EGU General Assembly 2020

EGU2020-18526

Compound-specific isotopic analysis of fatty acids in three soil profiles to estimate organic matter turnover in agricultural soils

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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. Compound-specific isotope analysis (CSIA) have been used to investigate the assimilation of carbon from external inputs into SOM. In this study, we determined the distribution and δ13C CSIA of fatty acids as dominant part of the soil lipid fraction to assess turnover times and to explore the effect of changes in agricultural practice under Mediterranean climate.

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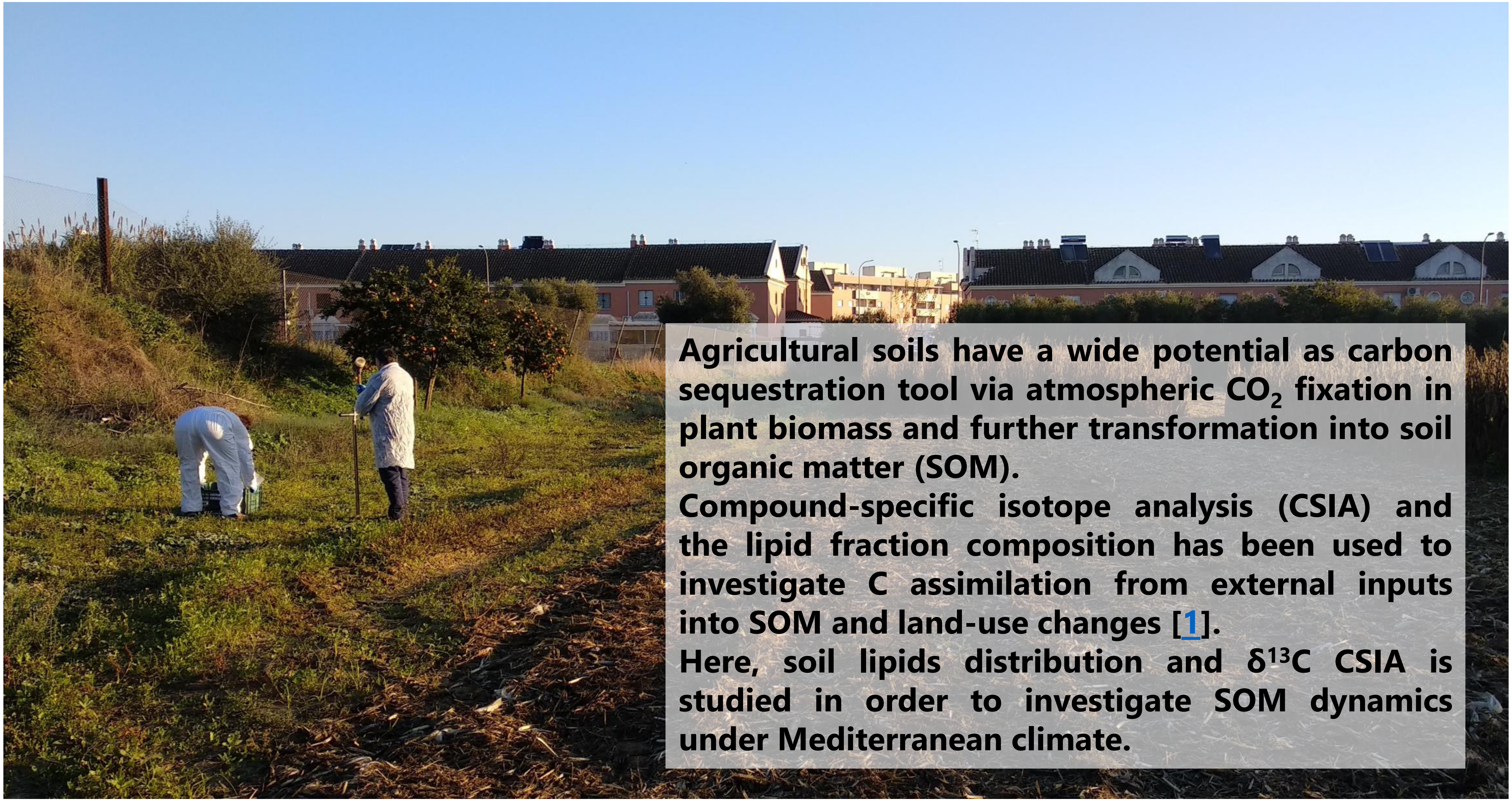


