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Aggregate C depletion by plowing and its restoration by diverse biomass-C inputs under no-till in sub-tropical and tropical regions of Brazil

Florent Tivet [a,c,*], João Carlos de Moraes Sá [b], Rattan Lal [c], Clever Briedis [d], Paulo Rogério Borszowskei [d], Josiane Bürkner dos Santos [d], Anderson Farias [e], Guilherme Eurich [e], Daiani da Cruz Hartman [e], Mario Nadolny Junior [e], Serge Bouzinac [a], Lucien Séguy [a]

[a] Centre de Coopération Internationale en Recherche Agronomique pour le Développement, CIRAD, UPR SIA, F-34398 Montpellier, France
[b] Department of Soil Science and Agricultural Engineering of State University of Ponta Grossa, Av. Carlos Cavalcanti 4748, Campus de Uvaranas, 84030-900 Ponta Grossa, PR, Brazil
[c] Carbon Management and Sequestration Center, School of Environment and Natural Resources, The Ohio State University, OARDC/FAES, 2021 Coffey Road, Columbus, OH 43210, USA
[d] Graduate Program in Agronomy of State University of Ponta Grossa, Av. Carlos Cavalcanti 4748, Campus de Uvaranas, 84030-900 Ponta Grossa, PR, Brazil
[e] Undergraduate Program in Agronomy of State University of Ponta Grossa, Av. Carlos Cavalcanti 4748, Campus de Uvaranas, 84030-900 Ponta Grossa, PR, Brazil

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ABSTRACT

Encapsulation of soil organic carbon (SOC) within aggregates is one of the principal mechanisms for long-term C sequestration, macroaggregate formation and stabilization. Our objectives were to quantify the changes in aggregate size distribution, aggregate-C concentrations and stocks upon conversion of native vegetation (NV) to conventional plow-based tillage (CT), and to assess the rate of aggregation and SOC recovery with no-till (NT) under diverse biomass-C inputs. The study was conducted at both sub-tropical (Ponta Grossa – PG, State of Paraná) and tropical (Lucas do Rio Verde – LRV, State of Mato Grosso) sites in Brazil. The SOC content under NV was used as a baseline to evaluate the depletion rate under CT and the restoration rate under NT. A specific emphasis was given to the largest macroaggregate size class (8–19 mm) because of its importance to protecting the recently deposited labile SOC. A discriminant analysis of principal components (DAPC) indicated that NV soil is modified by conversion to an arable land use and that, mechanical tillage, biomass input, and their interactions drastically influence the distribution of aggregate-size classes, aggregation indices, and SOC distribution within aggregates. At both sites, soil aggregation indices were positively impacted by NT and associated with SOC concentration in the labile fractions (e.g., total polysaccharides (TPS), hot water extractable organic C (HWEOC), particulate organic C (POC)). At the PG site, the 8–19 mm aggregate size fraction was significantly affected by land use and tillage treatments and represented 54%, 43%, and 72%, under NV, CT, and NT in 0–20 cm depth, respectively. Furthermore, the 8–19 mm size fraction stored 55%, 45%, and 71% of the total SOC stock under NV (53.8 Mg C ha^{-1}), CT (28.5 Mg C ha^{-1}) and NT (51.2 Mg C ha^{-1}), respectively. At the LRV site, the 8–19 mm aggregate size fraction decreased from 50% under Cerrado NV to 35% under CT, and ranged from 33% to 51% under diverse biomass-C input under NT in 0–20 cm depth. The 8–19 mm size fraction stored 52%, 37%, and 41% of the total SOC stock across all aggregate sizes under NV (25.4 Mg C ha^{-1}), CT (11.7 Mg C ha^{-1}), and NT (9.9–18.1 Mg C ha^{-1}), respectively. The difference in SOC stock among land uses is largely attributed to storage in the 8–19 mm aggregate size class, indicating that NT cropping systems rebuilt the largest macroaggregates, which are crucial for stabilization of SOC.

Abbreviations: ASI, aggregate stability index of soil; CT, conventional plow-based tillage; H_{LIF}, humification index; HWEOC, hot-water extractable organic carbon; LIFS, Laser-Induced Fluorescence Spectroscopy; LRV, Lucas do Rio Verde; MGD, mean geometric diameter of aggregates; MT, minimum tillage; MWD, mean weight diameter of aggregates; NT, no-till; NV, native vegetation; OM, organic matter; PG, Ponta Grossa; POC, particulate organic carbon; SOC, soil organic carbon; RI, resilience index; TPS, total polysaccharides; WSA, water-stable aggregates.

* Corresponding author at: Centre de Coopération Internationale en Recherche Agronomique pour le Développement, CIRAD, UPR SIA, F-34398 Montpellier, France. Tel.: +33 4 6761 5643; fax: +33 4 6761 7513.
E-mail address: florent.tivet@cirad.fr (F. Tivet).

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