Organic carbon decomposition rates with depth under an agroforestry system in a calcareous soil

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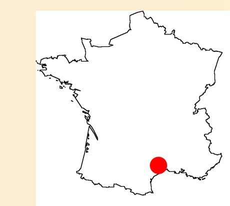
Introduction

- Agroforestry systems increase soil organic carbon (SOC) stocks (Cardinael et al., 2015, 2017, 2018a,b), but little is known concerning the potential decomposition rate of SOC at different depths.
- SOC dynamics have poorly been studied under Mediterranean climate due to the presence of soil inorganic carbon (SIC) in soils (Chevallier et al. 2016).

Objectives of the study

- Assess SOC mineralisation potential as a function of soil depth in an agroforestry plot compared to an agricultural control plot.
- Estimate the contribution of SIC to CO_2 emissions at different depths.

Study site



- Silty and carbonated Fluvisol.
- Hybrid walnuts (*Juglans regia* × *nigra*) planted in 1995. Density: 110 trees ha^{-1}.
- Durum wheat (*Triticum turgidum* L. subsp. *Durum*), sown in the alleys and in the agricultural control plot.

Materials and methods

- Soil cores sampled in agricultural **control** plot, in agroforestry **tree rows** and **alleys**
- Measures of SOC and SIC contents (Micro-GC) and their respective $\delta^{13}C_{SOC}$ and $\delta^{13}C_{SIC}$ (IRMS – Micro-Gaz)
  - [SIC] and $\delta^{13}C_{SIC}$: orthophosphoric acid dissolution
  - [SOC] and $\delta^{13}C_{SOC}$: 550°C treated soil
- Soil incubation (duration 44 days):
  - 4 replicates per location: Control; Tree row; Alleys
  - **4 depths** : 0-10; 10-30; 70-100 and 160-180 cm (n=48).
  - 40 g soil placed in 500 ml jars
  - Moisture pF 2.5 – 20°C, microbial biomass measured at the end
- Measures of the amount and the $\delta^{13}C$ of the CO_2 emitted from soils

$$CO_{2\,measured} = CO_{2\,organic} + CO_{2\,inorganic}$$

$$\delta^{13}C\text{-}CO_2 = f_{SIC} \times \delta^{13}C_{SIC} + (1-f_{SIC}) \times \delta^{13}C_{SOC}$$

where $\mathbf{f_{SIC}}$ is the contribution of SIC to CO_2 emissions.

Results

Depth (cm)	SOC concentration ($mg\ C\ g^{-1}$ soil)			SIC concentration ($mg\ C\ g^{-1}$ soil)		
	Control	Alley	Tree row	Control	Alley	Tree row
0-10	7.4 ± 0.4bA	8.1 ± 0.5bA	16.9 ± 2.3aA	61.6 ± 0.9aA	54.9 ± 2.3aAB	58.4 ± 2.8aA
10-30	7.6 ± 0.1bA	8.1 ± 0.5bA	8.5 ± 0.6aB	62.3 ± 1.5aAB	62.9 ± 3.7aAB	58.8 ± 2.0aA
70-100	5.3 ± 0.3aB	5.3 ± 0.1aB	5.1 ± 0.3aC	56.0 ± 2.7aABC	48.0 ± 1.2aA	50.1 ± 1.9aA
160-180	5.0 ± 0.5aB	4.8 ± 0.4aB	4.3 ± 0.4aC	52.5 ± 1.4aC	48.7 ± 1.7aA	52.5 ± 2.1aA

Table 1. SOC and SIC concentrations.

- Soil heterotrophic respiration was only higher under tree rows at 0-10 cm. CO_2 emissions decreased dramatically with soil depth.
- In topsoil layers, most CO_2 derived from SOC. In deep soil layers, most CO_2 derived from SIC.