Agricultural soils have a wide potential as carbon sequestration tool via atmospheric CO_2 fixation in plant biomass and further transformation into soil organic matter (SOM).

Compound-specific isotope analysis (CSIA) and the lipid fraction composition has been used to investigate C assimilation from external inputs into SOM and land-use changes [1].

Here, soil lipids distribution and $\delta^{13}C$ CSIA is studied in order to investigate SOM dynamics under Mediterranean climate.

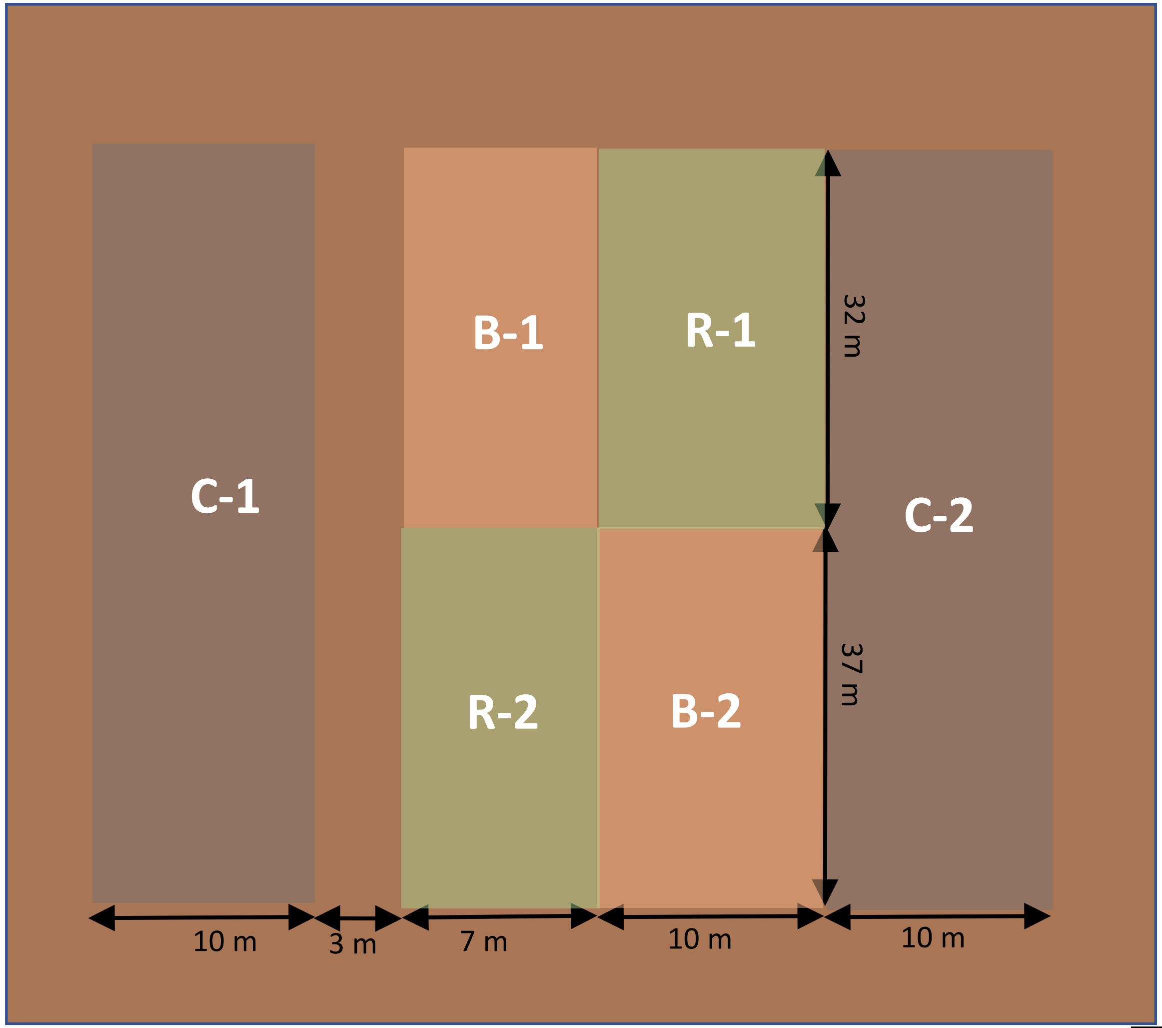
Experimental design

https://commons.wikimedia.org/w/index.php?curid=3944708

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 C_3 (wheat) to C_4 (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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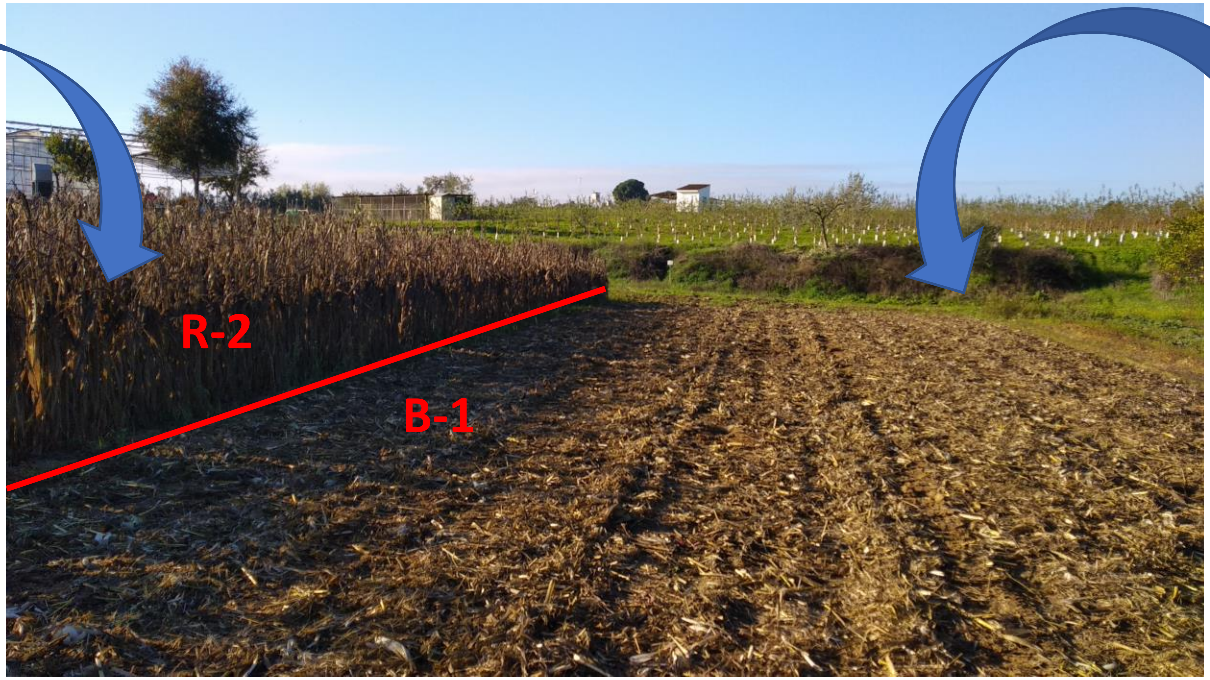
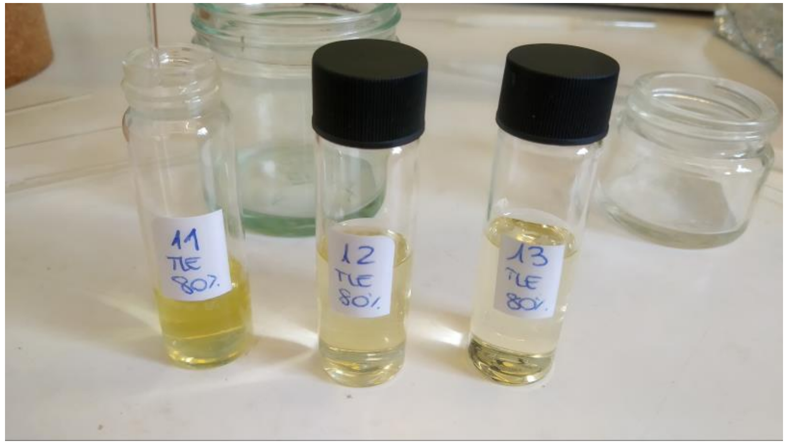


