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Storage of deep carbon in the Berambadi watershed (India): a comparative study between agroforestry and irrigated agriculture

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Agricultural systems face the challenge to adapt to global changes. In this context, agroforestry is increasingly seen as a way of limiting the impact of extreme events on crops, as the combined presence of deep roots and associated microbiota helps maintaining nutrients and water available to plants in the soil.
The ANR Nutrilift project aims at assessing whether the presence of deep-rooted trees in agroforestry systems has a significant effect on the functioning of the deep Critical Zone and on the biogeochemical cycles of carbon and nutrients at the scale of these agro-ecosystems. These questions were addressed with a multidisciplinary approach (geophysics, hydrology, biogeochemistry, pedology, microbiology, experimentation, modeling, etc.) in two contexts, irrigated cultivated plot (IP) and agroforestry (AF). The study site is located in the Berambadi watershed (South India, SNO M-TROPICS). The role of trees (i.e., teak trees) and the presence of deep roots on soil nutrient and carbon dynamics was studied using 10-meter deep wells, finely characterized at the scale of soil horizons and root traits. Humidity, pCO_2, pore water composition and root dynamics (through scanner imaging systems) were continuously monitored. In parallel, controlled soil incubation experiments (i.e., microcosms) were performed. Carbon stocks and forms were obtained from dry combustion and Rock-Eval® thermal pyrolysis analyses, while microbial activity and diversity were determined by environmental DNA analysis and incubation experiments.
In agroforestry system, the microbial communities associated with the rhizosphere are more diverse than those of the average soil, with specific taxa such as mycorrhizal fungi. Deep carbon stocks and forms are different in the agroforestry and the irrigated agriculture pits, due to different initial organic matter sources, and deep microbial activity dependent on organic matter input. In agroforestry, the carbon stocks are larger, and carbon forms at depth (9m) are stored in a more stable reservoir. The presence of deep-rooted trees brings root organic matter to the deep soil layers, some of which recalcitrant, and the microbial communities associated with the roots could slow down the organic matter decomposition. Thus, the forms and stocks of carbon in deep agricultural soils, linked to the microbial communities in the environment,

can be modulated by the presence of trees. More detailed functional ecology studies could confirm the hypothesis that carbon reservoirs in agroforestry and irrigated plots have different dynamics due to different rates of decomposition by micro-organisms. This would have implications for the resistance and resilience of such agro-ecosystems in the context of climate change.

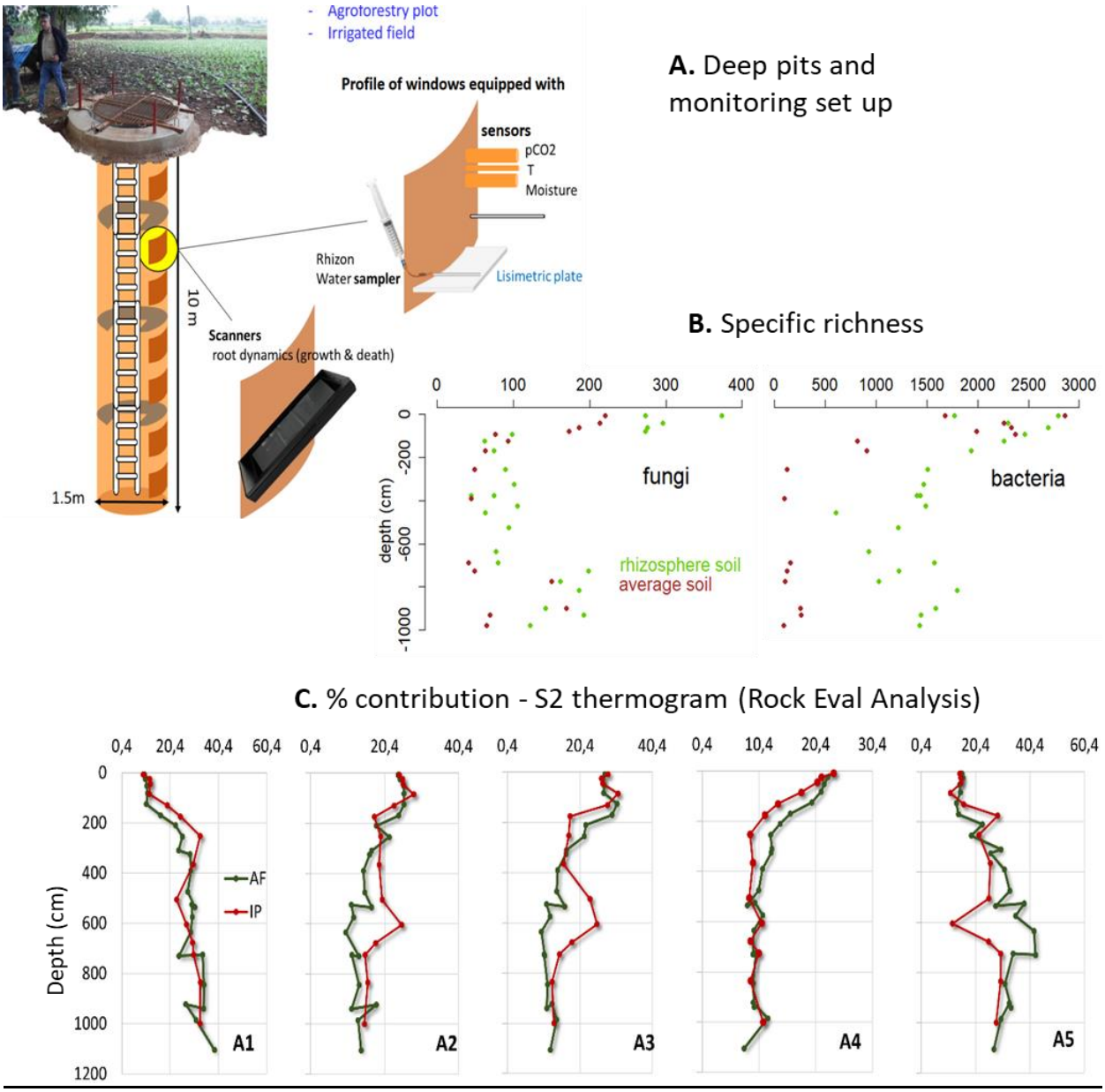

Figure showing A/ the field system with a schematic diagram of the deep pits monitored for root activity, gas chemistry and soil solutions, B/ bacterial and fungi specific richness results comparing populations between the average soil (red) and the rhizosphere soil (green) for the agroforestry pit and C/ the profiles of the different contributions (in %) making up the deconvolution of the S2 thermogram from the Rock-Eval® thermal analyses of AF and IP soils.