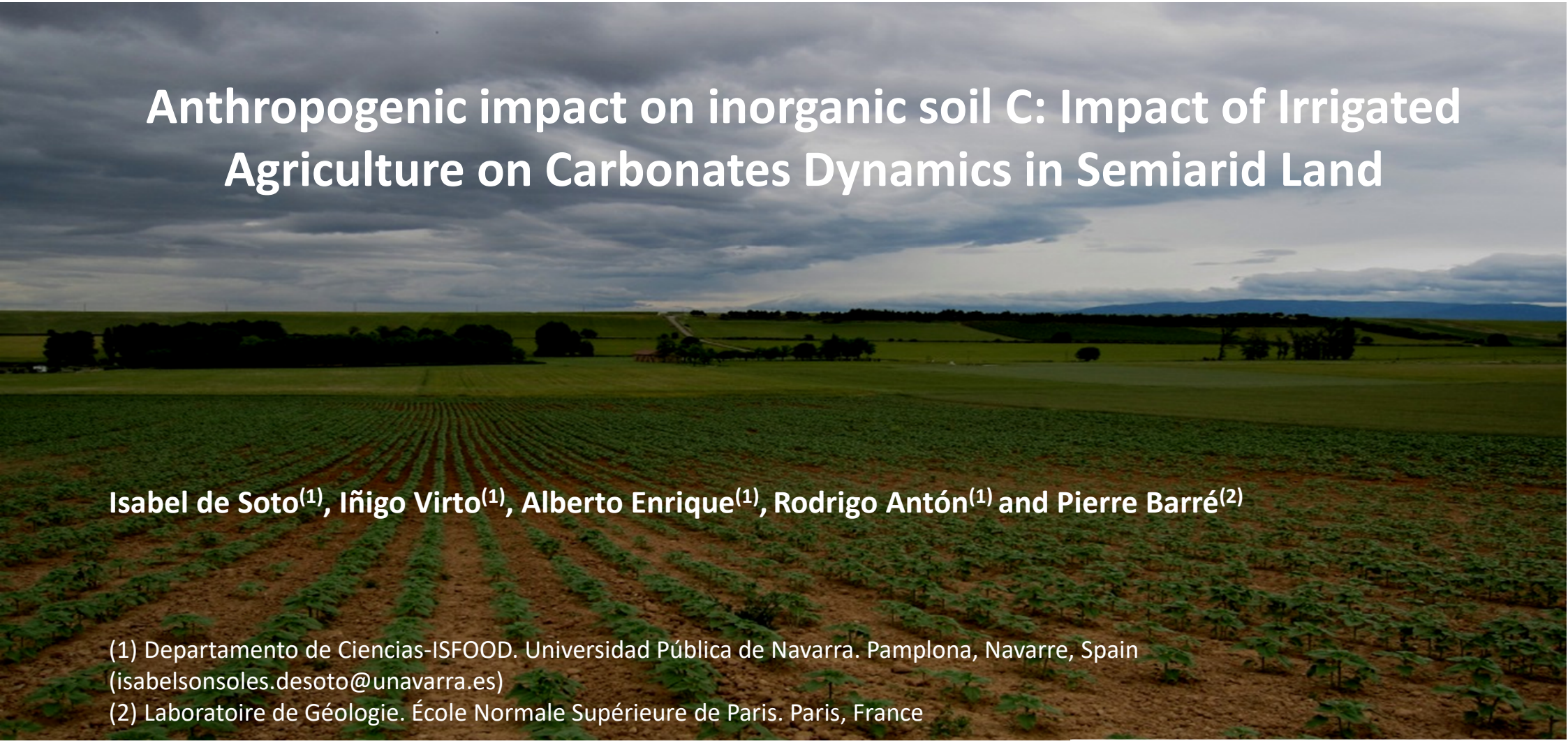
Anthropogenic impact on inorganic soil C: Impact of Irrigated Agriculture on Carbonates Dynamics in Semiarid Land



Isabel de Soto[(1)], Iñigo Virto[(1)], Alberto Enrique[(1)], Rodrigo Antón[(1)] and Pierre Barré[(2)]

(1) Departamento de Ciencias-ISFOOD. Universidad Pública de Navarra. Pamplona, Navarre, Spain (isabelsonsoles.desoto@unavarra.es)
(2) Laboratoire de Géologie. École Normale Supérieure de Paris. Paris, France

