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Assessing the carbon sequestration potential of *Cocos nucifera* (coconut) in a hortipasture based agroforestry system

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Abstract

Cocos nucifera (Coconut) is a major plantation crop with carbon-capturing potential along with the added benefit of intercropping. The present study was carried out to assess the carbon sequestration capacity of 22 years old *Cocos nucifera* based hortipasture. The average biomass yield accumulated in 22 years old *Cocos nucifera* trees ranges from 76.6 kg/tree to the maximum of 122.8 kg/tree. The carbon accumulation is 50 % of its biomass which ranges from 38.31 to the maximum of 61.4 kg/tree. At the present system of coconut farming with better management strategies and with suitable intercropping the coconut plantations can be effectively considered as a potential C sequestration source to mitigate the climate change problems.

Keywords: *Cocos nucifera*, carbon sequestration, agroforestry, hortipasture, biomass accumulation, carbon stock, intercropping, climate change mitigation

Introduction

Human activities, such as burning fossil fuels (coal, oil and gas), cement production and other practices (crop residue burning, deforestation, and excessive fertilizer use) has significantly increased greenhouse gas emissions. Carbon dioxide, nitrous oxide, methane and other greenhouse gases have raised global temperature by 1°C since pre-industrial times, intensifying the greenhouse effect (Davis *et.al.*, 2010) [6]. Carbon management is a global concern to lower the increasing amount of greenhouse gases in the atmosphere especially in forest ecosystem (Ashaq Ahmad Daret *et.al.*, 2026, Wani, 2019) [3, 20]. One of the main goals of international policy is to restore forest cover and find low-cost carbon trapping methods (Shively *et. al.*, 2004) [13]. In India, agroforestry system cover 28.03 M ha (Ahmad *et.al.*, 2021) [1], serving as significant carbon sinks. Different species and regions have different capacities for storing carbon in agroforestry (Meragiaw, 2017) [9].

Tree based intercropping system is one of the best options to sink carbon and nourish the people who depends on land for livelihood, by way of integrating food production with environmental services (Soto-Pinto *et.al.*, 2010) [16]. We need to capture carbon through suitable crop substitutes for intensive cropping because intensive cropping system and agroforestry (Montagnini and Nair, 2004) [10] promote sustainable land use. Coconut is one of the main plantation crops dependent on 12 million people across the country that can be used to capture carbon with various intercrops. (Namitha *et.al.*, 2025) [11]

Carbon sequestration again depends on environmental, socio-economical and age of the trees. The carbon storage capacity would varies across species and geography also. Further the amount of carbon in any agroforestry system depends on the structural and functional units of different components with in the systems put into practice. In general hortipasture system has the potential to sequester over 70Mg/ha in the top 20 cm of the soil. There is also clear evidence to suggest that, the type of agroforestry system greatly influences the source or sink role of the trees.

Coconut are one such major plantation crop with carbon-capturing potential along with the added benefit of intercropping. Coconut varieties differ in their ability for carbon sequestration. The carbon stock was significantly the highest in East Coast Tall (27.32 t ha⁻¹) followed by hybrid WCT x GBGD (27.01 t ha⁻¹). The lowest carbon stock were observed in coconut hybrid MYD x ECT (Ghavaleet. *al.*, 2020) [7]. This is attributed to the highest plant girth and plant height among the different hybrids and varieties. Therefore, the present study was carried out to assess the carbon sequestration capacity of 22 years old coconut trees under degraded wastelands of hortipasture system.

Materials and Methods

The present study was carried out in the existing hortipasture system where in which 22 years old *Cocos nucifera* (Local tall variety) trees were maintained. To assess biomass and carbon allocation in the existing twenty two year old coconut in hortipasture system. Individual tree height and girth was measured at chest height. Carbon sequestration was calculated by non-destructive method. For the experimental purpose, 22 years old Coconut trees need to be replaced to assess the system effect of hortipasture on the crop components preciously which are understoreyed.

Documentation of biomass and carbon allocation in *cocos nucifera*

Carbon sequestration takes place in plants when they photosynthesize CO₂ from the atmosphere into biomass, which means that it accumulates in “sinks” rather than being released into the Earth’s atmosphere. They can also augment the soil with carbon by adding organic waste, especially dead and rotting root tissue, root exudates, *etc.*

The amount of carbon stored was estimated in coconut trees equals 50 per cent of its dry biomass. Where as to assess the tree carbon sequestration in coconut, non-destructive method was followed.

Step 1

Calculating Above ground biomass (AGB) by the method suggested by Anusha Maitreya *et.al.*, (2023) [2]

Above Ground Biomass (AGB) (kg/tree) = Volume X Wood density.

Where standard average value of wood density is 0.6 kg/cm³ was used to calculate AGB (Anusha Maitreya *et.al.*, 2023) [2].

Volume of the tree is calculated by using the formula as follows

$V = \pi r^2 h$. Where (V = volume, r² = Radius, h = height) in cm³

Step 2

Calculating Below ground biomass (BGB) suggested by Ravindranath and Ostwald, (2008) [12]

Below Ground Biomass (BGB) (kg/tree) = AGB (kg/tree) x 0.26. Further total biomass and total carbon is calculated by the following method.