TLE extraction and δ13C CSIA



Extractions and further chromatographic analysis were conducted thanks to a research stay in the Organic Geochemistry Unit at Univ. Bristol. Procedures are described elsewhere [2]

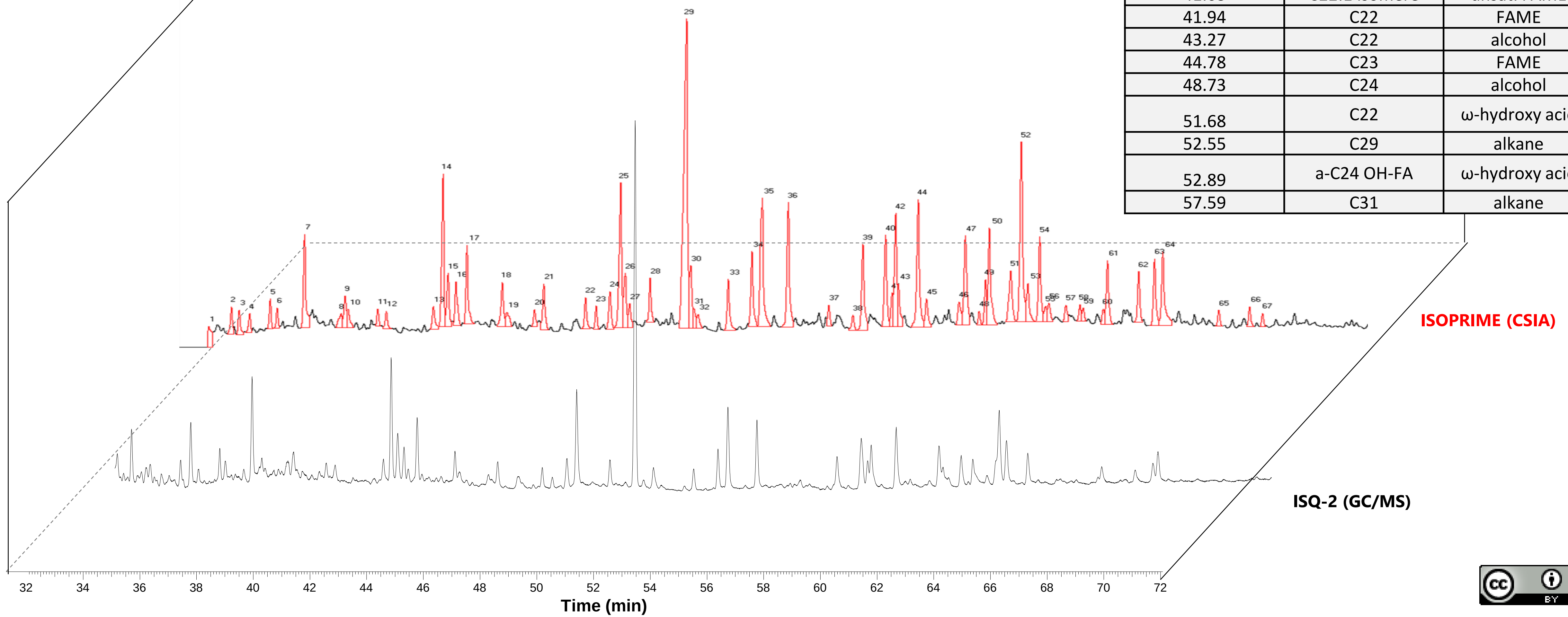
TLE were analysed by gas-chromatography combustion chamber isotope ratio mass spectrometry (GC-C-IRMS) for $\delta^{13}C$ CSIA. Compounds were identified through their mass spectra by gas-chromatography mass spectrometry (GC-MS) and quantified with a flame ionization detector (GC-FID).

