Quantification of biomarkers as an estimation of soil organic matter turnover and sources under a crop rotation

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Highlights:
Soil lipids encompass substances of mainly plant or microbial origin, which encompasses biomarkers associated to soil microbial communities and soil organic matter (SOM) dynamics. According to their structure, biomarkers from total lipid extracts (TLE) would exhibit different degrees of susceptibility to degradation, affecting thus their preservation in soils. In this study, we assessed SOC contributions from aboveground and developed a wider approach based on the allocation of C to quantitatively assess the sources of organic matter in low SOM content, highly weathered Mediterranean soils.
Agricultural soils have a wide potential as carbon sequestration tool via atmospheric CO₂ fixation in plant biomass and further transformation into soil organic matter (SOM). Lipid biomarker analysis is an efficient tool for tracing organic matter sources in diverse environments. Here, soil lipids distribution is studied in order to investigate SOM dynamics under Mediterranean climate following a C3-C4 rotation experiment.
Soil samples were taken at “La Hampa” experimental field, located in Seville (Southern Spain).

A natural isotopic labelling experiment was conducted and started in 2016 to monitor changes from C₃ (wheat) to C₄ (maize) crops.

Three different treatments were sampled: control plots (C) and two different maize rotation plots, consisting in leaving the aerial roots after harvesting (R) and applying shredded maize biomass to the soil surface (B).
Soil sampling

Soil samples were taken at three depth intervals (5, 20, 40 cm) in **November 2018, two years** after starting the rotation experiment.

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TLE extraction

Extractions and further chromatographic analysis were conducted thanks to a research stay in the Organic Geochemistry Unit at Univ. Bristol. Procedures are described elsewhere [1]. TLE were analysed and identified through their mass spectra by gas-chromatography mass spectrometry (GC-MS) and quantified with a flame ionization detector (GC-FID).
Composition of TLE extracts

The total lipid extracts were dominated by a homologous series of n-alkanols (saturated alcohols), short-, mid- and long-chain fatty acid methyl ester (FAME), branched FAME, unsaturated (mono- and polyunsaturated) FAME and sterols.

[Pie charts and data for Control, Biomass (B), and Aerial roots (R)]
Composition of TLE extracts

In general, and in relation with all compounds, the abundances increased up to 20% compared with the control plots representing the initial content.

Short-chain FAME, monounsaturated FAME were the most abundant fractions of free lipids.
Great abundance in various isomers of C16:1, C18:1, C20:1 and C22:1; these are believed to be mainly synthesised by soil bacteria. A significant increase of these compounds in rotation plots leads to an effective microbial consumption of labile organic matter in the surface soil [3].
Conclusion remarks

- The combination of extractable lipids has been shown to validate the use of TLE as a proxy for source and other information on vegetation change and soil processes.
- These results indicate that, only after three years of crop rotation, a considerable contribution of soil organic carbon is inherited from bacterial activity.
- The great abundance of short-chain FAME and some monounsaturated forms lead to an effective microbial consumption of labile organic matter in the surface soil as an alternative to tillage, especially when the aerial roots are left after harvesting.
- TLE extraction from highly-mineralized agricultural soils comprises a great tool for tracing the impact of crop rotation on carbon storage.
Here you have some useful references:

Deposit here any question or suggestion you may have about our research. As we do with soil samples, we’ll dig into that :)