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Organic carbon, water repellency and soil stability to slaking at aggregate and intra-aggregate scales

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Water repellency (WR) is a property of some soils that inhibits or delays water infiltration between a few seconds and days or weeks. Inhibited or delayed infiltration contributes to ponding and increases runoff flow generation, often increasing soil erosion risk. In water-repellent soils, water infiltrates preferentially through cracks or macropores, causing irregular soil wetting patterns, the development of preferential flow paths and accelerated leaching of nutrients.
Although low inputs of hydrophobic organic substances and high mineralization rates lead to low degrees of WR in cropped soils, it has been reported that conservative agricultural practices may induce soil WR.
Although there are many studies at catchment, slope or plot scales very few studies have been carried out at particle or aggregate scale. Intra-aggregate heterogeneity of physical, biological and chemical properties conditions the transport of substances, microbial activity and biochemical processes, including changes in the amount, distribution and chemical properties of organic matter.
Some authors have reported positive relationships between soil WR and aggregate stability, since it may delay the entry of water into aggregates, increase structural stability and contribute to reduce soil erosion risk. Organic C (OC) content, aggregate stability and WR are therefore strongly related parameters. In the case of agricultural soils, where both the type of management as crops can influence all these parameters, it is important to evaluate the interactions among them and their consequences. Studies focused on the intra-aggregate distribution of OC and WR are necessary to shed light on the soil processes at a detailed scale. It is extremely important to understand how the spatial distribution of OC in soil aggregates can protect against rapid water entry and help stabilize larger structural units or lead to preferential flow.
The objectives of this research are to study [i] the OC content and the intensity of WR in aggregates of different sizes. [ii] the intra-aggregate distribution of OC and the intensity of WR and [iii] the structural stability of soil aggregates relative to the OC content and the intensity of WR in soils under different crops (apricot, citrus and wheat) and different treatments (conventional tilling and mulching).
Soil samples were collected from an experimental area (Luvic Calcisols and Calcic Luvisols) in the province of Sevilla (Southern Spain) under different crops (apricot, citrus and wheat) and different management types (conventional tillage with moldboard plow) and mulching (no-tilling and addition of wheat residues at rates varying between 5 and 8 Mg/ha/year).
At each sampling site, soil blocks (50 cm long × 50 cm wide × 10 cm deep) were carefully collected to avoid disturbance of aggregates as much as possible and transported to the laboratory. At field moist condition, undisturbed soil aggregates were separated by hand. In order to avoid possible interferences due to disturbance by handling, aggregates broken during this process were discarded. Individual aggregates were arranged in paper trays and air-dried during 7 days under laboratory standard conditions. After air-drying, part of each sample was carefully divided for different analyses: [i] part of the original samples was sieved (2 mm) to eliminate coarse soil particles and homogenized for characterization of OC and N contents, C/N ratio and texture; [ii] part of the aggregates were dry-sieved (0.25-0.5, 0.5-1 and 1-2 mm) or measured with a caliper (2-5, 5-10 and 10-15 mm) and separated in different sieve-size classes for determination of WR and OC content; [iii] aggregates 10-15 mm in size were selected for obtaining aggregate layers using a soil aggregate erosion (SAE) apparatus and WR and OC content were determined at each layer; finally, [iv] in order to study the relation between stability to slaking, WR and OC, these properties were determined in 90 air-dried aggregates (about 10 mm in size) selected per treatment (mulched or conventional tillage) and crop (apricot, citrus and wheat). In this case, every set of aggregates was randomly divided in three groups (n = 30) for assessing stability to slaking, WR and OC, respectively.
OC content in the fine earth fraction of soils under different crops did not show important variations, although it

increased significantly from conventionally tilled to mulched soils. The distribution of OC content in aggregates with different size varied among soils under different crops, generally increasing with decreasing size. At the intra-aggregate level, OC concentrated preferably in the exterior layer of differently sized aggregates and of aggregate coatings and interior from conventionally tilled soils, probably because of recent organic inputs or leachates. In the case of mulched soils, higher concentrations were observed, but no significant differences among aggregate regions were found. The intensity of water repellency, determined by the ethanol method, did not show great variations among differently sized aggregates under different crops in the 0-10 cm layer, but increased significantly from conventionally tilled to mulched soils. Coarser aggregates were generally wettable, while finer aggregates showed slight water repellency. Regardless of variations in the distribution of OC in different layers of aggregate from conventionally tilled soils, great or significant differences in the distribution of water repellency at the intra-aggregate level were not found. In case of mulched soils such differences were not significant. Finally, the intensity of water repellency was much more important than the concentration of OC in the stability to slaking of aggregates.