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Estimación de captura de carbono en el sistema agroforestal de Teobroma cacao L

Estimation of carbon capture in the agro forestry system of Theobroma cacao L.

Rolando Arteaga-Duran; Yuris Rodríguez-Matos; Yisenia Del Toro- Ricardo

Universidad de Guantánamo, Facultad Agroforestal, Cuba
Correo(s) electrónico(s)
rolandoad@cug.co.cu
yurisrm@cug.co.cu, yurisrodriguezm@gmail.com
yiseniadr@cug.co.cu
ORCID: https: //orcid.org/: 0000-0001-5241-4537
http://orcid.org/ 0000-0002-5032-6362
https: //orcid.org/: 0000-0001-6146-3998

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Resumen

El trabajo se desarrolló en la UBPC José Maceo de Baracoa, con el objetivo de evaluar la estimación de captura de carbono en el Sistema Agroforestal cacaotero, a partir de 14 parcelas de 500 m^2, calculándose el CO_2 retenido en toneladas y la estimación de forma directa, con los precios de mercado disponibles por tonelada de carbono. Los índices de biodiversidad arrojaron alto porcentaje de sombreado. La concentración total de carbono en la biomasa vegetal fue de 65, 44 t C/ha y el valor económico del secuestro de CO_2 en el Sistema Agroforestal cacaotero fue 2 401,75 USD$/ha.

Palabras clave: Sistema Agroforestal; Biomasa; Secuestro de carbono; Biodiversidad.

Abstract

The work was developed in Jose Maceo UBPC in Baracoa, with the objective of evaluating the estimation of carbon storage in the cocoa Agroforestry System, from 14 plots of 500 m2, calculating the CO2 retained in tons and the estimation directly, with the available market prices per ton of carbon. Biodiversity indices showed a high percentage of shading. The total concentration of carbon in the plant biomass was 65.44 t C/ha and the economic value of CO2 capture in the cocoa agroforestry system was US$2,401.75/ha.

Keywords: Agroforestry system; Biomass; Carbon capture; Biodiversity.

Introduction

Worldwide, it is considered that the loss of biodiversity and the increase in the concentration of carbon dioxide in the atmosphere contribute to global warming and are the most important problems from the environmental point of view, therefore, analyzing the potential of forest systems can contribute to the maintenance of biodiversity and decrease the concentration of atmospheric CO2 according to León (2016), who explains that agroforestry systems in the world are oriented to improve land productivity and at the same time, they are ecologically sustainable, as they can efficiently contribute to the creation of integral production systems that help maintain productivity, protect natural resources, minimize environmental impacts and meet the economic and social needs of farmers.

Due to the complex structure of agroforestry systems (AFSs), which accumulate biomass in all its levels, which translates into greater Carbon sequestration according to Castro's (2017) explanation, where the Carbon content of the accumulated biomass has a conversion factor of 0.5 over the aerial biomass.

Agroforestry systems, by associating woody species with agricultural crops become an economic and ecological option to mitigate climate change, carbon storage, being in correspondence, where the cultivation of cocoa in Guantanamo, combined with different forest species, is considered one of the traditional agricultural products of social and economic importance for generating income to families as stated by Castillo, et al. (2018).

Agro forestry systems in Baracoa do not escape these realities, not meeting the necessary characteristics to achieve sustainability. In this context, the objective of the present work is to determine the estimation of carbon capture in the Agroforestry System of Teobroma cacao L., in Jamal, Baracoa.

Development

The present work was carried out in Los Yacer farm, belonging to José Maceo UBPC in El Jamal, Baracoa municipality in Guantanamo province, from June 2019 to June 2020, in a brown sialytic ochric soil without carbonates, in order to evaluate the floristic composition of the cocoa ecosystem.

A survey of the plots was carried out in the plantations, for which the Standard Ramal 595 of Silvicultural Treatments according to MINAG (1983) was used, applying a simple random sampling without replacement. Fourteen plots of 500 m2 were established, where the different species were evaluated at a distance of 100 m among them.

The diameter of all the trees in each plot was measured at 1.30 m from the ground with a diametric tape; the total height was measured with a ruler graduated in centimeters when it did not exceed three meters and when it was greater, with a Blume Leiss hypsometer (Suunto). Carbon capture in the cocoa agroforestry system was evaluated using the Mercadet and Alvarez (2009) methodology. The data obtained were processed with a file created in Microsoft Office Excel 2010.

The importance value index was determined by the methodology of Keels, et al. (1997), from the sum of relative abundance, relative frequency and relative dominance of each species:

IVIE = AR + FR + DR

Where: RA (Relative Abundance), RF (Relative Frequency), RD (Relative Dominance), RF (Relative Frequency), RD (Relative Dominance), RA (Relative Abundance).

$$RA = \frac{\text{\# of individuals of one species}}{\text{\# total number of individuals of all species}} \times 100$$

$$RF = \frac{\text{\# of plots in which a species occurs}}{\text{Total, of occurrence in all plots}} \times 100$$

$$RD = \frac{\text{Basal area of a species}}{\text{Basal area of all species}} \times 100$$

The volume of tree stems was converted into tons of biomass according to the methodology of Segura (2001):

BMF (t) = volume (m3) x basic density of the species (kg/m3) /1000).