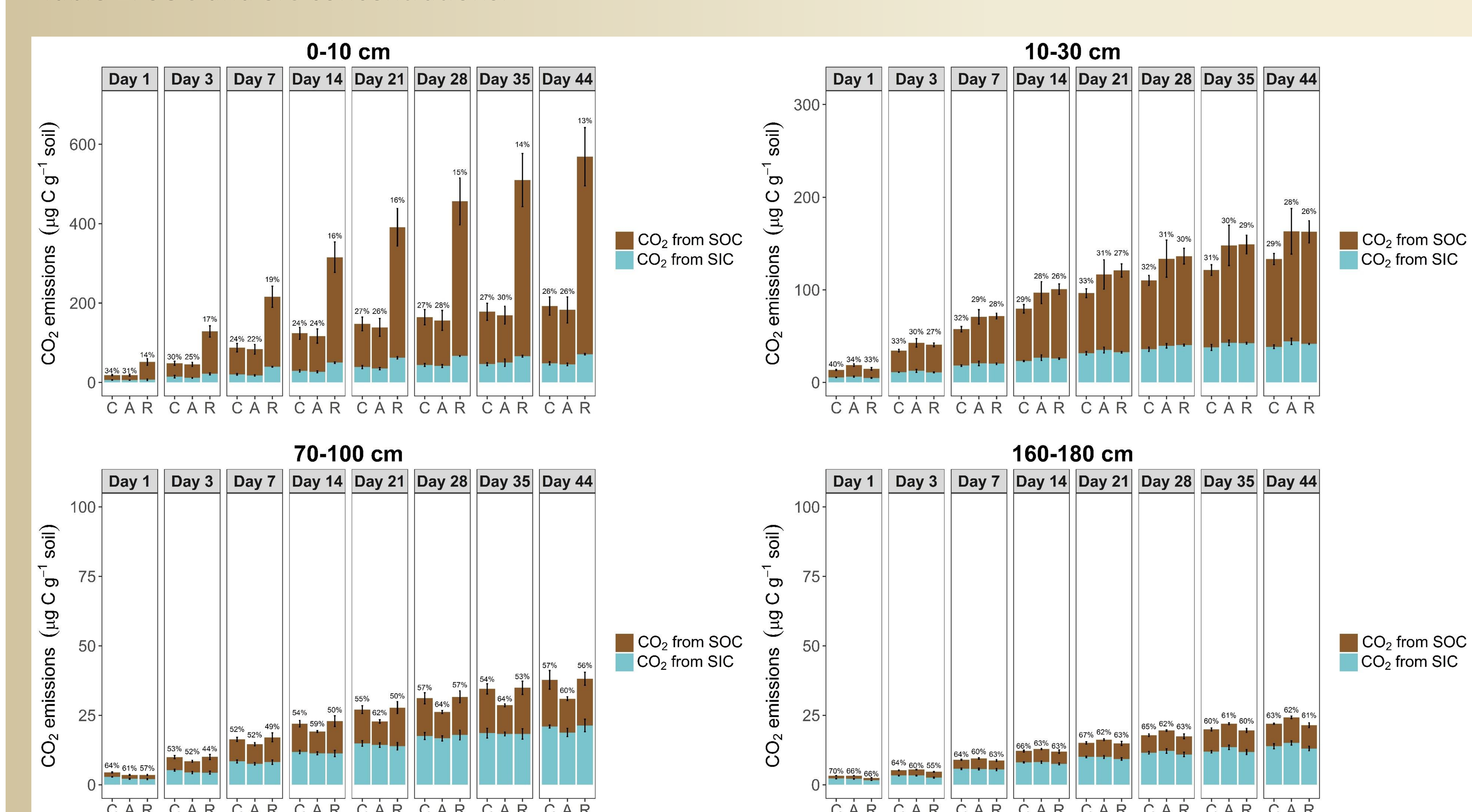


Figure 2. Contribution of soil organic carbon (SOC) and soil inorganic carbon (SIC) derived CO2 to cumulated CO2 emissions. C: Control; A: Alley; R: Tree row.

Depth (cm)	Location	k_1 (day^{-1})
0-10	Tree row	0.059 ± 0.002bB
	Alley	0.081 ± 0.007aA
	Control	0.076 ± 0.003abA
10-30	Tree row	0.069 ± 0.004aB
	Alley	0.068 ± 0.005aA
	Control	0.064 ± 0.002aA
70-100	Tree row	0.092 ± 0.007aA
	Alley	0.095 ± 0.027aA
	Control	0.086 ± 0.015aA
160-180	Tree row	0.061 ± 0.003aB
	Alley	0.061 ± 0.000aA
	Control	0.057 ± 0.005aA

Table 2. SOC decomposition rates.

