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

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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.

To gain knowledge on the importance of the effect of irrigation on carbonates dynamics in the tilled layer of agricultural Mediterranean soils, we conducted a three-step study embracing field observations and numerical simulation.

In the first step, carbonates stocks and size-distribution were quantified for two different situations (irrigation and non-irrigation) in paired plots of three irrigation districts in Navarre (Spain). Our results, showed that although the net annual balance of total carbonates-C between irrigated and non-irrigated plots was neutral, 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).

In a second step, numerical simulations of the geochemical interactions between soil carbonates, the soil solution and irrigation water were run using actual soil characteristics and soil solution data from the tilled layer (0-30 cm) of two paired plots 9 years after irrigation started. A sensitivity analysis was also conducted to investigate the potential impact of water quality and crop types as sources of variability in the model outputs. 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.

Lastly, and because 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, their proportion was estimated in paired plots from carbonates-C isotopic signatures: a preferential accumulation of pedogenic carbonates in the finest size fractions (87-92%) was observed with irrigation (61-74% without irrigation).

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. A numerical model will be developed to study the expected changes in the carbonate dissolution/precipitation cycles in semi-arid Mediterranean areas and these results will be compared with the concentration and characteristics of carbonates (size distribution and isotopic signature as an indicator of their geological or pedogenic origin) in the experimental plot.

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 unirrigated to irrigated land in Navarre.