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Short communication

Cultivation effects on biochemical properties, C storage and ^{15}N natural abundance in the 0–5 cm layer of an acidic soil from temperate humid zone

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Abstract

Changes in some soil chemical, including ^{15}N values, and biochemical properties (microbial C, FDA hydrolysis, glucosidase and urease activities) due to two tillage systems, conventional tillage (CT) and no-tillage (NT), were evaluated in an acid soil from temperate humid zone (NW of Spain) and compared with values obtained for a reference forest soil. The results showed that in the surface layer (0–5 cm depth) tillage tended to increase soil pH and to decrease organic matter levels and microbial biomass and activity values. The data also indicated that 8 years of NT, compared to CT, resulted in greater organic matter content and increased microbial biomass and activity, the changes being more pronounced for the microbial properties. Adoption of NT resulted in an increase of soil C storage of 1.24 Mg C ha^{-1} $year^{-1}$ with regard to CT. The suitability of ^{15}N as a potential tracer of land-use in this acid soil was also confirmed.

Keywords: Microbial biomass; Soil enzymes; ^{15}N abundance; C sequestration; Tillage

1. Introduction

Soil organic matter (SOM) is an important soil quality attribute because of its influence on physical, chemical and biological properties and processes that, in turn, contribute to improve soil productivity (Gregorich et al., 1994). Recent concern for world-wide climate change has also increased the interest in SOM and its role in the global C budget through sequestration of atmospheric C (Lal, 2001). Assessment of SOM is therefore a valuable step to identify the overall quality of a soil and the sustainability of land management. Studies of soil ecosystems under long-term management involving different tillage practices as well as undisturbed native soils have demonstrated that tillage may cause a substantial

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decrease of SOM content and labile pools of nutrients (Elliott, 1986; Karlen et al., 1994; Wander and Bollero, 1999). On the contrary, the change of tillage methods to reduced- or no-tillage practices is recommended to sequester organic C and hence to reduce the net emission of greenhouse gases (Lal, 2002). Short- and medium-term changes in SOM following a change in soil management or land-use are less well understood because they are difficult to measure by conventional methods.

In the temperate humid zone of NW Spain, conversion of natural forest to arable lands and pastures is the most widespread change in land-use in the past hundred years. Therefore, large areas of forest are being cultivated with crop sequences under conventional tillage. Most of these crop rotations are considered to be strongly degrading systems because of the negative effect of intensive tillage on SOM, soil structure, etc., and the small quantity of plant residues on the soil after harvesting. However, information on the impact of tillage systems on properties of these acidic soils is scarce and is mainly limited to physical properties (Benito and Díaz-Fierros, 1992). At present, conservation tillage is being adopted in this area as an alternative to restore soil structure and fertility. The aim of this work was to evaluate whether changes in soil chemical, including $\delta\ ^{15}N$ values, and in biochemical properties due to two tillage systems (conventional tillage and no-tillage) could be detected after 8 years of maize–ryegrass rotation. Soil properties were also analysed using the same soil without disturbance as reference.

2. Material and methods

The experimental field was located in the Gayoso-Castro farm (43°06′N, 7°27′W, 420 m a.s.l.) at Castro de Ribeiras de Lea (Galicia, NW Spain). The soil is a Gleyic Cambisol with sandy loam topsoil. Tillage treatments were arranged in a complete randomised block design with four replications and 2 m separation established around each plot (20 m × 5 m). Since 1994, the same annual ryegrass–maize rotation has been cultivated under two tillage systems, conventional tillage (CT) and no-tillage (NT). Silage maize is being sown in rows 0.7 m apart in late May and harvested in September. Before sowing, plants established in the NT treatments were destroyed with glyphosate application at a dose of 5 L ha^{-1} whereas in the CT treatments they were buried by ploughing at 25–30 cm. Further agrochemical applications were identical for both treatments (CT, NT): one mixture of herbicides (33% acetachlor and 16.5% atrazine), insecticide (clorpiriphos) and 12–12–24 N–P–K at rates of 4 L ha^{-1}, 0.33 L ha^{-1} and 700 kg ha^{-1}, respectively. Measurements of chemical and biochemical properties were carried out on all soil samples collected before sowing (0 time) and at different time intervals during the maize cropping (2, 4 and 12 weeks after sowing). In each sampling plot, samples were taken at 0–5 cm depth from 16 points uniformly distributed in the central rows between the maize plants and mixed to obtain a composite sample per plot. Additionally, a control soil (NC) was sampled at random in an adjacent (50 m apart) forest soil without human disturbance during the last 60 years. After sieving at 4 mm, the homogenized soil samples were stored at 4 °C prior to further analyses of biochemical properties.

Microbial biomass C was determined using the method described by Vance et al. (1987). Enzyme activities of several hydrolases were measured as indicators of soil metabolic activity. Fluorescein diacetate (FDA) hydrolysis, β-glucosidase and urease activities were assessed as reported by Schnürer and Rosswall (1982), Eivazi and Tabatabai (1988) and Kandeler and Gerber (1988), respectively. Total N content and $\delta\ ^{15}N$ values of soils were measured on finely ground samples (<100 μm) with an elemental analyser (EA) coupled on-line with an isotopic ratio mass spectrometer (Finnigan Mat, delta C, Bremen, Germany). Total inorganic N was measured in 2 M KCl extracts and extractable C in 0.05 M K_2SO_4 (Basanta et al., 2002).

All results were obtained by triplicate determinations and were expressed on the basis of oven-dried (105 °C) weight of soil. Data obtained at different field plots (four field replicates per treatment) were statistically analysed by standard analysis of variance (ANOVA 1) and, in cases of significant F-values, Tukey's minimum significant difference test was used to separate the means. For cultivated soils, the percentage of data variation attributable to soil management and sampling time was calculated using two-way analysis of variance.