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Carbohydrates and thermal analysis reflects changes in soil organic matter stability after forest expansion on abandoned grassland

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Grassland abandonment, followed by progressive forest expansion, is the dominant land-use change in the Southern Alps, Europe. Land-use change can affect not only the amount of organic matter (OM) in soil but also its composition and stability. Our objective was to investigate changes in organic matter properties after forest expansion on abandoned grasslands, combining analysis of carbohydrates, indicative of labile OM compounds with prevalent plant or microbial origin, with thermal analysis. Thermal analysis was used as a rapid assessment method for the characterization of SOM stability.

A land-use gradient was investigated in four land-use types in the subalpine area of Trentino region, Italy: i) managed grassland, mown and fertilized for the past 100 years; ii) grassland abandoned since 10 years, with sparse shrubs and Picea abies saplings; iii) early-stage forest, dominated by P. abies and established on a grassland abandoned around 1970; iv) old forest, dominated by Fagus sylvatica and P. abies. Mineral soil was sampled at three subplots in each land use type with eight soil cores, which were subsequently pooled by depth (0-5 cm, 5-10 cm, 10-20 cm). Sugars were extracted from bulk soil samples through acid hydrolysis with H2SO4 (0.5 M). The analytical composition of sugar monomers was performed with HPAEC technology (Dionex ICS5000), equipped with PAD-detection. Thermal stability was assessed with a differential scanning calorimeter DSC100, heating soil samples up to 600°C at a heating rate of 10°C min-1 in synthetic air. Peak height (W g OC-1) of 1st DSC exotherm, dominated by burning of labile OM compounds, was used as thermal stability index.

In the abandoned grassland, carbohydrates compounds accounted for a greater proportion of soil OC than in other land use types. Microbially derived sugars, as rhamnose and galactose, were more abundant in managed and abandoned grasslands compared with early-stage and old forest. The amount of thermally labile sugars, estimated as the peak height of the 1st exotherm, was higher in the abandoned grassland compared with managed grassland and old forest in 0-5 cm depth. Moreover, thermally labile compounds were higher in early-stage than in old forest in 0-5 cm depth. A highly significant correlation was found between thermally labile compounds and carbohydrate content in soil ($P = 0.008$, $r = 0.725$).

The obtained results suggest that both thermally-labile compounds and carbohydrates are more abundant soon after grassland abandonment, which can lead to lower OM stability. The combination of chemical and thermal analysis of OM can thus provide useful insights on organic matter composition and stability.