Soil organic carbon fractions in uncultivated and tilled profiles of mountain Mediterranean agroecosystems

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Introduction

In the global carbon cycle, one of the most important terrestrial pools for carbon storage and exchange with atmospheric CO₂ is the soil organic carbon (SOC).

According to chemical stability and turnover times, SOC can be fractionated in the labile and recalcitrant carbon pools.

The labile (L) is easily degraded and the recalcitrant carbon (R), more stable because its much slower turnover time, is particularly relevant to the role of soil as a long-term terrestrial carbon sink.

Soil erosion redistributes soil and SOC across agricultural landscapes (Zhang et al., 2006, Quine and Van Oost, 2007, Navas et al., 2009).

In this work, the vertical and lateral distribution of SOC, L and R carbon fractions is examined along a transect with different land uses. Fallout 137Cs is used to identify erosion and deposition profiles. The labile and recalcitrant carbon fractions are related with the radiocarbon to assess their distribution patterns at eroded and deposition sites.

Material & Methods

Along a representative toposequence of a mountain Mediterranean agroecosystem twelve soil profiles were collected using a 7.2 cm diameter automatic core driller (Figure 1).

Representing the different land uses in the transect, 4 cultivated profiles were collected at each of the upper, middle and bottom parts of the transect.

Six profiles were on natural vegetated uncultivated sites and six on cultivated sites. The depth of sampling was the total soil depth: 20 to 55 cm.

Soil profiles were sectioned at 5 cm depth increments totalling 89 interval samples.

The soil redistribution in each profile was estimated from 137Cs inventories (Quijano et al., 2011) using the models by Soto and Navas (2004, 2008).

The content of SOC, labile and recalcitrant carbon were measured by dry combustion method using a LECO RC-612 analyzer (Nelson and Sommers, 1996) and are reported as concentration (%) and as content per surface area expressed as inventories (kg m⁻²).

Results

For all interval soil samples mean SOC content is low and varies from minimum contents at deep intervals of cultivated soils and maximum contents at soil surface intervals in natural soils. The content of the labile fraction is always higher than the recalcitrant fraction and the largest differences occur in natural soils (Table 1). The strongest correlations occur between SOC and the labile fraction, and they are more moderate with the recalcitrant fraction (Table 2).

The vertical distribution of SOC, L and R carbon fractions in uncultivated profiles is highest in surface layers and decreases exponentially with depth. In cultivated profiles, SOC, L and R carbon fractions are homogeneously distributed in the profile due to mixing by tillage and contents are higher in the plough layer (Figure 2).

The depth distribution of SOC and L and R fractions presents a similar pattern to that described for 137Cs in the transect (Gaspar et al., 2011). The 137Cs mass activity and contents of SOC, labile and recalcitrant carbon are directly and significantly related (Table 2).

In uncultivated profiles the contents of SOC, L and R fractions are higher and significantly different from contents in cultivated profiles (Figure 3).

At deposition sites of both cultivated and uncultivated profiles, increases of 137Cs inventories are paralleled with increases of the labile and recalcitrant carbon fractions.

At erosion sites, less clear patterns occur. At cultivated eroded sites, the labile fraction increases for increasing 137Cs inventories but at uncultivated eroded sites the recalcitrant fraction decreases (Figure 4).

Inventories of SOC, labile and recalcitrant carbon vary largely along the transect (Figure 5). The greatest occurrences occur at the natural uncultivated soils. Loss of soil carbon due to mineralization and uptake by crops results in lower inventories at the cultivated profiles.

Mean inventories of SOC and labile and recalcitrant carbon are higher at the upper part of the transect and significantly different from the other two parts. At erosion and deposition sites mean inventories are always lower and significantly different at the bottom part than at the middle and upper parts of the transect (Table 3).

Conclusions

Important and significant differences were found between cultivated and uncultivated sites for the soil organic carbon content, labile and recalcitrant pools that are strongly affected by the land use. In uncultivated sites carbon fractions are higher than in cultivated sites. For both land uses, the labile carbon is greater than the recalcitrant carbon fraction.

The distribution of SOC, labile and recalcitrant carbon along the transect is affected by the soil redistribution patterns. At deposition sites an increase of 137Cs is related with an increase of labile and recalcitrant carbon. At cultivated eroded sites only the labile carbon follows this pattern. On the contrary in uncultivated eroded sites the carbon fraction tends to decrease for 137Cs increases.

Increases of labile and recalcitrant carbon at deposition sites would have implications for the capacity of soils to sequester carbon. Further research has to be done to clarify the behaviour of the carbon fractions at eroded sites.