ISCRAES 2022
International Symposium on Climate-Resilient Agri-Environmental Systems
28-31 August 2022, Dublin, IRELAND

Grassland Systems

The use of near-infrared reflectance spectroscopy (NIRS) in the prediction of soil carbon stock in Northern Italy cropping systems

Aldo Dal Prà [1,2], Maria Teresa Pacchioli [2]*, Alessandra Immovilli [3], Paolo Mantovi [2], Fabrizio Ruozzi [3], Francesco Ferrero [4], Giorgio Borreani [4] and Ernesto Tabacco [4]

[1] Istituto di BioEconomia, Consiglio Nazionale delle Ricerche, Italy; [2] Centro Ricerche Produzioni Animali – CRPA spa, Italy,
[3] Fondazione CRPA Studi Ricerche ETS, Italy; [4] Università degli Studi di Torino, Dipartimento di Scienze Agrarie, Forestali e Alimentari, Italy,
* Corresponding author: m.t.pacchioli@crpa.it

Website
forage4climate.crpa.it

Work financed by
LIFE15 CCM/IT/000039
Forage systems for less GHG emission and more soil carbon sink in continental and Mediterranean agricultural areas

Introduction

The European Union assigns a key role to carbon farming (CF) for reaching a climate-neutral economy. CF involves the management of both land and livestock, and while advanced methods for assessing carbon emissions are available, the LIFE Forage4Climate project highlighted the inadequacy of predictive models of carbon stock (CS) changes at farm level.

The project recommends measuring soil organic carbon, soil texture as a percentage of loam, sand and clay, and soil bulk density to calculate CS. While chemical analysis remain time consuming, costly, and polluting regarding OC, NIRS is widely recognized as reliable predictive technique for chemical and physical parameters.

This work aims to contribute to the evaluation of the use of the NIRS technique for the direct assessment of CS content and its variation over time.

Methods

A study was carried out on 365 soil samples from Northern Italy in order to calculate NIRS prediction models for dry matter, soil organic carbon (OC), texture (clay and sand). Air-dried and sieved 2 mm soil samples were chemically analysed for OC, evaluated for sand and clay, and scanned with SpectraStar Near-Infrared analyzer (2400 RTW model, wavelengths from 1,200 to 2,400 nm).

Results and discussion

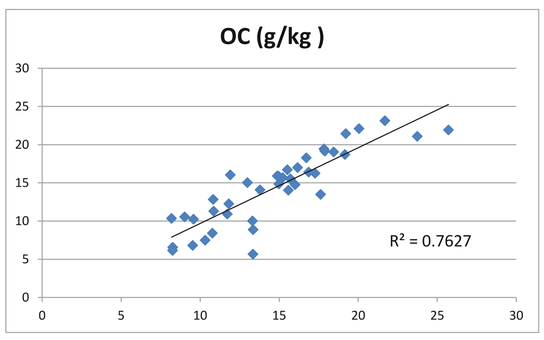
The prediction models have coefficients of determination for calibration (R^2) of 0.905, 0.743 and 0.859 for OC, clay and sand respectively.

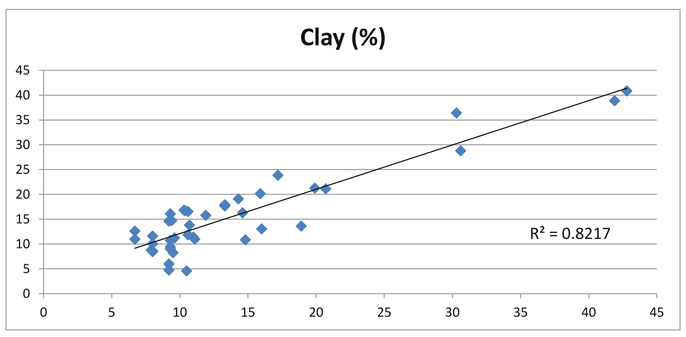
Table 1 – Dataset used for calibration

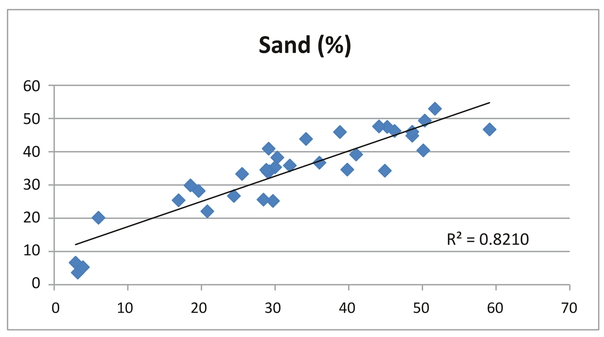
	Dry Matter (%)	Organic Carbon (g/kg)	Clay (%)	Sand (%)
N° of Samples	365	362	250	250
Mean	96.5	16.4	20.2	33.7
Min	90.2	2.8	2.5	2.2
Max	99.3	41.6	52.2	81.9
s. d.	1.64	6.79	12.5	20.8

