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SOC stock in woody crops in Madrid Region depends on the soil conservation management

El almacenamiento de SOC en cultivos leñosos en la Región de Madrid depende de la práctica de conservación del suelo

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ABSTRACT

Cover crops or groundcovers in woody crops are a highly recommended conservation practice to protect soil against erosion and to increase soil organic carbon (SOC) stock. A study in southeastern Madrid Region was performed comparing plots under a soil conservation management (mechanically mowed, chemically mowed and no soil management) regarding tilling (total of 34 plots). This work was carried out from 2018 to 2021. Only plots under mechanically mowing significatively increased SOC stock comparing with nearby tilling plots (+4.9 Mg·ha^{-1}). Plots managed chemically mowing or with no management due to weed scarcity did not increase SOC stock regarding their homologues tilled plots. Under the edaphoclimatic conditions of the study area, mechanically mowed plots reached 33.5 Mg SOC·ha^{-1} on average at 0-30 cm depth. This value is quite below regarding similar studies in other areas, showing the highly restricted edaphoclimatic conditions of the study zone.

Keywords: cover crops, SOC stock, mechanically mowing, chemically mowing, herbicide.

RESUMEN

Las cubiertas vegetales son una práctica muy recomendada para el manejo del suelo en cultivos leñosos, con el objeto de proteger el suelo frente a la erosión y aumentar el contenido de carbono orgánico que almacena. Un estudio en la zona sureste de la Comunidad de Madrid comparando parcelas con manejos alternativos al laboreo (cubierta vegetal segada mecánicamente, cubierta vegetal eliminada con herbicida y sin manejo debido a la escasa vegetación) frente a parcelas labradas fue llevado a cabo entre 2018 y 2021 (34 parcelas en total). Tan solo las parcelas con cubiertas vegetales segadas, incrementaron significativamente el contenido de carbono orgánico del suelo (SOC) frente a parcelas próximas labradas (+4.9 Mg·ha^{-1}), mientras que las parcelas con cubiertas segadas con herbicida o las parcelas que no tenían manejo del suelo porque tenían escasa vegetación no tuvieron un contenido diferente de SOC frente a sus homólogas labradas. Bajo las condiciones edafoclimáticas de la zona de estudio, las parcelas con cubiertas segadas mecánicamente llegaron a almacenar de media 33.5 Mg SOC·ha^{-1} en el espesor de 0-30 cm, que es un valor menor que el de otros estudios similares en zonas diferentes, mostrando las importantes limitaciones edafoclimáticas de esta zona.

Palabras clave: cubiertas vegetales, stock de carbono, siega mecánica, siega química, herbicida.

INTRODUCTION

Most olive groves are managed by tillage in the Madrid Region (>71%), as in other Spanish regions (MAPAMA, 2019). This practice leads to soil erosion with an important loss of organic carbon and nutrients (Gómez *et al*., 2009; Bienes *et al*., 2010).

Alternative soil managements are crucial to avoid soil and nutrient loss, in order to reach a sustainable agriculture. Permanent or annual cover crops, seeded or spontaneous, and mulching are strategies to protect the soil from erosive processes (FAO & ITPS, 2021; Sastre *et al*., 2017). Moreover, carbon sequestration in soils is a key process for adaptation and mitigation of the expected negative impacts of Climate Change (Rodríguez Martín *et al*., 2016).

MATERIAL AND METHODS

This work was performed mainly in "Comarca de Las Vegas", a shire at the south-east of Madrid Region with high extensions of woody crops (mainly olive groves). The climate is classified as Continental Mediterranean, with a mean annual temperature of 14.7ºC, accumulated annual precipitation of 370 mm, and a reference evapo-transpiration (ET_0 Penman-Monteith) of 1170 mm.

The first stage of the project was to find farmers who did not use tillage as soil management in their woody crops. More than 30 plots were visited, selecting 15 private rainfed olive groves, and adding two research IMIDRA's farms to the trial (Figure 1): "La Chimenea" and "El Socorro". These are experimental farms with olive orchads and vineyards, respectively.