The biomass corresponding to the branches and foliage (aerial biomass) was calculated using the Biomass Expansion Factor whose value is 1.74, leaving: BMA (t) = BMF (t) x FEB (s/u), in addition, root biomass (BMR) was estimated by multiplying the biomass of the stem by the default value 0.3: BMR (t) = 0.3 x BMF (t).

Total biomass (BMT) was calculated as the sum of its components.

BMT (t) = BMF (t) + BMA (t) + BMR (t).

The carbon retained (CR) by species was calculated using the fraction of carbon in wood (FCM) determined for Cuban conditions by Mercadet, et al. (2011), and the carbon retained in total biomass (CRBT), in addition to the fraction of carbon content in wood (FCCM) determined for Cuban conditions:

CRBT (t) = BMT (t) x FCCM

Conversion of the calculated carbon to equivalent carbon (CO2e):

To calculate how much retained carbon represented in tons of CO2 removed from the atmosphere, it was multiplied by 44/12 (3.67 t CO2), which is the ratio existing between the total weight of the CO2 molecule (44) and the carbon atom (12).

The value of carbon capture was estimated directly, based on the available market prices per ton of carbon (C), for which the work of Oliveira (1996) was used as a reference.

Currently, carbon storage rights are traded on the international market at a price of US$0.01 kg C-1 and US$10 T C-1. This price represents the willingness to pay for an environmental benefit, and therefore can be applied to the amount of carbon capture in agroforestry systems.

To evaluate the experimental results, a completely randomized design (CRD) was used, where the agroforestry systems with cocoa constituted the treatments, after determining if there was statistical significance, Fisher's test of means was applied ($p \leq 5\%$).

Data processing was carried out using different statistical packages: Bio Diversity Pro, Microsoft Excel for Windows 2000 was used to create tables, graphs and statistical analysis, and Microsoft Office Word was used to prepare the document. The data were analyzed by regression.

According to the results shown in Figure 1, in the agroforestry system, the species of greatest ecological importance are: Roystonea regia with 59.98%, Samanea saman with 17.56%, Gliricidia sepium with 15.56%, Trema micranthum with 13.51% and Cedrela odorata with 13.38%.

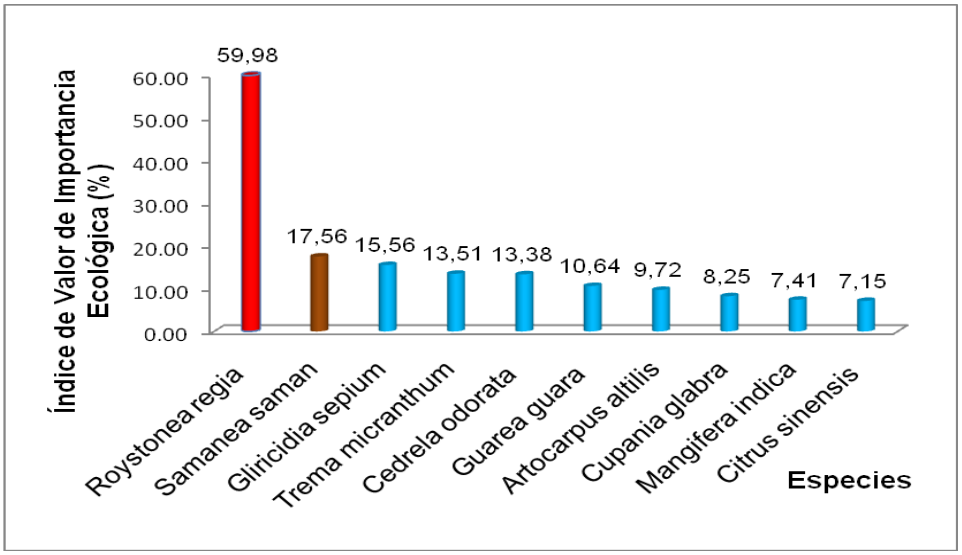

Figure 1. Index of Ecological Importance Value (IVIE) of the SAF.

Source: Own elaboration.

Castillo, et al. (2018) agree with these results, making clear that the species of ecological importance value are those that better correspond to the edaphoclimatic conditions by having a better physiological functioning and allow a higher probability of survival in the short, medium and long term, besides that, they are the ones that better develop in the forest or agroforestry systems: cocoa, coffee, through their horizontal and vertical structure.

They also agree with these values Gavilan and Rubio (2015), making it clear that the species with lower values are given through climatic alterations and population, where many of the threats to biodiversity that occur in the region are given directly or indirectly by exposing to changes in the ecosystem structure.

