High organic inputs explain shallow and deep SOC storage in a long-term agroforestry system

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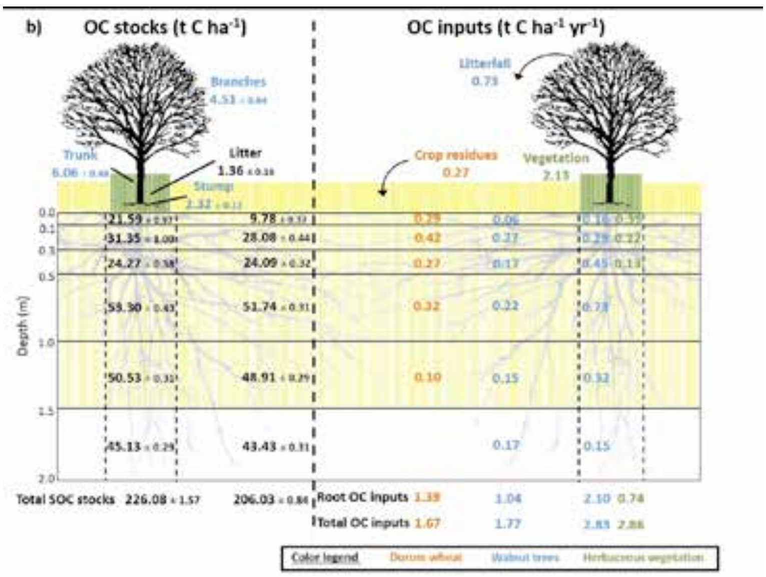
In agroforestry systems (AFS), soil organic carbon (SOC) stocks are generally increased, but it is difficult to disentangle the different factors responsible for this storage. We used an 18-year-old silvoarable system associating hybrid walnut trees and durum wheat and an adjacent agricultural control plot to quantify all OC inputs to the soil – leaf litter, tree fine root senescence, crop residues, and tree row herbaceous vegetation – and measured SOC stocks down to 2m of depth at varying distances from the trees. We then proposed a model that simulates SOC dynamics in AFS accounting for both the whole soil profile and the lateral spatial heterogeneity. The model was calibrated to the control plot only.

Measured OC inputs to soil were increased by about 40% (+1.11 tCha−1 yr−1) down to 2m of depth in the AFS plot compared to the control, resulting in an additional SOC stock of 6.3 tCha−1 down to 1m of depth. However, most of the SOC storage occurred in the first 30 cm of soil and in the tree rows. The model was strongly validated, properly describing the measured SOC stocks and distribution with depth in AFS tree rows and alleys. It showed that the increased inputs of fresh biomass to soil explained the observed additional SOC storage in the AFS plot. Moreover, only a priming effect variant of the model was able to capture the depth distribution of SOC stocks, suggesting the priming effect as a possible mechanism driving deep SOC dynamics.



Measured soil organic carbon stocks and organic carbon inputs to the soil in the 18-year- old agroforestry plot. Associated errors are standard errors. Values are expressed per hectare of land type (control, alley, tree row). To get the values per hectare of agroforestry, data from the alley and tree row have to be weighted by their respective surface area (i.e., 84 and 16 %, respectively) and then added up. OC: organic carbon; SOC: soil organic carbon. SOC stock data are from Cardinael et al. (2015b), and data for tree root OC inputs are combined from Cardinael et al. (2015a) and Germon et al. (2016).

Keywords: deep roots, deep SOC, SOC modeling, priming effect, C sequestration.

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