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Effect of sustainable land management practices on soil aggregation and stabilization of organic carbon in semiarid mediterranean ecosystems

Noelia Garcia-Franco (1,2), Juan Albaladejo (2), María Almagro (2), Martin Wiesmeier (1), and María Martínez-Mena (2)

(1) Chair of Soil Science, TUM School of Life Sciences Weihenstephan, Technical University of Munich, Freising, Germany (noelia.garcia-franco@wzw.tum.de), (2) Soil and Water Conservation Department, CEBAS-CSIC (Spanish Research Council), Campus de Espinardo, Murcia, Spain (mmena@cebas.csic.es)

Arid and semiarid regions represent about 47% of the total land area of the world (UNEP, 1992). At present, there is a priority interest for carbon (C) sequestration in drylands. These areas are considered as very fragile ecosystems with low organic carbon (OC) saturation, and potentially, high capacity for soil OC sequestration. In addition, the restoration of these areas is one of the major challenges for scientists, who will be able to identify and recommended the best land uses and sustainable land management (SLM) practices for soil conservation and mitigation of climate change in these environments. In this regard, in semiarid Mediterranean ecosystems there is an urgent need for the implementation of SLM practices regardless of land-use type (forest, agricultural and shrubland) to maintain acceptable levels of soil organic matter (SOM) and the physico-chemical protection of the OC.

Long- and short-term effects of SLM practices on soil aggregation and SOC stabilization were studied in two land uses. The long-term experiment was conducted in a reforestation area with Pinus halepensis Mill., where two afforestation techniques were implemented 20 years ago: a) mechanical terracing with a single application of organic waste of urban soil refuse, and b) mechanical terracing without organic amendment. An adjacent shrubland was considered as the reference plot. The short-term experiment was conducted in a rain-fed almond (Prunus dulcis Mill., var. Ferragnes) orchard where two SLM practices were introduced 4 years ago: a) reduced tillage plus green manure, and b) no tillage. Reduced tillage was considered as the reference plot given that it is the habitual management practice.

Four aggregate size classes were differentiated by sieving (large and small macroaggregates, microaggregates, and the silt plus clay fraction), and the microaggregates occluded within small macroaggregates (SMm) were isolated. In addition, different organic C fractions corresponding with active, slow and passive pools were separated using a density fractionation method.

Our results showed that the chemical stabilization of OC, was the main mechanisms of C sequestration in the two study sites, which occurred through the formation of complexes with silt and clay particles and its physical protection in microaggregates formed within macroaggregates. In addition, the chemical stabilization was promoted by the mineral composition of the soil matrix. Both studied sites, especially that involving organic soil amendment in the forest system, and the green manure treatment in the agricultural system exhibited an increase in the labile pool of OC in the soil. This increase promoted the formation of macroaggregates, in two ways: 1) directly, by acting as a binding agent between soil particles, and 2) indirectly, by stimulating the microbiological activity, especially that of the fungi - which "package" the particles with their hyphae. The establishment of these new macroaggregates favors the formation of microaggregates. In addition, in the agricultural soils, minimum tillage seems to be necessary, from the point of view of carbon sequestration, since it promotes the incorporation of plant material and the formation of aggregates into deeper layers