# Linking root biomass and traits with soil C and nutrients stocks and microbial activity down to 100 cm depth in a young Mediterranean agroforestry system

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In the subsoils, roots represent a major source of organic matter. Moreover, the C inputs from rhizodeposition, root turnover (mostly perennial species) and root mortality at harvest (annual crops) have a long residence time in soil due to slow decomposition rates. However, deeper understanding of the root impact on soil C stocks and nutrient dynamics is still required, especially in deep horizons of mixed species agroecosystems.

This study aims to assess the heterogeneity of the root distribution and the root traits in two main components of an alley-cropping system, i.e. the crop and the understory vegetation strip (UVS) located under the tree rows; and to relate the root variables to soil physical, chemical and microbiological properties according to the distance from the tree and to soil depth.

The experimental alley-cropping site "DIAMS" (Mauguio, France) was planted in 2017 with *Robinia pseudoacacia* (294 trees $ha^{-1}$). In May 2020, we assessed the fine root biomass density, distribution, functional traits, chemical composition and some soil physical, chemical and microbiological properties in 3 soil layers (0-20, 20-50 and 50-100cm), 3 locations (the UVS under the tree rows, the wheat (Crop-1m) at 1 to 2m perpendicular to the tree line (under tree shade) and the crop (Crop-4m) at 3.4 to 4.5m from the tree (no tree shade)) and in 3 independent replicated plots.

The crop roots at 0-20 cm of depth had a biomass reduced by 3-fold near the UVS compared to far from it. UVS and crops showed similar root traits response to depth with a decrease of specific root length and stele diameter associated with an increase of root C:P ratio. The estimated annual root C inputs represented less than 0.6% of the organic C stocks and was less important under the UVS than the crop, at depth, due to C input pathways (turnover vs. mortality, respectively). Between 0 and 50 cm of depth, the soil C stocks increased with root C stocks, whereas below 50cm the relationship was negative, suggesting that root effect on soil-C might shift in subsoil. At all depths, the root stoichiometry had a tight link with extracellular enzyme N activities. According to ecoenzymatic stoichiometry, subsoil seemed more nutrient limited.

Altogether, our results suggested that increasing root biomass up to 50 cm (in our case) can foster soil C storage. In contrast, in deeper soil layers, an increase in root inputs, having high C:N ratios, could induce microbial N limitations and consequently restraint soil C storage.

**Keywords:** *Robinia pseudoacacia*, soil C sequestration, alley-cropping, root traits, soil enzymatic activity