Root shoot ratio is 0.26

Total biomass = AGB+BGB

Total carbon = Total biomass x 50%

The data were subjected to analysis of variance as a factorial randomized block design using the General Linear Model procedure of SPSS and means were compared for statistical significance by Duncan’s multiple range tests (Snedecor and Cochran, 1994) [15].

Result and discussion

The biomass and carbon distribution in Above Ground Biomass (AGB) of *Cocos nucifera* in the twenty two year-old hortipasture system was described in Table 1. Twenty two year-old *Cocos nucifera* had above ground biomass of 86.95 kg tree⁻¹ and a tree volume was 144.9 kg m⁻³. The mean diameter at breast height (DBH) of the twenty two year-old *Cocos nucifera* was 28.74 cm. From the above parameter, total biomass of the twenty two year-old *Cocos nucifera* was computed and presented in Table 2. The above ground components of coconut were contributed 86.95% and below ground components were contributed 22.60 % biomass to the total biomass. A total of 13.69 t C ha⁻¹ was stored in the twenty two year-old *Cocos nucifera*. A total of 86.95% carbon was allocated in the above ground components whereas nearly 22.60 % carbon was allocated in the below ground components of the trees.

The absence of data on biomass compartmentation and carbon allocation in various species has made it challenging to evaluate the potential for carbon storage. Only the above-ground biomass potentials of the majority of species utilized but the below-ground biomass pattern is also crucial to understanding the species capacity to store carbon. In addition to sequestering for about 14 tha⁻¹ of carbon, the highly commercial *Cocos nucifera* tree yields a profit of about 2 lakh per hectare per annum. Since *Cocos nucifera* below-ground biomass is 22.60%, we should take the tree BGM into account and figure out how to increase carbon storage.

Although the AGB by itself was the biggest carbon storage facility, the roots and litter of the tree species are crucial for sequestering carbon in the soil reservoir. AGM carbon must be locked up in post-harvest products for a longer time, depending on its intended use. Similar results were obtained by Singh and Lodhiyal (2009) [14].

Table 1: Carbon sequestration in the above ground biomass of *Cocos nucifera* based hortipasture system

S.No	Height of the tree (m)	Diameter of the tree(cm)	Radius of the tree(cm)	Volume (kg/m ³)	AGB (kg/tree)
1	18	32.20	16.10	146.5	87.90
2	20	25.42	12.71	101.3	60.77
3	24	29.20	14.60	160.6	96.38
4	23	30.00	15.00	162.5	97.50
5	24	26.40	13.20	131.3	78.78
6	25	29.24	14.62	167.3	100.4
Mean					86.955

Table 2: Total carbon sequestration in *Cocos nucifera* based hortipasture system

S.No	AGB (kg/tree)	Root shoot ratio	BGB (kg/tree)	Total biomass (kg/tree)	Total carbon (kg/tree)
1	87.90	0.26	22.85	110.8	55.40
2	60.77		15.80	76.60	38.31
3	96.38		25.06	121.4	60.70
4	97.50		25.35	122.8	61.40
5	78.78		20.48	99.30	49.61
6	100.40		26.10	126.5	63.32

Cocos nucifera cropping systems would mimic a forest, thus they play an important role in environment protection by way of fixing the carbon (Bhagya *et.al.*, 2017) [4]. Thomas (2016) [18] suggested that planting certain crops, such as coconuts, can combat the effects of climate change along with carbon sequestration. Maheswarappa (2008) [8] reported that 98.2 t of carbon sequestration in well maintained coconut monoculture.

Soil carbon storage is an indicator of the carbon sequestration potential of the soil. Since BGB contributes nearly 22 % of carbon sequestered, soil storage is very much considerate. In the rhizosphere soil of a multi-storeyed cropping system of coconut, organic compounds like amino acid, phenol and total sugar content were significantly higher when compared to mono crop (Bopaiah and Shetty, 1991) [5]. Sudha and George (2011) [17] reported that coconut + pineapple maintained the highest organic carbon content (1.30%) in soil, whereas maize intercropped in coconut maintained only 1.21 per cent soil organic carbon. This helps to choose a better crop combination for higher carbon stock in a coconut plantation.

Conclusion

Planting coconut trees is one of the cost effective and durable ways to overcome the current increase in atmospheric carbon dioxide. Due to its high Gross Primary Productivity (GPP) and Net Primary Productivity (NPP), the coconut tree directs majority of its photosynthetic output towards its leaves, fruits, peduncle and fine roots. The average biomass yield accumulated in different trees ranges from 76.6 kg/tree to the maximum of 122.8 kg/tree. The carbon accumulation is 50 % of its biomass which ranges from 38.31 to the maximum of 61.4 kg/tree. Apart from providing the biological yield, it fixes the carbon which helps to safeguard the environment by way of reducing the carbon di oxide gas emission. High carbon content soils are more fertile, leading to increased agricultural productivity and better water retention capacity. Carbon sequestration also play a crucial role in climate mitigation. Hence, at the present system of coconut farming with better management strategies and with suitable intercropping the coconut plantations can be effectively considered as a potential C sequestration source to mitigate the climate change problems.

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