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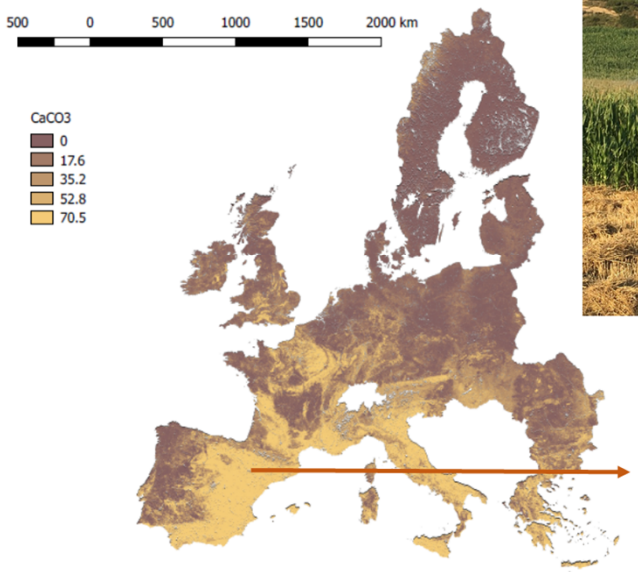
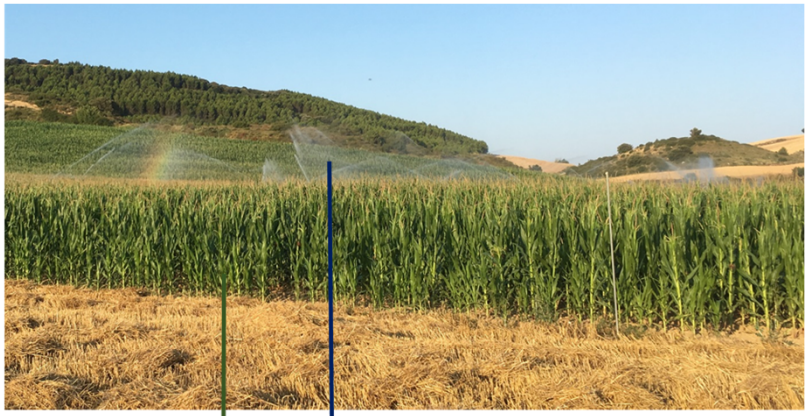
1- INTRODUCTION

In many semiarid Mediterranean soils, **carbonates can constitute a significant proportion** of the soil mass. Unlike other soil inorganic components, **carbonates can react in the short term** to changes in the **soil water regime** and the **physical-chemical conditions** of the soil solution.

The **introduction of irrigation can be associated to such changes**, as it changes the water balance, the composition of the soil solution, and the concentration of CO_2 in the soil atmosphere.





$$CaCO_3 + CO_2\,(g) + H_2O \leftrightarrow Ca^{2+} + 2HCO_3^-$$

What consequences?

The main objective of this study is to gain knowledge on the importance of the **effect of irrigation on carbonates dynamics in the tilled layer of agricultural Mediterranean soils**.

2- MATERIALS AND METHODS

We conducted a **three-step** study embracing **field observations and numerical simulation**:

1. Quantification of **carbonates stocks and size-distribution** for two different situations (irrigated corn and non-irrigated wheat) in **paired plots of three irrigation districts** in Navarre (Spain).

2. Development of **geochemical simulations** of the interactions between soil carbonates, soil solution and irrigation water after 9 years of irrigation. The simulation was a batch-reaction, which was performed in four consecutive steps. The period chosen for the simulation **was one average year** but the simulations were **divided in 12 month periods**.

3. Estimation of the proportion of pedogenic carbonates using carbonates-C isotopic signatures

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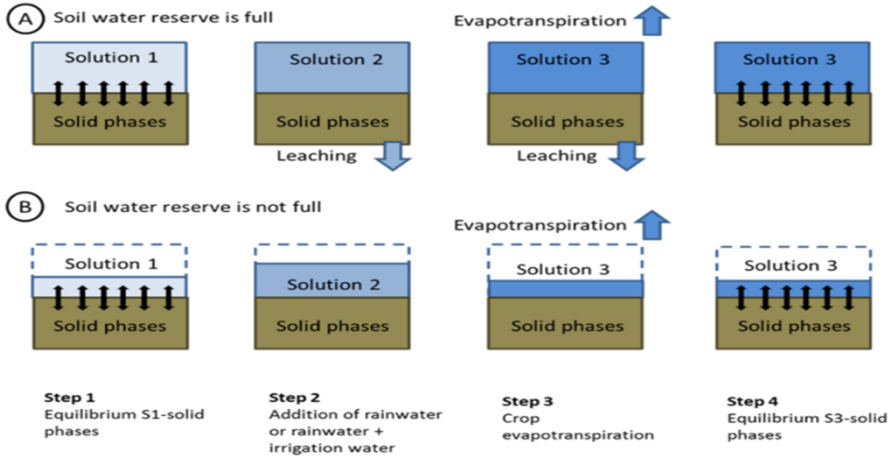
Valtierra *Xeric Haplocalcid*



Schematic representation of the procedure adopted in the simulation. (A) for the simulation of the months when the soil water reserve is full and (B) for months when the soil water reserve is not completely full).

