Área: AMB

Soil carbon sequestration in agricultural areas: Evaluation of C content and features of soil organic matter by laser photonic techniques

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Highlights

Well-managed pastures were able to increase soil C stock
C determined by LIBS showed a good correlation with the reference method
LIFS was able to assess the aromaticity of soil organic matter in intact samples

Abstract

Low-C-emission agriculture is essential for its sustainable growth, which aims at higher production with a low or zero C emission balance. Soil plays an important role in agricultural productivity, in which it has the potential to accumulate C.[1] The accumulated C can be transformed into C credits and is also profitable for the farmers. In addition to the C quantification, the evaluation of its chemical composition (quality) is essential to predict the resilience and lifetime in the soil. Laser-based photonic techniques are fast alternatives and less expensive than traditional ones; The technique principle is the excitation of elements or molecules, followed by the detection of the photons emitted using a spectrometer.[2,3] The study aimed to quantify soil C and evaluate its quality using Laser-induced breakdown spectroscopy (LIBS) and Laser-induced fluorescence spectroscopy (LIFS), respectively, in experimental agricultural areas, under well-managed pastures and integrated livestock-forest systems, compared to conventional pasture (DP) and an area of native vegetation (FO), located at Embrapa Pecuária Sudeste, São Carlos-SP, Brazil. Soil C was quantified using LIBS with a Q-switched ND:YAG laser, emitting at 1064 nm, with pulse energy of 40 mJ and 10 Hz, whose the emission line at 247.0 nm was used for C quantification. The soil C quantified by LIBS was correlated with a reference technique (Elemental analyzer, model 2400, PerkinElmer, USA). Soil organic matter (SOM) quality was evaluated by LIFS, whose the spectra were acquired directly on whole soil pellets with an excitation at 405 nm and emission 465−800 nm. The spectral area was normalized by C content, obtaining an aromaticity index (H_{FIL}). To evaluate a possible correlation between H_{FIL} with the aromaticity of SOM by ^{13}C NMR, SOM extractions were carried out from whole soil samples in the area with the highest C stock by solubility method, obtaining three humic fractions: fulvic acids (AF), humic acids (HA) and humin (HUM). All fractions were analyzed by ^{13}C CP/MAS NMR. The rainfed pasture with a moderate stocking rate (RMS) increased the soil C stock (162.25 Mg C ha^{-1}) in relation to DP (102.54 Mg C ha^{-1}), reaching levels statistically equal to the native vegetation (148.32 Mg C ha^{-1}). LIBS showed a correlation of 0.80 with the reference technique, demonstrating feasibility to soil C quantification. The H_{FIL} index of intact soil samples had a correlation of 0.83 with aromaticity degree of HUM fraction, detected by ^{13}C NMR, suggesting that SOM aromaticity is mainly related to HUM content. Pasture management showed the ability to increase soil C stock, whose SOM from RMS comprised mainly aliphatic moieties. Well-managed pastures with fertilization, low animal stocking rate, and animal rotation seem to increase the introduction of fresh organic matter, leading to soil carbon sequestration, helping to achieve low-C-emission agriculture.

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