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PANEL: SOIL COMPONENT

Soil organic carbon stocks in crop/pasture sequences – results from the oldest long-termagricultural experiment in Latin America [1]

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Abstract: The aims of this study were to assess the long-term effects of different CPR on SOCstocks on the subsoil, and to draw conclusions about the capacity of CPR to sequester C in Uruguay.We conclude that incorporating pastures in continuous crop sequences increased soilorganic carbon stocks through the soil profile by an average of 28%.

Key words: Sustainable agriculture; Soil bulk density; Equivalent soil mass, Forage legume;Mixed swards.

Introduction

Including pastures into crop-pasture rotations (CPR) is a management strategy that hasbeen widely proven to increase SOC stocks in the top soil (soilsrevealed.com). Far less studieshave evaluated the long term benefits of crop-pasture rotations (CPR) on SOC stock for the entire soil profile (Rumpel et al., 2015); none in Latin America (Terra & Prechac, 2006). Giventhe typical distribution of clay within the soil profile, subsoils often have a greater capacity to sequester organic carbon (Pravia et al., 2019), The aim of this study was to assess the long-termeffects of CPR with contrasting proportion of pasture on SOC stocks on the subsoil to draw conclusions about the capacity of CPR to sequester C in Uruguay.

Materials and Methods

The long-term experiment is located at the experimental station “La Estanzuela” of the Instituto Nacional de Investigación Agropecuaria (INIA), in Southern Uruguay (34°20 S, 57°41W, 82 m.a.s.l.), in the Pampas and Campos Biome in South America. The experiment was established in 1963. A complete description of soil physico-chemical characteristics at the experimental site is provided by Grahmann et al. (2020). The main treatment characterization is presented on Table 1. Differences between CPR were the proportion of the sequence occupied by pasture phase, from 0 % (continuous annual cropping-CA) to 66% of the time with pastures(66%Past), and whether the pasture phase is 50% of the time of the CPR and included solely legume species (50%Lot) or a mixture of grass and legume species (50%Past).

Table 1. Crop-pasture rotation treatments for the Long term experiment in La Estanzuela, Uruguay. Cropping sequences are described as present in the fields in 2009, including agronomic adaptations since 1963.

AS*	Abbreviation	System description	Year of cropping sequence					
			1	2	3	4	5	6
1	CA0	Continuous annual cropping without fertilizer	Sorghum	Barley/Sunflo wer	Wheat	Repeated		
2	CA +	Continuous annual cropping with fertilizer	Sorghum	Barley/Sunflo wer	Wheat	Repeated		
6	CASoy	Continuous annual cropping with fertilizer	Barley/Sorg hum	Sunflower	Wheat	Repeated		
7	33%Past	66% Crops 33% Pasture (1 year RC)	RC	Barley/Sunflo wer	Wheat/RC	Repeated		
5	50%Past	50% Crops 50% Pasture (3 years F +WC +BT)	Sorghum	Barley/Sunflo wer	Wheat/Pastur e	3 years of Pasture		
3	50%Lot	50% Crops 50% Pasture (BT)	Sorghum	Barley/Sunflo wer	Wheat/BT	3 years of BT		
4	66%Past	33% Crops 50% Pasture (1 year RC, 3 years F + WC + BT)	Barley/RC	RC	Wheat/Pastur e	3 years of Pasture		
	AS: Agricultural System or original treatment number; F: tall fescue (*Festuca arundinacea* Schreb.), WC: White clover (*Trifolium repens*), BT: Birdsfoot trefoil (*Lotus corniculatus* L.)							

The soil profile was sampled in 2007 (block 1), 2008 (block 2) and 2009 (block 3). A single composite sample consisting of 6 soil cores of 4.2 cm diameter was collected per plot forfive depth increments: 0–10, 10–20, 20–40, 40-60 and 60-80 cm. Soil bulk density of each plotand depth was determined as the dry soil mass divided by sampled volume. Organic C concentration was measured by wet combustion with $K_2Cr_2O_7$ (Tinsley, 1967). The SOC stockswere determined for each rotation for the soil profile from 0 to 80 cm, summing up individual depths as the product of soil bulk density and organic C. SOC stocks were quantified at equivalent soil mass (ESM) following Ellert et al. (2007). We used the lowest soil masscriterium, which corresponded to the 50%Lot treatment.