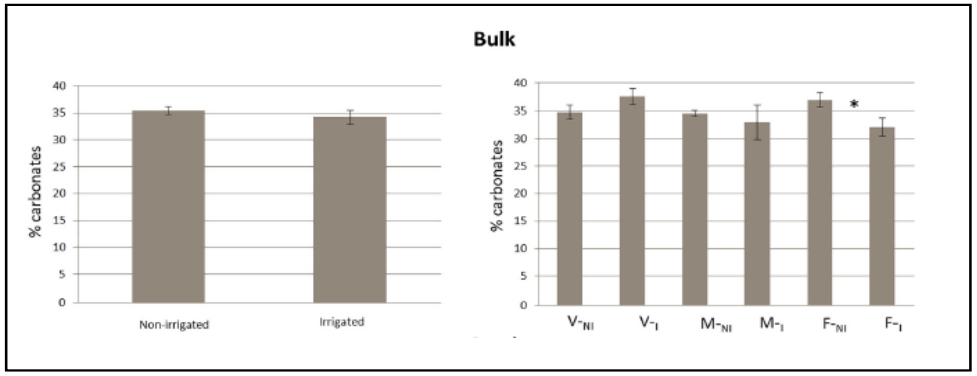
de Soto, I.S., Virto, I., Barré, P., Fernández-Ugalde, O., […] Bescansa, P. 2017. Geoderma 297: 48-60.

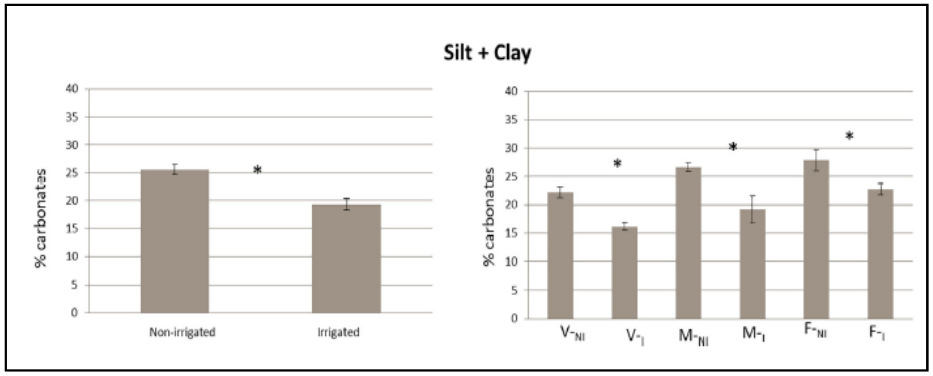
3- RESULTS

3.1. Quantification of carbonates stocks and size-distribution

Although there are not significant differences in the concentration of carbonates in the bulk soil between irrigated and non-irrigated plots, **carbonates concentration was lower with irrigation in the finest (< 50 µm) soil fractions** (25.6 ± 2.6 carbonates 100 g^{-1} without irrigation for 19.3 ± 2.1 with irrigation, on average).

Concentration of carbonates in the bulk soil and their distribution in the studied size fractions in the irrigated and non-irrigated plots and in each studied area. (V-NI: Valtierra non-irrigated. V-I: Valtierra irrigated. M-NI: Miranda non-irrigated. M-I: Miranda irrigated. F-NI: Funes1 non-irrigated. F-I: Funes1 irrigated)



