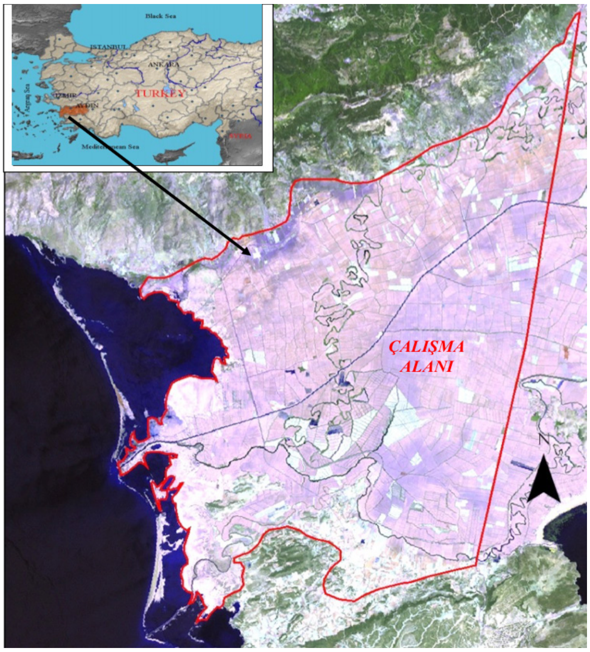

Figure 1. The study area

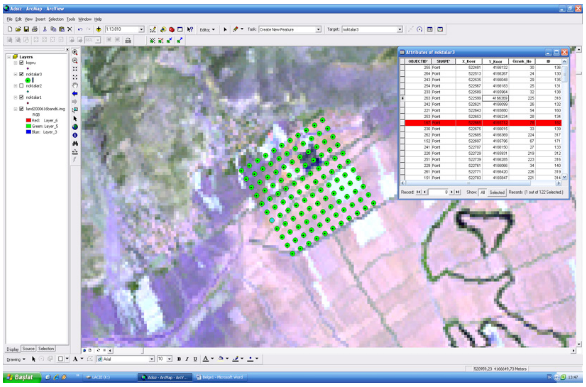

Figure 2. Spatial distributions of soil samples

Figure 3. Measurement of the spectral reflectances of soil

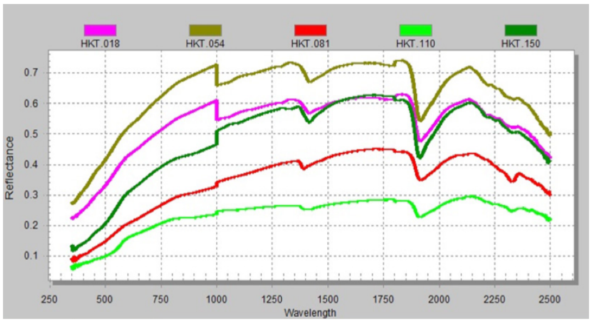

Figure 4. Reflectance measurements of soil samples

RESULTS and DISCUSSION

According to the results of the study the r^2 values of the calibration set were calculated for the EC–values as 0.95 and for the salinity values as 0.89. The validation r^2 values were determined for the EC and salinity 0.67 and 0.61 respectively. The calibration for organic carbon was found to be $r^2<0.50$. Therefore, the evaluation of the organic carbon was found to be poor (Table 1, 2).

The main feature of the study area soils is that they have a high concentration of salt, lime and very different soil texture classes. According to the literature and the results the reflection decreases due to the effect of the soil moisture in the saline soils which have high level of groundwater (Lobell and Asner, 2002). In this context some evident properties of the soil masked some other soil parameters because of the predominant activity of the reflection. However, the NIRS measurements of the field soils were measured later at the air–dried soils in the laboratory and the moisture effect was partially eliminated. As a result the major salinity problem of this area could be estimated according to NIRS as in the upper levels of the mid–level.