Among the most abundant species in the agroforestry system, there are some that do not have the characteristics of shade trees: Roystonea regia, Guarea guara, Citrus sinensis, Cupania glabra, Trema micranthum and in the smaller ones they do not have them either, which is because the species must be leguminous, with deep roots, thin leaves to let part of the direct and diffuse radiation into the system to increase the yield of cocoa.

Similar results were reached by Aguirre, et al. (2016), when stating that the evaluation of environmental factors and their impacts on the ecosystem causes degradation in the area, due to the loss of biodiversity that provides ecosystem degradation, further explains, that in agroforestry systems that have adequate characteristic with respect to the study area, where they found that the species Cedrela odorata (L.) is part of this type of ecosystem, being this of local and national commercial value, also allows achieving the function of shading trees to raise the yield of Theobroma cacao.

Áryal, et al. (2014), in studies conducted in two cocoa agroforestry system farms, agree with the results achieved through the woody perennial species found: Gliricidia sepium (J.), recognizing its result not only as shade, but also in the subsequent increase in the availability of nutrients to improve the physical and chemical structure of the soil.

According to the measurement sources, the greatest volume of organic carbon capture is concentrated in the biomass of living trees versus shrub and herbaceous vegetation, at the vegetation level, because they represent the greatest volume of biomass in the measurement sources studied.

The species of the study retain a total of 65.44 t of carbon, standing out in their contribution: Roystonea regia, Samanes samán, Theobroma cacao and Spondias mombin with a retention of 29.02, 14.36, 21.711 and 6.386 t of carbon respectively (Table 1).

All the species evaluated together constitute a carbon store, which in turn allows them to be considered as a conservation and CO2 reduction strategy. In fact, and according to Naire, et al. (2009), in terms of atmospheric CO2 reduction, trees offer the dual benefit of direct carbon capture and reduced CO2 production by fossil fuel power plants. They also function as a sink for atmospheric CO2; therefore, their increase in terms of quantity makes it possible to reduce the concentration of greenhouse gases.

These results validate the universal criterion that forests are natural carbon reservoirs, as defended by Brown (1997), demonstrating the importance of forest species for their contribution to carbon storage, and making it clear that one of the reasons for owning and claiming more trees is that they trap carbon dioxide (CO2), the greenhouse gas with the greatest impact on climate change. Some trees have a greater absorption capacity than others, an important fact when it comes to planting new trees in order to fight global warming.

SAF Cacao	**Carbon Storage**	**Carbon equivalent**	**Value of CO_2/t (USD)**	**CO2 capture marking value**

		(CO_2e)		
	65,4428	240,18	10	2401,75

Table 1. Capture and economic valuation of the carbon stored in the system.

Source: Own elaboration.

The analysis showed an estimate of carbon stored per hectare in the systems resulting in approximately 2,401 dollars (USD) per year. Of this amount, 42.38% was contributed by Theobroma cacao. These economic results, from an environmental perspective, together with the income corresponding to the commercialization of the final product, represent an increase in the value of the FFS.

Based on these results, it is possible to measure and compare the different benefits generated by ecosystems; it can serve as an instrument to demonstrate the importance of the management and administration of natural resources, and it also demonstrates the economic efficiency of their sustainable use by integrating into its analysis benefits that are greater than those perceived in monetary terms. On the other hand, there is a potential to manage and recover areas degraded by poor management.

In addition to the profitability achieved by increased agricultural production, agroforestry systems provide important environmental services, such as moisture conservation, greater soil protection, biodiversity conservation and enrichment, and carbon capture.

It is important to take into consideration the economic result as a fundamental element to achieve a sustainable use of the ecosystem and although the economic valuation is not the instrument to be taken into account for all decisions, it represents one of the aspects involved in the decision making process, together with other important political, social and cultural considerations, in addition, the proposal to introduce trees in the agricultural production systems aims to increase the areas with forest species and reduce the pressure on natural forests for timber and non-timber forest resources; therefore, it is recommended that agroforestry systems be established in agricultural areas without eliminating the original vegetation.

In agroforestry systems developed in cocoa plantations, the economic indicators are more advantageous, since there is a minimization of production costs, because there is a more efficient use of both cultural work and inputs that are applied, as well as space and available resources.

In this sense, agroforestry systems represent a strategy for the generation of environmental services such as carbon sequestration. Agroforestry systems contribute to the generation of environmental services, especially those that include works and technologies for soil conservation and water harvesting, according to Morán, et al. (2014).

It is essential to value all the goods and services provided by PES and it is essential to support projects that provide efficient soil management for sustainable food production and conservation of natural resources, as stated by Oliveira (1996).

These authors also explain that it is necessary to investigate the characteristics and uses of native species, which could play an important role in the productivity and profitability of the systems, for which there is a great variety of potential crops that can be incorporated with an adequate topological arrangement.

Conclusions

Biodiversity indices showed a high percentage of shading with suitable species in the cocoa agroforestry system. The total concentration of carbon in the plant biomass of the study area shows a high potential for carbon stocks.

The cocoa agroforestry system has an economic income based on CO2 sequestration, which is favorable for the ecosystem.

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