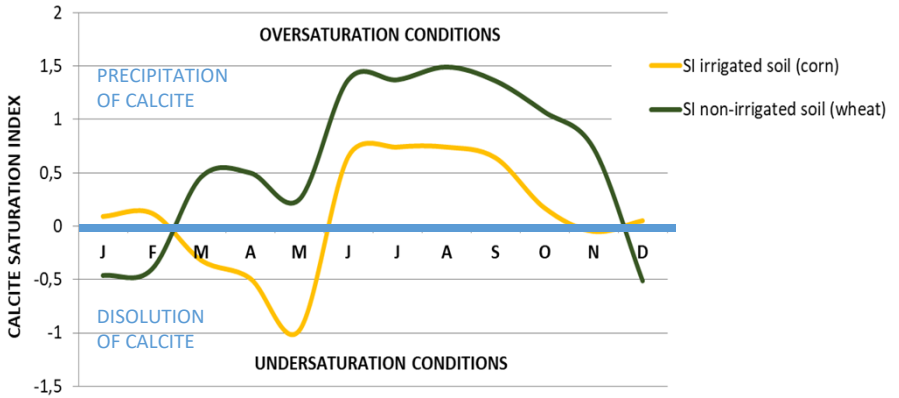


I. S. de Soto, I. Virto, P. Barré, O. Fernández-Ugalde, R. Antón, I. Martínez, C. Chaduteau, A. Enrique , P. Bescansa. (2017). A model for field-based evidences of the impact of irrigation on carbonates in the tilled layer of semi-arid Mediterranean soils. *Geoderma* 297: 48–60

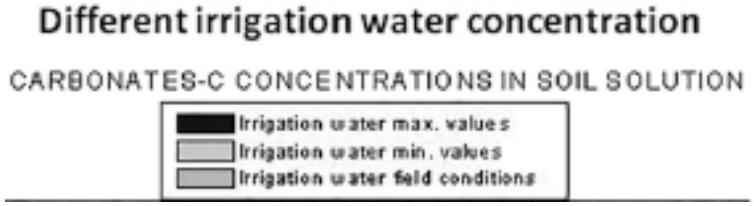
3- RESULTS

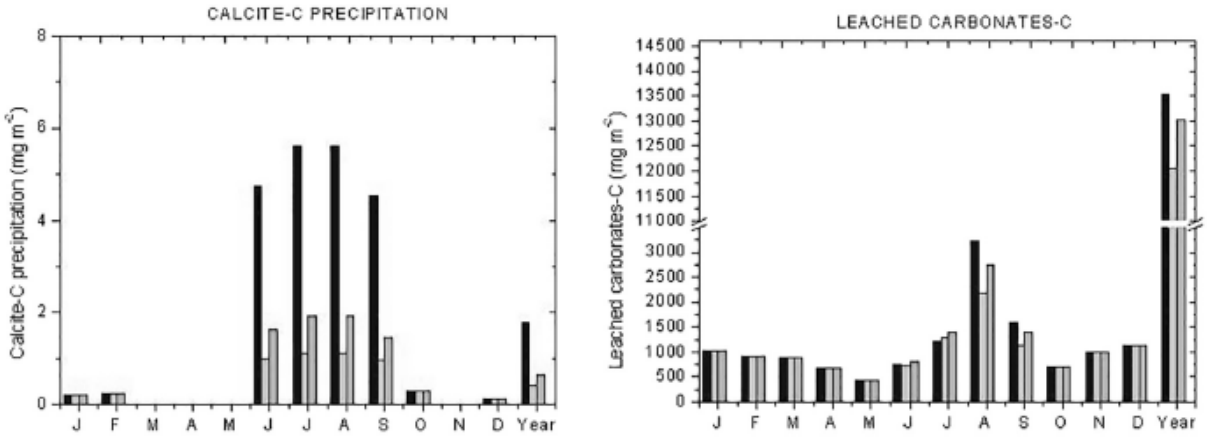
3.2. Numerical simulations

The **modelling results** showed **annual losses of carbonates-C** in the range of **12.06-13.52 g m^{-2} $year^{-1}$** in the studied depth under irrigation, *depending on the quality of irrigation water*, for 0.46 g m^{-2} without irrigation.



Simulated monthly calcite saturation indexes in irrigated corn and non-irrigated wheat at Funes.





Sensitivity analysis results: Simulated carbonates-C dissolution, precipitation and leaching under irrigation in Funes as affected by the concentration of irrigation water