Table 2. Prediction of calibration and validation values by using PLS regression model

Soil Property	Calib. r^2	SEC	Calib. Outlier	Valid. r^2	SEP	Valid Outlier	SS	RPD	Range	RER
pH	0.20	0.15	–	0.00	0.17	–	0.17	1.00	0.75	4.41
EC	0.95	0.53	142, 152	0.67	1.17	143, 144, 145	2.02	1.73	9.68	8.27
Total Salt%	0.89	0.04	142, 152	0.41	0.07	143, 144	0.09	1.29	0.47	6.71
$CaCO_3$%	0.42	1.56	135, 249	0.38	1.70	–	2.13	1.25	8.81	5.18
Organic Carbon%	0.30	0.45	–	0.09	0.49	–	0.51	1.04	2.1	4.29

Calib. r^2= Calibration corelation coefficient, SEC: Standart error of calibration, Valid. r^2= Validation correlation, SEP= Standart error of prediction, RPD= Residual prediction deviation of validation RER= Change of the measured values/Standart error of prediction, Range

Some researchers (Chang *et al.*, 2001), have indicated that the NIRS reflection spectroscopy technique is suitable for predicting the different properties of the soil and have evaluated 3 values based on the RPD levels (>2, 1.4–2.0 <1.4). The prediction errors of the data set of estimating the RPD were found by dividing the (SEP). According to the decreased RPD values the reliability of the technology were less found. In other words the more increased ratio of (RPD) the better estimation will be gained. Thus, it is possible to say that the prediction equation is described by the majority of the variation observed in the data set.

CONCLUSION

In this study, the success of NIRS (Near Infrared Reflectance Spectroscopy) technique was investigated to estimate the content of organic carbon in saline soils. It has been determined that texture and moisture content of soils are effective on reflection values. It has been observed that the determination of the change in reflection under similar conditions and similar moisture contents will reduce the error margin. The reflection differences caused by the differences in the texture classes have shown to be statistically more meaningful when similar groups are evaluated together. It has been concluded that it is necessary to evaluate the organic carbon content alone by bringing the parameters affecting the reflection to the soil into a similar situation, the results of the obtained reflection can be evaluated and the organic carbon contents can be determined with the NIRS technique close to reality.

REFERENCES

Anonymous, (2002) Turkish State Meteorological Service (TSMS).

Chang CW, Laird DA, Mausbach MJ, Hurburgh CR (2001) Near-infrared Reflectance Spectroscopy. Principal Components Regression Analyses of Soil Properties. Soil Science Society of America Journal 65: 480–490.

Ge Y, Morgan CLS, Grunwald S, Brown DJ, Sarkhot DV (2011) Comparison of Soil Reflectance Spectra and Calibration Models Obtained Using Multiple Spectrometers. Geoderma 161: 202–211.

Lobell DB, Asner GP (2002) Moisture effects on soil reflectance. Soil Sci. Soc. Am. J. 66, 722–727. Peng X, Shi T, Song A, Chen Y, Gao W (2014) Estimating Soil Organic Carbon Using VIS/NIR Spectroscopy with SVMR and SPA Methods. Remote Sensing 6: 2699-2717.

Stevens A, Udelhoven T, Denis A, Tychon B, Lioy R, Hoffmann L, van Wesemael B (2010) Measuring Soil Organic Carbon in Croplands at Regional Scale Using Airborne Imaging Spectroscopy. Geoderma 158: 32–45.

U.S. Salinity Laboratory Staff (1954) Diagnosis and Improvement of Saline and Alkaline Soils. Handbook 60, Washington, D.C. USA.

Vasques GM, Grunwald S, Sickman JO, (2008) Comparison of Multivariate Methods for Inferential Modeling of Soil Carbon Using Visible/Near-Infrared Spectra. Geoderma 146: 14–25.

Walkey, A., and Black, L.A., 1934. An examination of the Degitjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil. Sci. 37: 29-38.

Wold S, Martens H, Wold H (1983) The Multivariate Calibration Problem in Chemistry Solved by the PLS Method. in Matrix Pencils. Proceedings of a Conference Held at Pite Havsbad, 22–24 March 1982, Sweden, 285-289.

Zhu D, Ji B, Meng C, Shi B, Tu Z, Qing Z (2007) The Performance of N-Support Vector Regression on Determination of Soluble Solids Content of Apple by Acousto-Optic Tunable Filter Near-Infrared Spectroscopy. Anal. Chim. Acta 598: 227–234.