Characterization by thermal analysis of soil organic matter storage induced by organic amendments

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Due to the increasing societal demand for the development of renewable energy sources and CO_2 mitigation, new agricultural practices are emerging, such as anaerobic digestion to produce biogas, soil conservation agriculture, and the advancement of organic matter treatment through pyrolysis. These novel practices result in the reintroduction of more biomass (cover crops), along with various residual organic matters (anaerobic digestion digestates, organic waste compost, biochars), and may induce Soil Organic Carbon (SOC) sequestration. Soil Organic Carbon (SOC) sequestration can contribute to partly offsetting greenhouse gas emissions, and mainly to increased soil quality and climate change adaptation *(Rumpel et al., 2020)*. Thus, there is a need for credible and reliable measurement/monitoring, reporting and verification platforms, both for national reporting on SOC storage, soil quality and for emissions trading *(Smith et al., 2020)*.

The Rock-Eval® thermal analysis is recognized for a range of applications, including the characterization of hydrocarbons in solid rocks, petroleum products and sedimentary rocks. Its use to characterize the nature of Soil Organic Matter (SOM) is also being developed, particularly for agronomic and environmental purposes. In this context, the originality of this study consists in using Rock-Eval® to explore its potential to characterize the nature of organic matters (in this experiment : silage maize, silage maize after anaerobic digestion, silage maize after pyrolysis), and then to characterize SOM after the addition of these organic matters.

The results of these characterizations are interpreted in the light of soil respiration measurements. Durability and significance of the SOC storage in soils depends on the biological decomposition/stability of organic amendments and SOM. CO_2 production measurements, during two laboratory incubations (142 and 56 days), has enabled the calculation of carbon storage resulting from the addition of organic matters. Soil respiration measurements also enabled us to trace organic matters and SOM decomposition, using ^{13}C-CO_2 as a tracer.

Throughout the incubation, CO_2 production from controls (i.e., unamended soils) were steady. Soils amended with silage maize and digested silage maize showed a higher CO_2 production than those of controls. For soils amended with pyrolyzed silage maize, CO_2 production was equal to CO_2 production from controls. SOC storage resulting digested silage maize addition was higher than silage maize addition. Pyrolyzed silage maize addition induced a storage of up to 99% of organic carbon added.

The measurement of ^{13}C-CO_2 has revealed that the greater carbon storage induced by the addition of digested silage maize compared to silage maize is primarily attributed to the lower organic matter degradability of digested silage maize. The measurement of ^{13}C-CO_2 has also highlighted a negative priming effect induced by the addition of digestate, which contributes to an increase in SOC storage.

Using the I-index of the Rock Eval® analysis, we determined that silage maize and digested silage maize decomposition mechanisms in soils resulted in the selective decomposition of biological tissues (Figure 1). Results also highlight that the use of the soil I and R -index is restricted to the study of the stability of Organic Matter (OM) and excludes carbonaceous matter such as biochar (Figure 1). This experiment gives insights on the potential use of I-index to predict C_{org} storage after the addition of organic amendments (Figure 2). This exploratory study opens up promising avenues of research for the development of agronomic and environmental quality indicators for organic amendments and SOM based on Rock-Eval® analysis.

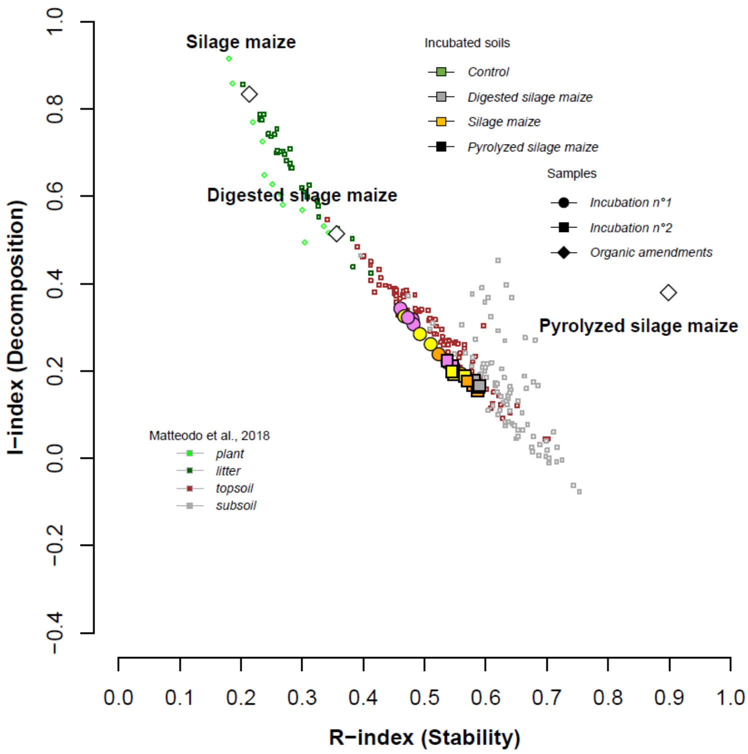

Figure 1. Positioning of organic products and incubated soils as a function of the I and R -index relative to measurements made by Matteodo et al. (2018).

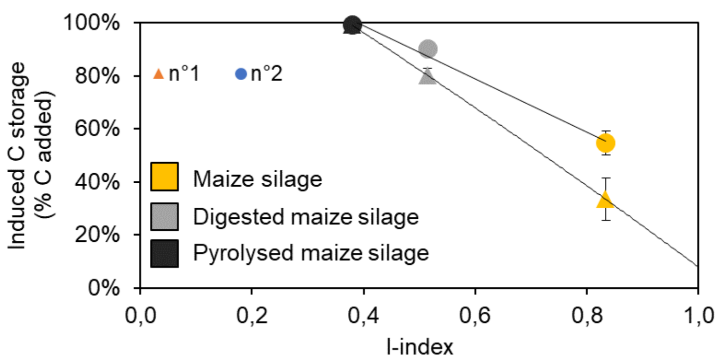

Figure 2. Correlation between C storage induced by the addition of residual organic matters (% C added) and their I -Index in soils, after incubations n°1 et 2. For the regression associated with incubation n°1, the C storage induced by pyrolyzed silage maize addition in soil is estimated by the value obtained at the end of incubation n°2.