Table 2 – Dataset used for validation

	Dry Matter (%)	Organic Carbon (g/kg)	Clay (%)	Sand (%)
N° of Samples	30	40	43	43
Mean	97.2	14.7	13.8	31.9
Min	94.9	8.2	6.7	2.9
Max	99.1	25.7	42.8	59.1
s. d.	1.08	4.22	8.4	14.8







Correlations between analysed and predicted values

30 to 43 samples not included in the calibration dataset were used to validate the models, with the following correlation coefficients (R^2) between analysed and predicted: OC 0.7627; clay 0.8217; sand 0.8210.

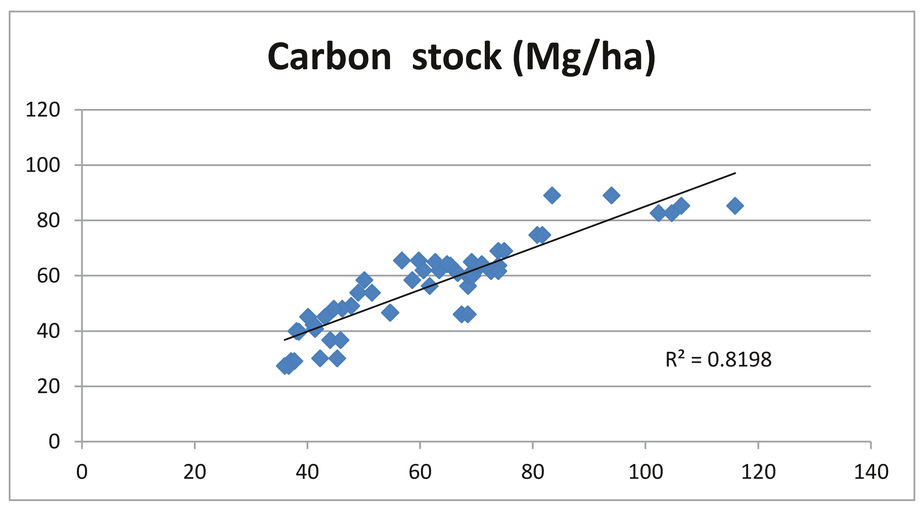
30 samples from validation dataset were divided into two aliquots and the 60 sub-samples were evaluated for bulk density (BD, dry soil weight/total soil volume) and soil carbon stocks (CS, Mg/ha). Field CSs were calculated from chemically analysed OC and directly assessed BD with volumetric rings, than compared to calculated CSs from NIR predicted OC, and BD predicted from OC, clay, sand, and loam utilizing most performable pedo-transfer function (PTF) from the literature (**).

Table 3 shows the characteristics of the dataset used to calculate the CS: in column 1 the CS values calculated from the actual bulk density, in columns 2 to 4 the CS calculated from the NIR carbon prediction data applying the different PTF, and in the last column the average from the 4 calculation models.

The correlation coefficient (R^2) of CS evaluated (average form the 4 models) with analysed *vs* predicted parameters is 0.8198.

Table 3 – Carbon stock evaluation (Mg/ha in the 30 cm layer)

		Carbon stock from NIRS parameters				
	BD	**(1)**	**(2)**	**(3)**	**(4)**	**(average 1-4)**
N° of Samples	60	60	60	60	60	60
Mean	59.97	49.35	52.32	57.19	60.92	54.95
Min	35.96	24.98	26.07	28.58	30.03	27.42
Max	115.9	79.22	84.71	92.66	99.68	89.07
s. d.	19.13	14.24	15.44	16.85	18.34	16.22



Correlation between carbon stock (Mg/ha in the 30 cm layer) evaluated with chemically analysed vs predicted parameters

Keywords: Carbon stock, NIRS, LIFE15/CCM/IT/000039

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Conclusions

The work shows how the NIRS technique can be applied to assess the parameters needed to determine the soil carbon stock. A quick and inexpensive assessment of CS opens the way to estimating its changes at farm level, where the effects of climate change mitigation actions related to soil management can also be measured.

An estimation of CS unconstrained by a series of time-consuming and polluting chemical analyses can contribute to the construction of a pathway for the payment of carbon credits in agriculture.

(**)
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