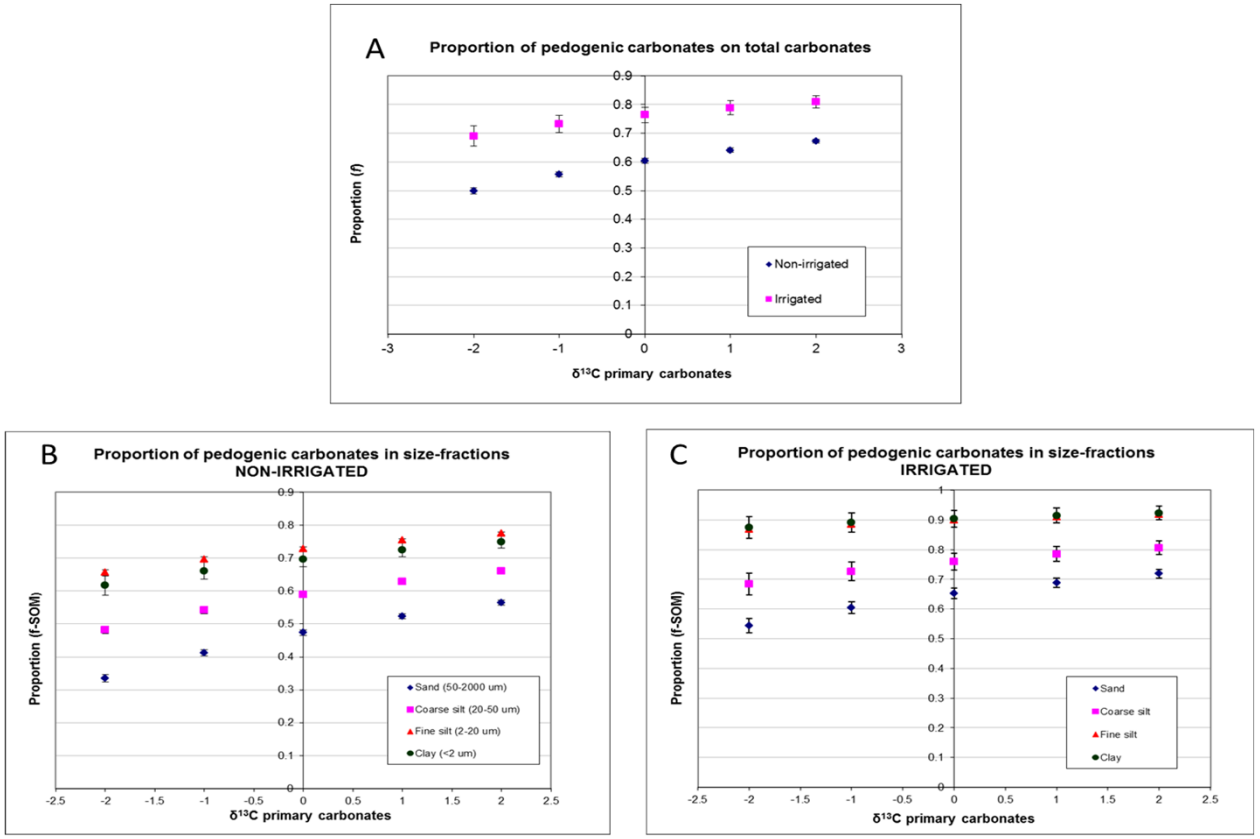
I. S. de Soto, I. Virto, P. Barré, O. Fernández-Ugalde, R. Antón, I. Martínez, C. Chaduteau, A. Enrique , P. Bescansa. (2017). A model for field-based evidences of the impact of irrigation on carbonates in the tilled layer of semi-arid Mediterranean soils. *Geoderma* 297: 48–60

3- RESULTS

3.3. Proportion of pedogenic carbonates using carbonates-C isotopic signatures

The acceleration of carbonate dissolution/precipitation cycles, together with the addition of calcium in fertilizers and irrigation water, can cause an **increase in the formation of pedogenic carbonates**.

A **preferential accumulation of pedogenic carbonates in the finest size fractions** (87-92%) **was observed with irrigation** (61-74% without irrigation).



(A) Proportion of pedogenic carbonate values for the common range of $\delta^{13}C_{carbPRIM}$ values between -2 to 2‰ for total carbonate (C) and particle size-fractions without (B) and with irrigation (C).

I. S. de Soto, I. Virto, P. Barré, O., A. Enrique. (2019). Effect of irrigation on carbonate dynamics in a calcareous soil using isotopic determinations. *Spanish Journal of Soil Science* 9 (2): 142-147

4- CONLUSIONS

The **main conclusions:**

- **Irrigation can significantly alter carbonates dynamics** in semi-arid Mediterranean land, which implies that human use can significantly alter the mineral phase of these soils **in a relatively short time lapse**.
- Irrigation can produce a *preferential accumulation of pedogenic carbonates* in the finer fractions.

5- FUTURE INVESTIGATIONS

New field observations and numerical simulations will be done in an experimental plot in which corn (*Zea mays L.*) has been grown since 2010 with and without irrigation in Enériz (Navarra, Spain).

Finally, the model will be validated at a regional scale, using a network of real representative agricultural plots in which there has been a change in land use from dryland to irrigated land in Navarre.

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