Soil Aggregation and Organic Carbon Protection in a No-Tillage Chronosequence Under Dryland Mediterranean Conditions

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Introduction

No-tillage is widely accepted as a soil management practice that has the potential to increase the soil organic carbon (SOC) pool contributing to mitigate CO_2 increase in the atmosphere. However, few studies have attempted to quantify the role of NT maintenance over time on SOC protection within aggregates.

The objective of this work was to study the effects of a NT chronosequence on soil aggregation and SOC protection in a dryland Mediterranean agroecosystem.

Methods

Location: Northeast Ebro Valley, Spain.

Climatic characteristics	Precipitation (mm)	Temperature (ºC)	ETo (mm)
	430	13.8	855

Soil Characteristics	Type	Texture ¶
	Typic Xerofluvent	47.5%, 41.7%, 11.8 %

¶ Sand – Silt – Clay

Date of sampling: July 2010, right after crop harvest.
Sampling depths: 0-5, 5-10, 10-20 and 20-30 cm.
Soil water-stable aggregates fractionation: wet sieving method adapted from Elliot (1986, Soil Sci. Soc. Am. J. 50: 627-633).
C concentration: wet oxidation method (Nelson and Sommers, 1982. Methods of Soil Analysis, Part 2., SSSA).
Experimental design:

In 1990, 1999, 2006 and 2009 successive portions of 1500 m^2 of an intensive-tilled field (i.e., 7500 m^2) were transformed to NT. Thus, in 2010, a surface of 1500 m^2 remained under CT and 6000 m^2 under NT with different years: 1 (NT-1), 4 (NT-4), 11 (NT-11) and 20 (NT-20) years (Figure 1).

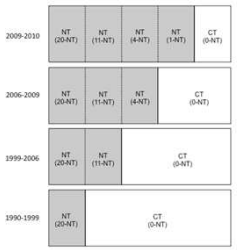

Fig. 1. Conceptual scheme of the no-tillage (NT) chronosequence

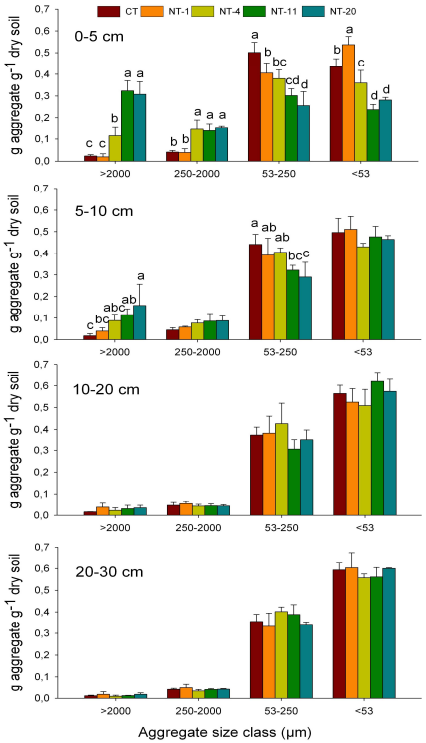

Fig. 2. Water-stable aggregate size distribution at the 0-5, 5-10, 10-20 and 20-30 cm soil depths in a no-tillage (NT) chronosequence with the following phases: conventional tillage (CT) and NT under 1 (NT-1), 4 (NT-4), 11 (NT-11) and 20 (NT-20) years. Error bars represent standard errors. Within the same soil depth and aggregate fraction, different lowercase letters indicate significant differences between years under NT chronosequence phases at *P*<0.05.

Results

- In the 0-5 cm soil depth, greater amount of large water-stable macroaggregates (> 2000 µm) was found in the NT-11 and NT-20 phases compared with the other three phases (i.e., CT, NT-1 and NT-4) (Fig. 2).
- In the 5-10 cm soil depth, the NT-20 phase presented greater amount of water-stable macroaggregates (> 2000 µm) than the NT-1 and the CT phases. However, no differences on water-stable macroaggregates were found below 10 cm depth.
- SOC concentration in microaggregates (53-250 µm) and silt- plus clay-sized particles (< 53 µm) was significantly greater in the NT-4, NT-11 and NT-20 phases compared with the CT and NT-1 phases in the 0-5 cm soil layer (Table 1). Greater SOC concentration was found below 10 cm depth in the CT phase. However, that fact was not accompanied with a greater stability of macroaggregates (Table 1).

Table 1. Soil organic carbon (SOC) concentration in different water-stable aggregate classes in the 0-5, 5-10, 10-20 and 20-30 cm soil depths in a no-tillage (NT) chronosequence with the following phases: conventional tillage (CT) and NT under 1 (NT-1), 4 (NT-4), 11 (NT-11) and 20 (NT-20) years. Within each depth and water-stable aggregate fraction, different letters indicate significant differences between chronosequence phases at P<0.05

Soil depth (cm)	Water-stable aggregate classes (µm)	SOC (g kg^{-1})				
		CT	NT-1	NT-4	NT-11	NT-20
0-5	250 – > 2000	24.9	18.6	25.8	29.5	30.7
	53 – 250	10.2 b	10.1 b	16.4 a	18.1 a	19.5 a
	< 53	10.3 b	8.8 b	19.5 a	19.9 a	13.4 ab
5-10	250 – > 2000	23.5	22.1	19.5	22.7	27.0
	53 – 250	10.2	10.9	11.4	12.3	13.1
	< 53	10.0	9.3	11.9	11.8	9.0
10-20	250 – > 2000	24.7 a	21.2 ab	13.1 bc	10.4 c	14.7 bc
	53 – 250	10.7	10.1	8.2	8.1	8.8
	< 53	6.0	8.3	9.7	8.9	7.4
20-30	250 – > 2000	18.6 a	13.8 ab	8.8 b	6.8 b	10.1 b
	53 – 250	9.9	9.2	7.5	6.7	6.9
	< 53	7.9	6.5	9.9	7.7	7.5

Conclusions

In Mediterranean semiarid agroecosystems, the maintenance of NT over time promote SOC sequestration in soil surface due to the increase in the proportion of water-stable macroaggregates and microaggregate-C concentration.

Acknowledgements: Field and laboratory technicians Carlos Cortés, Sílvia Martí, Josan Palacio, Javier Bareche and Xavier Penella. The first author was awarded with a FPU fellowship by the Spanish Ministry Education. This research was supported by the Comision Interministerial de Ciencia y Tecnología of Spain (AGL2007-66320-C02-01 y AGL 2010-22050-C03-01/02).

ASA-CSSA-SSSA International Annual Meetings, 21-24 October 2012, Cincinnati, Ohio, USA

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