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Sistemas Silvopastoriles

Hacia una diversificación sostenible

XII Congreso Internacional de Sistemas Silvopastoriles

II Congreso de la Red Global de Sistemas Silvopastoriles

IV Seminario Seminario Nacional de Sistemas Silvopastoriles

Montevideo, Uruguay 2023

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CIPAV

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Carbon balance of a small dairy farm with integrated livestock-forest system in Goiás, Central West region of Brazil

Balanço de C da produção de leite em unidade familiar com adoção de integração pecuária-floresta em Goiás, Brasil

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Abstract

The objective of this study was to estimate CO_2-eq emissions from milk production and evaluate the potential of integrated livestock-forest system to mitigate emissions via Carbon stocked in soil and *eucalyptus* trees in Santa Barbara Farm located in the State of Goiás, Central West region of Brazil, within the savanna biome (Cerrado). Tropical soils in the Cerrado are one of the most ancient in the world and therefore long-date weathered. In 2016, integrated livestock-forest system (ILF) was implemented in a pasture on a Geric Xanthic Ferralsol (Dystric Humic). Soil organic C (C_{org}) stocks in the Ferralsol were around 6 to 7 Mg ha^{-1} within 0.0-0.3 m layer. In the 4-year old ILF system, there were an extra 0.441 Mg ha^{-1} C_{org} stock related to same soil under continuous pasture within 0.0-1.0 m layer. The estimated total emission due to dairy production per year at farm level was around 520 Mg CO_2-eq or 142 Mg of C emitted to atmosphere. Most of emissions were related to animal feeding (58%). Considering total C_{org} stocks in 1-m depth of soil and 2-years old *eucalyptus* trees in the ILF system, yet the C balance was positive, indicating emission of 102.93 Mg of C to the atmosphere due to the present dairy production system conducted at Santa Barbara farm. At 4 years after implementation, the ILF system was a sink of 38.94 Mg of C from atmosphere, offsetting around 28% of total emissions, a significant number once the farmer intends to keep and increment the ILF area in order to sustain milk production levels due to thermal comfort delivered to the cows by trees.

Keywords: *C stocks, mitigation, eucalyptus trees, cool farm tool, savanna.*

Palavras-chave: *estoques de C, compensação, eucaliptos, cool farm tool, Cerrado.*

Introduction

Dairy farms represent 23% of agricultural sector in Brazil. Around 6% is located in Goiás, where 69% of dairy farmers are smallholders, accounting for 9.13% of national milk production (IBGE, 2017). The herd of milked cows in Brazil is the second largest in the world, with a significant contribution to the emission of greenhouse gases-GHG. In order to estimate GHG emissions in the agricultural sector, models and tools have been combined from different methods and calibrations.

Objectives

to estimate CO_2-eq emissions from milk production and evaluate the potential of integrated livestock-forest system to mitigate emissions via C stocked in soil and *eucalyptus* trees in a small dairy farm in Goiás, Central West region of Brazil.

Materials and methods

The study was conducted in Santa Barbara Farm located in the State of Goiás, Central West region of Brazil, within the savanna biome (Cerrado), with a total area of 48 ha, in which 44 ha consisted of pasture for dairy grazing and 4 ha consisted of native forest. In 2016, 3 ha of integrated livestock-forest system (ILF) was implemented in the pasture area with 1,548 *eucalyptus* trees (*Corymbia citriodora* x *C. torelliana*, clone AEC 043) planted on a Geric Xanthic Ferralsol (Dystric Humic), clay content ~ 22%. *Eucalyptus* trees were planted in alleys of four rows spaced 3.0 m between rows, 2.5 m between trees, and 22.0 m between alleys (Fig. 1), according to Pacheco *et. al.,* (2019). In February 2020, soil samples were collected to determine C concentration and bulk density in the ILF system within alleys of trees (L) and between rows of trees (BL). Areas of native forest (2.3 ha) and continuous pasture (1 ha) were also sampled for soil C stock determination. In each area, four soil pits distanced 20 m from each other were excavated for soil sampling in seven layers (0.0-0.1, 0.1-0.2, 0.2-0.3, 0.3-0.4, 0.4-0.6, 0.6-0.8, 0.8-1.0 m). Soil organic matter was determined by wet combustion with dichromate oxidation. Organic C (C_{org}) stocks was calculated considering conversion factor (1.724) for total C in soil organic matter and the average bulk density (g cm^{-3}) of the continuous pasture for each soil layer. C_{org} stocks were based on quantification in equivalent soil masses in Mg ha^{-1} for three soil layers 0.0-0.3 m, 0.3-1.0 m and 0.0-1.0 m (Sisti *et. al.,* 2004). Statistical analyses were performed using the linear mixed model procedure (Proc MIXED) of the SAS/STAT® statistical software (SAS Institute Inc., 2008) considering the clay content at each soil depth as a covariate: (1) above 20% and (2) equal to or below 20%. Dunnett's test was applied to compare whether there were significant differences between pasture and the ILF system and native forest. The Cool Farm Tool (CFT), livestock sub-module was the calculator selected for the quantification of total GHG emissions (CO_2-eq Mg) in the Santa Barbara dairy farm, with 50 Brazilian Dairy Crossbred (Holstein x Gir *Bos indicus*) maintained on fertilized Tanzania-grass (*Panicum maximum* Jacq.) and with an average milk production of 2,920 kg cow^{-1} per year. Data were collected in May 2020 and February 2023. To quantify C balance (Mg), the averaged total emission estimated by CFT was calculated considering molar weight of C (12 g mol^{-1}) in a molecule of CO_2 (44 g mol^{-1}). Total C accumulated within 0.0-1.0 m soil layer of the ILF system was compared to continuous pasture. Calculation of C stocks (Mg ha^{-1}) in 2-years old *eucalyptus* trees was done considering average density analysis of 100 trees measured in September 2018 (520 kg m^{-3}) and the average volume of each tree (0.096 m^{-3}), resulting in a biomass of 75.24 Mg in a group of 1,500 *eucalyptus* trees planted in 3 ha. The C accumulated in biomass of trees was calculated using the factor of 0.5 according to Penman *et. al.,* (2003).