Once the soil alternative management plots were selected, a close farm with the same crop and similar soil was chosen. From the 17 plots with soil conservation management 7 were mechanically mowed once or twice per year (mean of 7 years with this management), 3 were yearly chemically mowed (mean of 6 years with this management), and 7 had no soil management due to the scarcity of the spontaneous vegetation growing in these soils (mean of 6 years with this management).

Soils were classified according to the FAO's map (Centro de Investigaciones Agrarias del CSIC (Ministerio de Economía, Industria y Competitividad) & Consejería de Medio Ambiente y Ordenación del Territorio (Comunidad de Madrid), 1990) as follows: 2 Calcisols, 1 Cambisol, 2 Gypsisols, 5 Leptosols, 6 Luvisols and 1 Regosol.

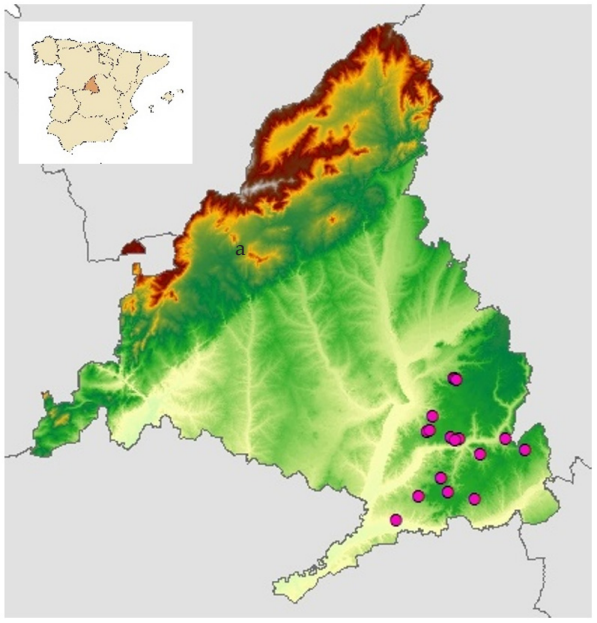

Figure 1 - Plots location in Madrid Region (n=16, each dot is a pair of plots: soil conservation management and tillage).

In each plot, 3 composite samples were taken in the inter-rows at 4 depths: 0–5, 5–10, 10–20 and 20–30 cm. The samples were sieved at 2 mm, to analyze soil organic carbon (SOC) by wet oxidation method (Walkley & Black, 1934). SOC stock was obtained as follows:

$$C\ Stock = conc. \times BD \times d \times (1\text{-}S) \times 10^2$$

where C Stock is the stock of carbon (Mg ha^{-1}); conc. is the concentration of carbon (%); BD is the bulk density (Mg m^{-3}); d is the thickness (m); and S is the stoniness (% of coarse fragments >2 mm).

One and two-way ANOVA tests were used for the groups of managements to establish significant differences between variables (LSD test for differences).

RESULTS AND DISCUSSION

SOC stock at 0-30 cm depth was statistically different for the different soil management (Figure 2). The means were 33.5 [18.7-66.4], 31.6 [23.2-39.8], 27.0 [19.0-32.7] and 28.6 [17.0-44.3] Mg·ha^{-1} for Mecanical mowing, Chemical mowing, with No management and Tillage, respectively (minimum and maximum values in brackets). Only under mechanical mowing there were statistical significant differences regarding Tillage. These results of carbon stock are higher than those found by Calvo de Anta *et al*. (2020) in soils of woody crops from Madrid (24 Mg SOC·ha^{-1}); but quite below to those described for soils in woody crops in Spain by Rodríguez Martín *et al*. (2016) being 38.09 Mg·ha^{-1} of SOC; or those considered by Bateni *et al*. (2019) in olive groves in Italy , being 36-71 Mg·ha^{-1}. This lower content of SOC stock is due to the edaphoclimatic conditions (Calvo de Anta *et al*., 2020), since this area is under semiarid or close to semiarid climate with thin soils, some of them with high content of gypsum or lime.