Finally, the $\delta^{13}C$ values obtained were corrected for the isotopic composition of the introduced methyl group.

Results

By coupling GC-MS and GC-C-IRMS, a total of 11 compounds were identified within the lipid fraction, common to all samples.

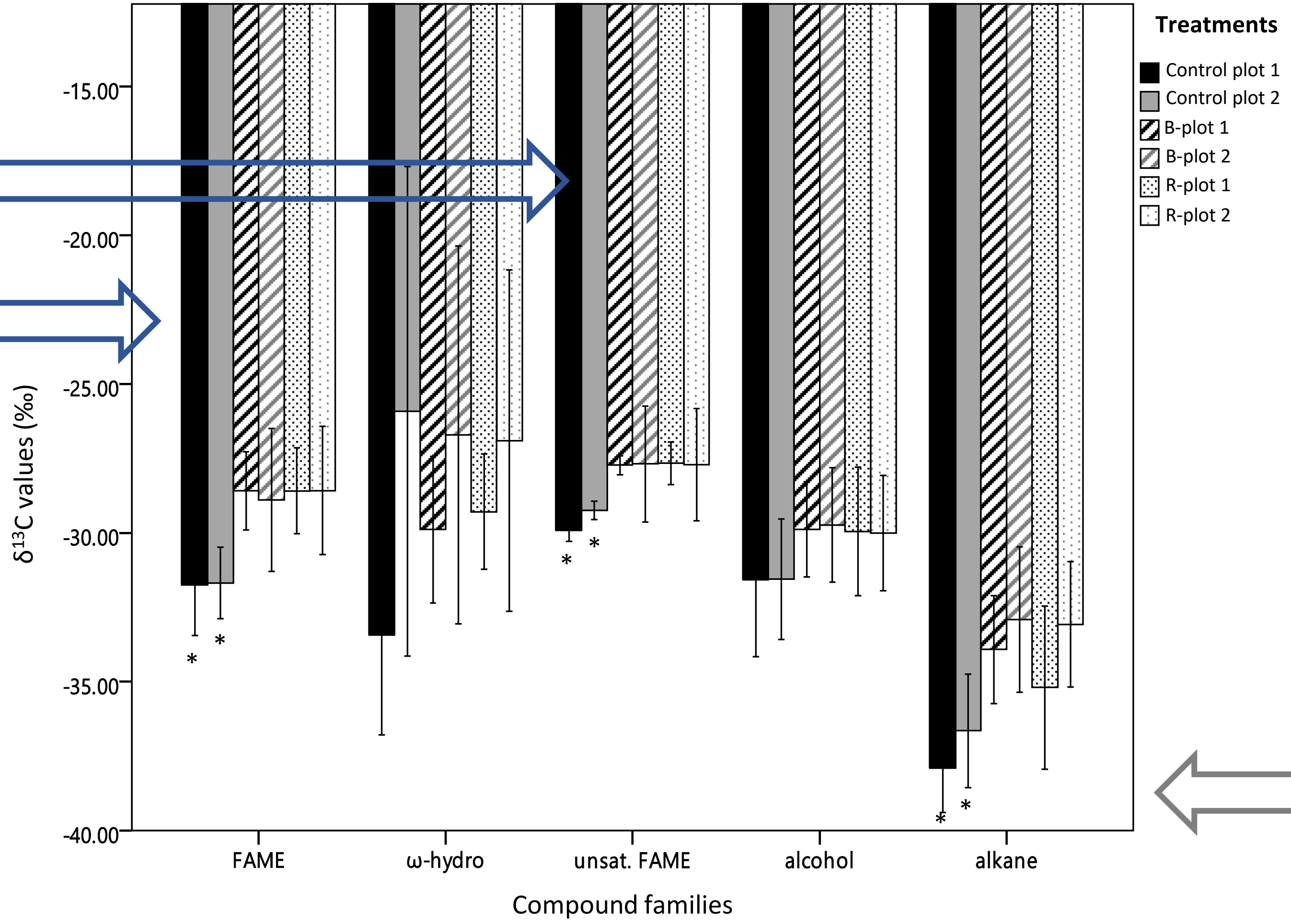
RT (min)	Compound	Group
34.99	C16	ω-hydroxy acid
36.12	C20	FAME
41.03	C22:1 isomere	unsat. FAME
41.94	C22	FAME
43.27	C22	alcohol
44.78	C23	FAME
48.73	C24	alcohol
51.68	C22	ω-hydroxy acid
52.55	C29	alkane
52.89	a-C24 OH-FA	ω-hydroxy acid
57.59	C31	alkane



