# EUCALYPTUS CARBON INCREMENT AND SEQUESTRATION IN AN INTEGRATED LIVESTOCK-FOREST SYSTEM IN BOM JESUS DO TOCANTINS, PA

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**ABSTRACT**
Among the benefits of the Integrated Production System - ILF is the enhancement of the forestry component of carbon immobilization in biomass, reducing $CO_2$ emission into the atmosphere and, consequently, reducing climate change. This study aimed to evaluate eucalyptus growth and estimate its carbon sequestration in an integrated livestock-forest system (ILF) located in the southeastern region of Pará. Data were collected at *Fazenda Riacho Grande*, in the municipality of Bom Jesus do Tocantins, PA. In order to assess the growth and carbon stock of the forest species, annual measurements were taken, one at 12 months and another at 27 months of age, in 3 plots measuring 1,271 m². The volume of 9.97 m³ $ha^{-1}$ and a mean annual increment (MAI) of 4.43 m³ $ha^{-1}$ $year^{-1}$ were observed, with an estimated carbon stock of 2.14 Mg of C $ha^{-1}$ and 7.83 Mg $ha^{-1}$ of $CO_2$ eq being sequestered from the atmosphere, thus providing a potential to neutralize methane emission of 2.08 AU $ha^{-1}$ $year^{-1}$ at 27 months of age.
**Key words:** Sustainability; Crop-forest integration; Carbon stock

## INTRODUCTION

The Integrated Livestock-Forest System (ILF) is a set of technologies that consists in diversifying and combining different productive systems in the same area, in intercropped cultivation, so that there is a synergistic effect among the components (BALBINO et al., 2011). The possibilities to combine components in the system are many and adjustments are necessary, depending on producers' interests as well as on edaphoclimatic and market aspects.

The forest component is perennial, and for that reason, when present in the systems, it enhances carbon immobilization in biomass for long periods (JOSE, 2009), thus silvopastoral systems can fix significant amounts of carbon in the soil and in biomass, providing an important contribution to climate change reduction (MÜLLER et al., 2009; LOSS et al., 2012), in addition to resulting in several benefits for the other components in the system, such as improvement in climate, soil, microorganisms, forage plants and animals, representing an important development strategy, both for diversification and income increase for rural producers and for environmental conservation.

Milk production in the southeastern region of Pará state is characterized by being developed in low-productivity processes, with a low degree of adequate land use and low productive efficiency. Most undertakings take place in pasture areas with very limited productivity, a low stocking rate (1 AU hectare $year^{-1}$) and an average production of 4-5 liters per animal/day, in an approximate period of seven months per year (VEIGA et al., 2006; GONÇALVES et al., 2006). Considering the importance of integrated production processes for environmental adaptation of regional systems in small properties for cow milk production, the use of the forestry component also improves the thermal comfort of animals, thus allowing for better production conditions.

Given the above, this study aimed to evaluate eucalyptus growth and estimate its carbon sequestration in a livestock-forest integration system located in the region of Bom Jesus do Tocantins, PA.

## MATERIAL AND METHODS

The study was conducted at *Fazenda Riacho Grande*, in the municipality of Bom Jesus do Tocantins, PA, from 2018 to 2021. The area is located at latitude 5°06'22.16" S, longitude 48°34'01.83" W and an altitude of 175 meters. According to Köppen (1936) the climate is tropical semi-humid (Aw/As) with average monthly temperatures between 22.7 and 32.1°C, and an annual average of 26.3°C. The soil has been classified as (Oxisols) Dystrophic yellow Latosol (SANTOS et al., 2013).

In September 2019, 2 t $ha^{-1}$ of dolomitic limestone was applied to the study area by broadcasting. In December of the same year, an ILF system (silvopastoral) was implemented, using eucalyptus (*Eucalyptus brassiana x Eucalyptus grandys* VD469) in a triple arrangement, with 25-m spacing between rows, 3-m spacing between lines and 3-m spacing between plants, resulting in 244 trees $ha^{-1}$, and occupying 19.5% of the area with a forest species, where pasture, which had already been formed with *Urochloa brizantha* cv. Marandu, had been used in the productive process with cows. The pits were opened manually, and 200g of single super phosphate was placed in the planting pits. Also, 200g $plant^{-1}$ of NPK 10-28-20 was applied twice in a circle shape at a distance of 20 cm from the plants The first application took place 15 days after planting and the second at 40 days. For cover fertilization, 200g $plant^{-1}$ of the NPK 10-28-20 formulation was used, divided into two applications, as well as 50g $plant^{-1}$ of FTE BR12 (micronutrients). Two controls were performed using an agrochemical (glyphosate) for crowning the eucalyptus in the wet season (rainy), during the whole first year. In the first year, the trees were protected by electric fences in order to prevent them from being damaged by the animals.

In order to assess the growth and carbon stock of the eucalyptus trees, measurements were taken at 12 and 27 months after planting. Data collection from the eucalyptus was carried out in three 315 x 45-m plots, totaling 1,271 m² in each plot, in which height (H) was measured from the vertex, and the diameter at breast height (DBH) by a tape measure. The volumes per plant and per hectare ($m^3$ $ha^{-1}$) were calculated using the adjusted equation of the model by Schumacher and Hall (1933), according to Campanha et al. (2017).

