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Species richness of tree plantations affects pathways of carbon incorporation into soil organic matter

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Inventories on forest and plantation soil carbon storage capabilities have often been found to be positively influenced by plant species richness. However, no satisfactory explanation has been reached so far, as, neither primary production or litter recalcitrance have been found in most cases to be sufficiently strong drivers of the observed phenomenon.

We tested the hypothesis that this enhanced C sequestration may derive from modifications in the relative proportions of pathways of C incorporation into SOM, leading to changes in the relative proportions of labile (non-humic, non-phenolic C) and refractory SOM components (humic, phenolic C) and in their physical stabilization by sorption (bound or not bound C) to soil minerals.

We sampled surface soil at two different depths (0-3 and 3-15 cm) in six mixed deciduous plantations located in the upper plain of the Friuli Venezia Giulia region, in the north-east of Italy. Soils have developed under the same climatic conditions and from calcareous parent materials, and are classified as calcaric aric-regosols and chromic endoskeletric cambisols. Plantations had the same tree density and standing age (19 years since reversion from arable land), but differed in the number of tree species (from 1 to 9).

Humic and non-humic substances fractions of soil organic matter (SOM) were obtained by extracting soil (1:10 w/v) first with 0.5M NaOH (non-humic and humic free C) and then by alkaline 0.1M sodium pyrophosphate (non-humic and humic C bound to mineral surfaces by Ca^{2+} bridges, bound C). Extracts were then fractionated by solid phase chromatography on crosslinked polyvynilpyrrolidone to separate non-phenolic substances from humic materials. We also measured soil microbial biomass C by fumigation-extraction (FE) and determined microbial biomass specific respiration rates under optimal mineralization conditions (25°C and 50% WHC) during a 10 days' laboratory incubation.

Species richness affected the relative proportion among SOM fractions and the amount of humic C increased with species richness. In the uppermost mineral soil layer (0-3 cm), free to mineral-bound humic substances displayed a trend contrasting that of the 3-15 cm layer, coherently with the divergent carbon dioxide emissions trends measured during laboratory incubation from samples taken from the two soil layers.

In tree plantations, species richness supports the development of complex interactions among the number of tree species, carbon dioxide emissions and the amount of C stored in free and mineral-bound humic and non-humic fractions. These interactions foster the incorporation of C inputs into more refractory fractions of SOM, either by favouring chemical stabilization through binding with phenols (formation of humic C) or by physical stabilization through binding with mineral components via the establishment of cationic bridges.