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Contribution of inorganic carbon to CO2 emissions under a Mediterranean agroforestry system

Tiphaine Chevallier[1], Rémi Cardinael[1,2,3], Bertrand Guenet[4], Thomas Cozzi[2], Cyril Girardin[2], and Claire Chenu[2]

[1]Eco&Sols, IRD, CIRAD, INRA, Montpellier SupAgro, Univ Montpellier, Montpellier, France (tiphaine.chevallier@ird.fr)

[2]AgroParisTech, UMR Ecosys, Avenue Lucien Brétignières, 78850 Thiverval-Grignon, France

[3]CIRAD, UPR AIDA, F-34398 Montpellier, France

[4]Laboratoire des Sciences du Climat et de l'Environnement, LSCE/IPSL, CEA-CNRS- UVSQ, Université Paris-Saclay, Gif-sur-Yvette, France

In the last years, soil organic carbon (SOC) dynamics have been explored for agronomic and environmental issues in different agro systems. Many soils of the world, especially in arid and semi-arid environments, contain large stocks of soil inorganic carbon (SIC) as carbonates. Yet, the SOC dynamics has been poorly investigated in these soils, due to the complexity of measurements and of the processes involved. Indeed, few previous studies have shown links between SIC and SOC dynamics. Theses interactions are initiated by biological activities, i.e. CO_2 production, are explained through equilibrium equations between soil carbonates and bicarbonates. However, few data were available on the specific impact of SIC on SOC mineralization especially at increasing soil depth.

Alley agroforestry systems increased SOC content in the tree rows without any change in the SIC content. The heterogeneity in organic inputs and SOC contents induced by alley agroforestry allows the investigation of the interactions between SIC and SOC on CO_2 emissions.

To assess contributions of SIC to CO_2 emissions with depth, we incubated carbonaceous soil samples coming from an 18-year-old agroforestry system (both tree row and alley) and an adjacent agricultural plot. Soil samples were taken at four different depths: 0-10, 10-30, 70-100 and 160-180 cm. Total CO_2 emissions, the isotopic composition ($\delta^{13}C$, ‰) of the CO_2 and microbial biomass were measured. The SIC concentrations were from 48 to 63 g C kg^{-1} soil and the SOC concentrations from 4 to 17 g C kg^{-1} soil. The total amounts of CO_2 emissions from soil were correlated to C contents and decreased with depth (from 183-569 µgC g^{-1} soil in top soil vs 21-25 µgC g^{-1} soil in subsoil).

The contribution of SIC-derived CO_2 was not homogenous along the soil profile. It represented about 20% in the topsoil and 60% in the subsoil of the total soil CO_2 emissions. As the SOC content and the microbial biomass, the SOC-derived CO_2 emissions were larger in the topsoil especially in the tree row compared to the alley and the agricultural plot. The SIC-derived CO_2 emissions were also larger in topsoil and in tree rows at 0-10 cm than in alleys or agricultural plots (71 µg C g^{-1} soil vs 45-48 µg C g^{-1} soil) or in the subsoil (13-15 µg C g^{-1}

soil), whereas the amount of SIC was similar in top and subsoil and in tree rows, alleys or agricultural soils. This indicate that CO_2 emissions from SIC were linked to the SOC content and its mineralization. In addition, our results suggest that the measurement of soil respiration in calcareous soils could be overestimated if the isotopic signature of the CO_2 is not taken into account. It also advocates more in-depth studies on carbonate dissolution-precipitation processes and their impact on CO_2 emissions.

Reference:

Cardinael, R., Chevallier, T., Guenet, B., Girardin, C., Cozzi, T., Pouteau, V., and Chenu, C. 2019 Organic carbon decomposition rates with depth and contribution of inorganic carbon to CO2 emissions under a Mediterranean agroforestry system, Eur J Soil Sci, https://doi.org/10.1111/ejss.12908.
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