According to Oliveira et al. (2018), in order to estimate the carbon stock (C) in the eucalyptus trunk, an average carbon content of 49% and an average wood density of 0.35 Mg $m^{-3}$ were considered, estimating 0.17 Mg of C $m^{-3}$. According to IPCC (2006), it can be considered that 1 t of C is equivalent to 3.6667 t of $CO_2$ eq, thus estimating a fixation of 0.62 Mg of $CO_2$ eq per m³ of wood. The trunk biomass was estimated by multiplying the volume by the respective density of the adopted wood, multiplied by the carbon content.

## RESULTS AND DISCUSSIONS

The trees implanted according to the ILF system in the studied region showed good development, with a mean height of 4.0 m and a mean DBH of 3.63 (Table 1) at 12 months and an estimated mean volume of 0.48 m³ $ha^{-1}$ and MAI of 0,48 m³ $ha^{-1}$ $year^{-1}$, with a capacity of 244 trees $ha^{-1}$. At 27 months, eucalyptus showed a gain of 155% and 186% in height and mean DBH, respectively, with a mean height of 10.2 m, a mean DBH of 10.50 cm, a mean volume of 9.97 m³ $ha^{-1}$ and MAI of 4.43 m³ $ha^{-1}$ $year^{-1}$. These results are similar to those by Campanha et al. (2017), who found eucalyptus (*Eucalyptus grandis* (Hill) ex Maiden x *Eucalyptus urophylla* ST Blake strains GG (100) in an ICLF system intercropped with agricultural crops (333 trees $ha^{-1}$, 15 x 2 m) in Sete Lagoas, MG, with a mean height of 10.3 m, mean DBH of 10.5 cm, volume of 15.8 m³ $ha^{-1}$ and MAI of 7.88 m³ $ha^{-1}$ $year^{-1}$ at 24 months. Such higher figures for volume and MAI were due to the larger number of trees, that is to say, a system with higher tree density in relation to that in this study. In an investigation conducted by Macedo et al. (2006), the results were greater than those in this study, as they found a mean height of 11.82 m, a mean DBH of 14.19 cm and volume of 19.94 $m^3$ $ha^{-1}$ in an ICLF system using eucalyptus species at an age of 28 months, in a 10 x 4-m arrangement forming a stand of 247 trees $ha^{-1}$.

Table 1. Mean height, DBH, volume and MAI of eucalyptus by months and by hectare in a Livestock-Forest Integration System (ILF). Bom Jesus do Tocantins, PA.

| **Height months** | **Mean height (m)** | **Mean DBH (cm)** | **Mean volume ($m^3$ $ha^{-1}$)** | **MAI[1] ($m^3$ $ha^{-1}$ $year^{-1}$)** |
|---|---|---|---|---|
| 12 | 4.0 | 3.67 | 0.48 | 0.48 |
| 27 | 10.2 | 10.50 | 9.97 | 4.43 |

[1]MAI = Mean Annual Increment.

Regarding carbon sequestration from the atmosphere, eucalyptus in the ILF system was responsible for sequestering 0.10 Mg of C $ha^{-1}$ at 12 months of age, reaching 27 months with a carbon stock of 2.14 Mg of C $ha^{-1}$ (Table 2).

It is estimated that 0.37 Mg $ha^{-1}$ of $CO_2$ eq is sequestered at 12 months, and 7.84 Mg $ha^{-1}$ of $CO_2$ eq at 27 months of age. According to IPCC et al. (2006) an AU (Animal Unit) that is equal to 450 kg (live weight), on average, emits 1.88 Mg $ha^{-1}$ of $CO_2$ eq $year^{-1}$. Thus, after 27 months of age, the ILF system with 244 trees $ha^{-1}$, in a 25 x 3 x 3-m arrangement, has the potential to neutralize methane emission to the extent of 2.08 AU $ha^{-1}$ $year^{-1}$, that is, in two years, a total of 4 adult bovines per hectare (4 AU). Such results corroborate those found by Campanha et al. (2017), who reported a neutralization potential of 2.77 AU $ha^{-1}$ $year^{-1}$ at 24 months, with a total of 5.5 adult bovines per hectare (5.5 AU) in two years in an ICLF system in the 15 x 2-m arrangement with 333 tress $ha^{-1}$.

Table 2. Estimated carbon and $CO_2$ eq stock per hectare in the trunk of eucalyptus trees and the potentially neutralized stocking rate for an Integrated Livestock-Forest System with 244 eucalyptus trees per hectare. Bom Jesus do Tocantins, PA.

| **Age months** | **Carbon stock (Mg de C $ha^{-1}$)** | **$CO_2$ eq stock (Mg $ha^{-1}$of $CO_2$ eq)** | **Neutralized stocking rate (AU $ha^{-1}$ $year^{-1}$)** |
|---|---|---|---|
| 12 | 0.10 | 0.37 | 0.20 |
| 27 | 2.14 | 7.84 | 2.08 |

Thus, it is observed that the tree component in the ILF system has a great capacity to mitigate GHG emissions from animal production, since, according to Alves et al. (2015), the mean stocking rate of Brazilian pastures comes close to 1.0 AU $ha^{-1}$ $year^{-1}$.

## CONCLUSIONS

*Eucalyptus* in the ILF system, under the observed conditions, showed a volume of 9.97 $m^3$ $ha^{-1}$ and MAI of 4.43 $m^3$ $ha^{-1}$ $year^{-1}$ at 27 months of age, with an estimated carbon stock of 2.14 Mg C $ha^{-1}$ and 7.83 Mg $ha^{-1}$ of $CO_2$ eq being sequestered from the atmosphere, thus providing a potential to neutralize methane emission of 2.08 AU $ha^{-1}$ $year^{-1}$ at 27 months of age.

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