$\delta^{13}C$ CSIA values

No significant differences in the isotopic composition were observed at different soil depths within treatments apart from a **slight $\delta^{13}C$ enrichment of 1.5 ‰** in the upper soil layer **(0-5 cm)** in the maize plots.

Results reported that only two years after maize cultivation, a significant δ13C enrichment of up to **2 ‰** was found in the **saturated C20, C22 and C23 FAME** and the **monounsaturated C22 FAME.**



No significant differences however were found for alcohols and hydroxy acids. This can be explained as other compounds FAMEs **(alcohols and hydroxyl acids**) are less specific plant markers and may have diverse origin [3].

Greater differences were observed **up to 5 ‰** in the wax-derived **C29 and C31 n-alkanes** relative to the control treatments without maize input.

Conclusion remarks

- CSIA analyses show that lipids from agricultural soils can reveal SOM transformation, compared with the conventional bulk soil $\delta^{13}C$ analyses.
- Lipid fractions would give the most realistic results for turnover calculations based on long-chain n-alkanes (C29, C31) and FAME as biomarkers.
- Soil organic matter content remained very low (< 1.3%)* over the entire duration of the experiment, with no significant differences despite the high amount of C4 biomass presumably added to the soil during the two growth periods.
- Together with the $\delta^{13}C$ enrichment observed in the maize plots, this points to high mineralization rates in these soils and implies both a rapid turnover of plant debris into the SOM.
- Variable contributions of C3 and C4 plant biomass to organic matter could be determined in highly mineralized, Mediterranean soils, as a clear differentiation between C3 and C4 plants was achieved by their respective molecular and isotopic properties.

*Data no presented in this display

Thanks for your “virtual” attention!

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

Here you have some useful references:

[1] Mendez-Millan et al (2014). *Biogeochemistry*, *118*(1-3), 205-223.

[2] Wang et al (2015). *Scientific reports*, *5*, 11043.

[3] Holtvoeth et al (2010). *Biogeosciences*, *7*(11), 3473-3489.

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