- SOC decomposition rate remained stable with depth. Only the size of the C pool decreased.

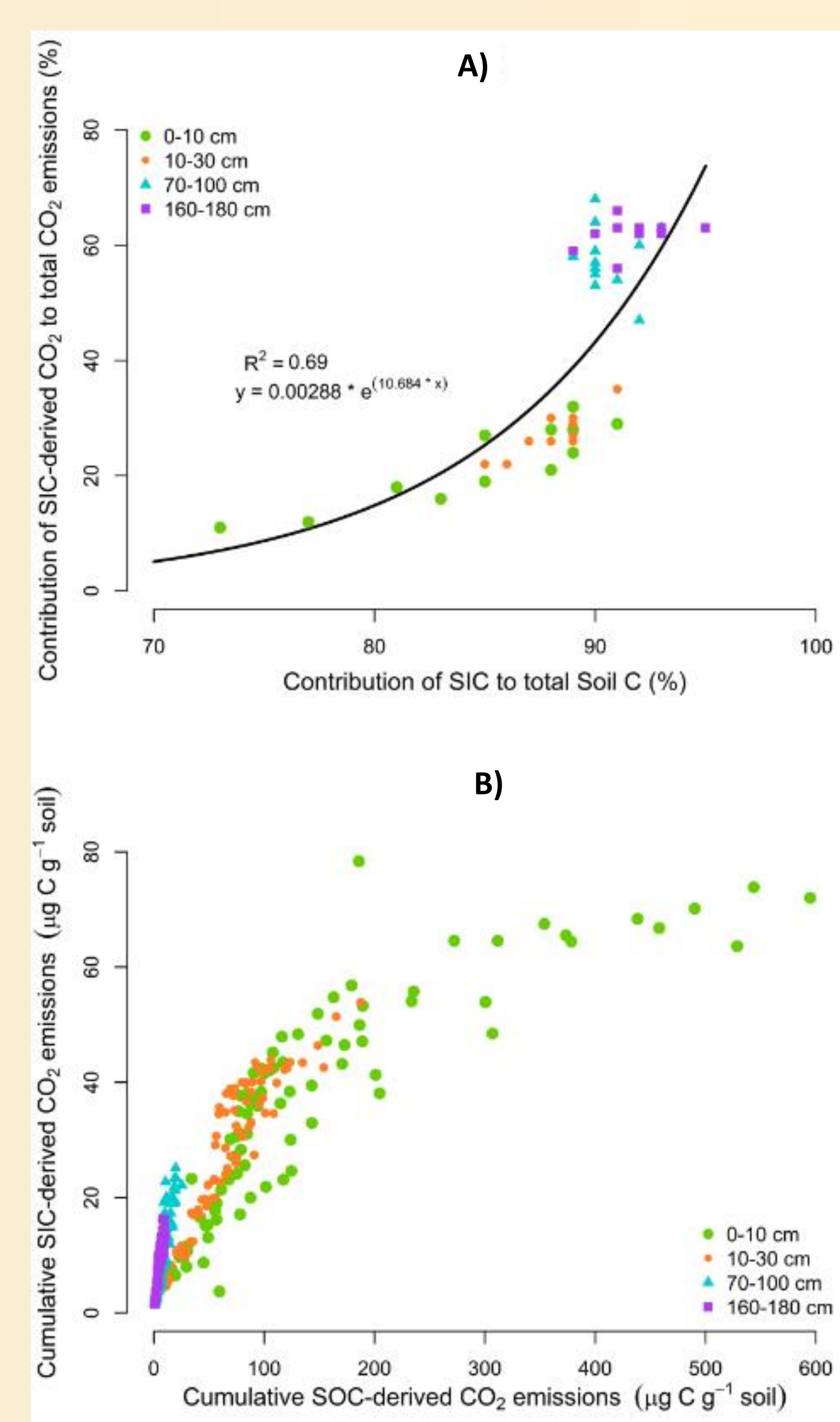


Figure 3. A) Contribution SIC-derived CO_2 as a function of SIC content. B) Cumulative SIC-derived CO_2 as a function of cumulative SOC-derived CO_2.

Conclusion

Subsoil organic carbon seems to be as prone to decomposition as surface organic carbon. SIC contribution to CO_2 emissions needs to be considered for studies on SOC dynamics in calcareous soils.

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