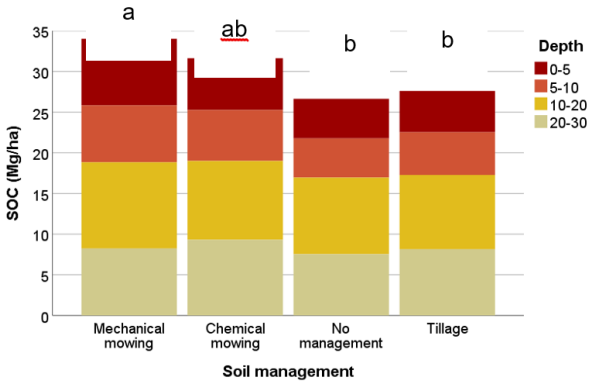

Figure 2 - Soil Organic Carbon (SOC) stock at 0-30 cm depth under different soil management. Different letter above the column means statistically significant differences according LSD test (p<0.05).

SOC stock in woody crops with a groundcover managed with a mechanical mowing increases by 20% regarding tillage. It means an increase of 4.9 Mg·ha^{-1} in groundcovers managed mechanically mowed for 7 years on average. This result is consistent with previous works of the group (Sastre *et al*., 2018), where an increase of SOC stock of 1 Mg·ha^{-1} year^{-1} under the permanent cover crop at 0-10 cm depth was measured. However, these results are far from those from Nieto *et al*. (2013) who measured an increase of 4.02 Mg·ha^{-1}·year^{-1} in olive groves with cover crops in southern Spain. This rise in 4.9 Mg·ha^{-1} SOC stock could be the limit that this type of soil under this climate could accumulate.

SOC stock variation between the pair of plots (Soil conservation management and Tillage) was calculated in order to evaluate the effect of the soil conservation management classes, for the same edaphoclimatic conditions (Figure 3). The main differences appears between Mechanical mowing in the upper horizons.

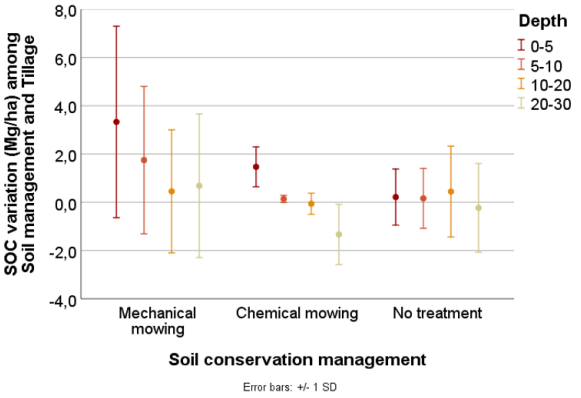

Figure 3 - Soil Organic Carbon (SOC) stock differences among soil conservation management and tillage in each plot.

A Two-way ANOVA was performed to determine the effect of the management and depth in the variations in SOC stock under the soil conservation management regarding tillage (Table 1).

Both factors, Soil Treatment and Depth, were significantly different, and there was no interaction between factors. Woody crops managed under Mechanical mowing stores significatively more SOC compared with tillage than the other two managements, that are similar between them. The largest differences in SOC variationappear at 0-5 cm depth, being statistically different than the variations at 10-20 and 20-30 cm depth. This is consequence of SOC stratification caused by the contribution of plant debris in the topsoil. Tillage homogenization is absent, contributing to a layered differentiation.

Table 1 - Two-way ANOVA and Least Significant Difference tests for pairwise comparison of Soil Organic Carbon stock variation at different soil treatments and depths

		p-value
Factor	Treatment	0.000
	Depth	0.012
	Treatment x Depth	0.080
		LSD mean of SOC variation (Mg ·ha^{-1})
Treatment	Mechanical mowing	1.55^{a}
	Chemical mowing	0.56^{b}
	No management	-0.06^{b}
Depth	0-5 cm	1.60^{a}
	5-10 cm	0.81^{ab}
	10-20 cm	0.31^{b}
	20-30 cm	0.02^{b}

Different lowercase letters indicates differences between levels of the factor according to LSD test at $p<0.05$.

CONCLUSIONS

SOC stock depends on the soil conservation management applied and on the local edaphoclimatic conditions. Only Mechanically mowing increase SOC stock at 0-30 cm regarding tillage, but there were no differences with Chemical mowing or No treatment. This information should be taken into account in order to be considered among the "greening" measures of the next Common Agricultural Policy. The 'green direct payment' (or 'greening') supports farmers who adopt or maintain farming practices that contribute to EU environmental and climate goals.

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