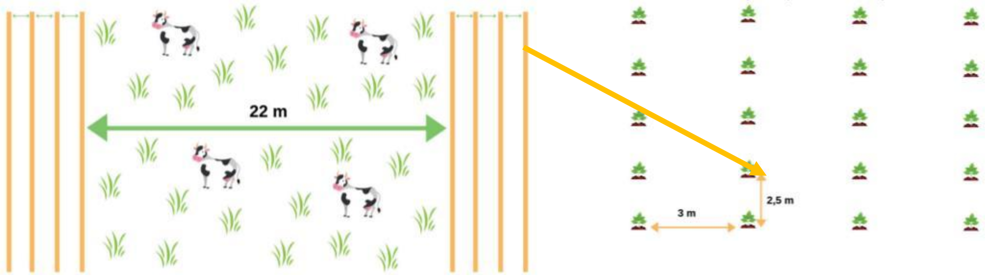

Figure 1. Design of the integrated livestock-forest system. Adapted from Pacheco *et. al.,* (2019).

Results and discussion

At 0.0-0.3 m soil layer, the C_{org} stocks (Mg ha^{-1}) under continuous pasture (6.55) and ILF system (6.52 L-6.55 BL) were larger than under native forest (6.15). However, below 0.3 m, within 0.3-1.0 m soil layer, the C_{org} stock was significantly lower ($p \leq 0.05$) under continuous pasture (12.52) than under native forest (13.62), and significant differences between continuous pasture and the ILF system were not observed (Table 1). Four years under ILF system did not have a significant effect on the C_{org} stock related to continuous pasture within the entire soil layer 1-m deep, although the increment in C_{org} stock under the ILF-BL (0.441) was equivalent to that of native forest (0.501). The largest amounts of C_{org} stock were below 0.3-m, showing 65% and 66% of the total C_{org} stock throughout the entire soil profile under the ILF system (Table 1).

The CFT analysis has given an average total emission of 520.2 Mg CO_2-eq due to milk production components at Santa Barbara farm. Most of emissions were related to animal feeding (58%) and enteric fermentation (31%), followed by transportation (4%) and grazing (4%). Considering total organic C stocked in 1-m soil depth and 2-years old *eucalyptus* trees in three hectares of a 4-years old ILF system, yet the C balance was positive, resulting in 102.9 Mg of C emitted to atmosphere due to the present dairy production system conducted at Santa Barbara farm (Table 2). Implementation of the ILF system helped to offset around 28% of total GHG emissions. Therefore, an extra area ≥ 11 ha implemented with ILF would be necessary to offset total emissions of Santa Barbara farm. The 28% is already a significant number once the farmer intends to keep and increment the ILF area in order to sustain milk production levels due to thermal comfort delivered to the cows by trees, which will keep growing and capturing C for at least more 10 years.

Table 1. Soil organic C stocks (Mg ha^{-1}) in three layers of a Ferralsol under continuous pasture, a 4-years old integrated livestock-forest system (ILF), within (L) and between (BL) alleys of trees, and a native forest.

	0.0-0.3 m		0.3-1.0 m		0.0-1.0 m		C accumulated*
	Estimate	*Std. Error*	Estimate	*Std. Error*	Estimate	*Std. Error*	
Pasture	6.553	*0.2448*	12.5178	*0.3119*	19.1655	*0.4961*	-
ILF-L	6.520	*0.2448*	12.5535	*0.3119*	19.1678	*0.4961*	*0.002*
ILF-BL	6.546	*0.2448*	12.9657	*0.3119*	19.6065	*0.4961*	*0.441*
Native Forest	6.146	*0.2581*	13.6225 **	*0.279*	19.6725	*0.4437*	*0.507*

**C accumulated: related to Pasture within 0.0-0.1 m; **Statistically different ($p \leq 0.10$) from Pasture by Dunnett's test.*

Table 2. Carbon (C) balance (Mg) in a small dairy farm with 4-years old integrated livestock-forest system (ILF) on a Ferralsol, located in Central West region of Brazil, within the savanna biome, cumulative catch in 2020.

Average total C emitted per year due to dairy farming	Extra soil organic C stock up to 1 meter in 3 ha of ILF	Total organic C in 1,500 *eucalyptus* trees 2-years old	C balance
+141.87	-1.32	-37.62	+102.93

Conclusions

Due to implementation of integrated livestock-forest system, the increment in stocks of organic C in 1-meter soil depth and 2-years old *eucalyptus* trees was responsible for offsetting 28% of total CO_2-eq emitted by milk production at Santa Barbara farm.

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