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Impacts of long-term management strategies on the vertical distribution of SOC stock

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Management strategies aiming to increase SOC stocks in agricultural soils have mainly focused on topsoil layers (0-30 cm), despite increasing research suggests that subsoil is pivotal for SOC storage and stabilization. As a result, there is a knowledge gap between prospects of deep SOC accumulation, and evidence from experimental studies–especially conducted in the long term–that highlight benefits and drawbacks of different management practices.
With this work, we studied the SOC stock change in long-term experiments (> 40 years) of northeastern Italy that compare different agricultural systems and soil types. Three long-term experiments were established between early 60s and 70s at the experimental farm of the University of Padova: 1) a crop rotation experiment (starting year 1962), that compares rotations (2, 4, 6 years) and monocultures (maize, wheat, permanent meadow) with different rates of N fertilizer and types of organic amendments in a silty loam alluvial Cambisol, which is the most widespread in the northern plain of Italy (288, 46.8-m2 plots); 2) a soil type and fertilization experiment (starting year 1964), that compares mineral N fertilizer and organic amendment inputs in three contrasting soil types, namely a sandy (Calcaric Arenosol), a clay (Gleyic-Vertic Chernozem), and a peaty (typic sulfisaprists euic, mesic) soil (18, 4-m2 open lysimeters); 3) a soil type and residue experiment (starting year 1970), that combines six mineral N fertilization rates with crop residue incorporation, or removal, in clay, sandy loam and sandy soils (108, 4-m2 open lysimeters). A hydraulic sampler was used to take in each plot undisturbed soil columns (length > 0.7 m), and measure bulk density, SOC content and stock at different layers according to the equivalent soil mass approach. Results showed that agricultural management acted differently among soil types, increasing the SOC layering in naturally poor OC soils. Sandy (22.7 t ha-1) and silty loam (65.5 t SOC ha-1) soils were less efficient to stock SOC than the clay-rich ones in the soil type and fertilization experiment top 70 cm. Clay soil was also associated with the highest SOC distribution in the deepest layer (50-70 cm), 30% vs 26% (sandy) vs 22% (silty loam) of the total SOC stock. In this context, a combination of minimum tillage and organic inputs with high humification coefficient may increase the SOC storage, despite some C saturation capacity occurred, especially in the sandy topsoil layers. Permanent meadow was the most impactful strategy to stock SOC in the long term along the soil profile. Promising strategies were also highlighted by high input farmyard manure (ca. 7 Mg ha-1 yr-1) in maize monoculture systems with deep roots that stocked as much as the meadow, despite being characterized by yearly deep tillage.