Results and discussion

Figure 1 presents SOC stocks from 0 to 80 cm depth. The four CPR treatments always had higher values ($P<0.10$) than CA. CPR (67%Past, 50%Past, 50% Lot,33%Past) presented SOC stock values of 122.27 Mg ha^{-1} compared to 87.53 Mg ha^{-1} with continuous cropping (CA0, CA+ and CASoy). On average, it represents 28% more SOC stocks on CPR, comparedto CA.

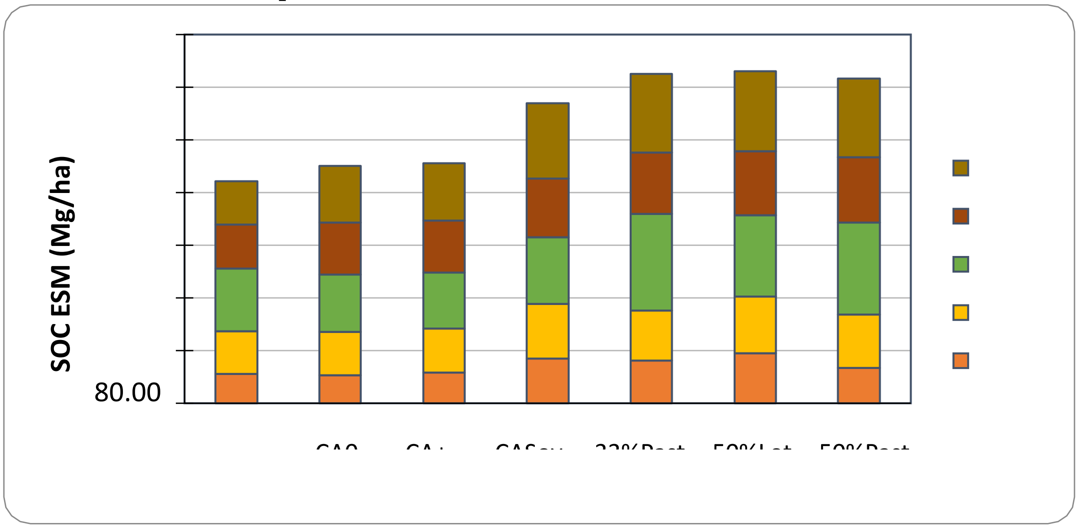

Figure 1- Soil Organic Carbon Stock (Mg/ha) in Rotaciones Viejas experiment after 35 years of establishment of the treatments , INIA-La Estanzuela Uruguay. Continuous annual cropping without fertilizer (CA0), CA with fertilizer (CA +), CA+ with soybean (CASoy), 66% Crops 33% Pasture

(33%Past), 50% Crops 50% Pasture (50%Past), 50% Crops 50% Lotus Pasture (50%Lot), 33% Crops 50% Pasture (66%Past). Differentletters indicate differences between treatments by Tukey test (P<0.05)

Increasing C inputs to the soil often increases SOC stocks (Fujisaki et al., 2018). Furthermore, besides representing the greatest land C sink in the biosphere, improving SOC isknown to improve soil structure, fertility and hence crop productivity (Lorenz & Lal, 2014). Therefore, CPR can play a central role to achieve sustainable intensification of agricultural systems in the Pampas.

Conclusions

Sequences that included pastures had on average 28% larger soil organic carbon stocksthan sequences that just had crops. A large part of this carbon was stored below 20 cm, particularly if pastures lasted two years or more. Thus, incorporating pastures in long-term continuous cropping sequences would provide a chance to sequester organic carbon.

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