REVIEW ARTICLE Agricultural Reviews, Volume 46 Issue 1: 143-146 (February 2025)

Carbon Sequestration Potential in Coconut based Cropping System: A Review

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10.18805/ag.R-2553

ABSTRACT

Carbon sequestration plays a significant part in alleviating climate change by changing over climatic carbon as plant biomass and soil organic carbon. Since trees can hold greater carbon in their biomass than other plant types, perennial plantations have a vital function in mitigating the adversities in climate. Coconut is a perennial palm with a life time of around 50-60 years has the capability to store carbon for a long time, especially in the stem. Due to the increased availability of space and solar radiation reaching the understorey, the carbon sequestration capacity of coconut plantations can be considerably increased. As a result, intercropping or agroforestry in coconut lands is important not only for food and economic security but also for carbon sequestration. On an average carbon sequestration potential of coconut trees range between 37 kg tree^{-1} yr^{-1} (dwarf variety) up to 56 kg tree^{-1}yr^{-1} (tall variety). After 20 years of establishment, monoculture coconut land can be transformed into perennial mixed cropping or agroforestry system that can sequester more carbon.

Key words: Carbon sequestration, Carbon dioxide, Climate, Coconut.

Climate emergency is certainly considered as one of the most important demanding situations of our time. Human activities, burning of fossil fuels including coal, oil and gas, cement production and other practices (burning of crop resides, deforestation and enormous use of fertilizers) have engendered considerable upsurge in the amount of greenhouse gases. Carbon dioxide, nitrous oxide, methane and other greenhouse gas emissions have elevated global temperatures by 1°C on account of pre-business times, booming the greenhouse effect (Davis *et al.,* 2010). The two decisive activities that apply to setback the global CO_2 level are; to lessen the human emissions of CO_2 or to enhance carbon sequestration in the ecosystem, fostering land-use practices like intensive cropping system and agroforestry (Montagnini and Nair, 2004). In India, a total of 28.03 Mha is covered by different agroforestry systems (Ahmad *et al*., 2021). They can act as an excellent sink for carbon. India contributes 7 per cent of the global CO_2 emission and rank third position in the world. Under this increased level of CO_2 in the atmosphere, we need to capture carbon through suitable crop substitutes for intensive cropping. Coconut is one of the main plantation crops dependent on 12 million people across the country that can be used to capture carbon with the added benefits of intercropping.

Carbon sequestration is the process that removes surplus carbon from the ecosystem and hoarding it in a reservoir (UNFCCC, 2007). It is a method of capturing and storing atmospheric carbon dioxide over lengthy periods of time in order to mitigate weather change.

Coconut- The versatile palm

Coconut (*Cocos nucifera* L.) is a long lived palm with assorted uses. In ancient Indian literature it is known as "KalpaVriksha", which means "tree that provides all the necessities of life". In other parts of the world it is also called the "tree of wealth" or "tree of life". Coconut has many uses, provides food, oil, fuel, timber and decorative aesthetics to millions.

In India, coconut is cultivated in 18 states and 3 union territories. More than 90 per cent of the area is in Kerala, Karnataka, Tamil Nadu and Andhra Pradesh. Kerala ranks first in area (0.76 Mha) and production of 7683 million nuts of coconut; however Andhra Pradesh stands first in productivity and Kerala ranks fifth (CDB, 2018). Even though the area under coconut cultivation is high in Kerala, the productivity is low. So that the productivity needs to be enhanced through better management practices. Improved management practices and adoption of intercropping/ high density multispecies cropping system in coconut garden helps for increased carbon storage in the biomass

Coconut-A potential sink for carbon

Not all vegetation sequester carbon equally. Most of the carbon that is captured from the atmosphere by annual is

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How to cite this article: Namitha, V.V., Raj, S.K. and Prathapan, K. (2025). Carbon Sequestration Potential in Coconut Based Cropping System: A Review. Agricultural Reviews. 46(1): 143-146. doi: 10.18805/ag.R-2553.

Submitted: 30-05-2022 **Accepted:** 15-10-2022 **Online:** 07-11-2022

either re-released during harvest or degraded. According to Ranasinghe and Silva (2007), coconut has an economic life span of 50-60 years that has the potential to act as a carbon sink. They do not require much soil disturbance and last for many years, which mean they are preeminent to safeguard the soil carbon than many other plants. The coconut has a carbon storage capacity of 24.1 t C ha^{-1}. It is also considered to be the most stable carbon store as it is a perennial plant that burns almost no residues on the farm compared to other crops such as rice and sugarcane. Bhagya *et al*. (2017) noted that coconut monoculture could provide 102.27 t ha^{-1} of above ground biomass and 51.14 t ha^{-1} carbon stocks, so that coconut cropping systems would mimic a forest, thus they play an important role in environment protection (Bhagya *et al*., 2017). Thomas (2016) suggested that planting certain crops, such as coconuts, can combat the effects of climate change. Maheswarappa (2008) reported that a total of 138.91 t of carbon (above ground plus underground carbon storage per hectare) were sequestered when coconut with mango was planted compared to sequestration in monoculture of 98.2 t of carbon.

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 × GBGD (27.01 t ha^{-1}). The lowest carbon stock were observed in coconut hybrid MYD × ECT (Ghavale *et al*., 2020). This is attributed to the highest plant girth and plant height among the different hybrids and varieties.

How carbon is sequestered?

Carbon sequestration takes place in plants when they photosynthesize CO_2 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 in a tree equals 50 per cent of its dry biomass.

Carbon stock= Biomass × 0.5 (Pearson *et al*., 2005).

Above ground carbon sequestration in coconut (Kumar *et al.,* 2008)

Stem dry weight (SDW) (kg)= Height × $(Girth)^2$ × 41.14.

Carbon stock (kg $palm^{-1}$)= SDW × 0.5 (50% of wood biomass is considered as the carbon stored).

CO_2 (t ha^{-1})= C (t ha^{-1}) × 3.67

Soil carbon stock (Srinivasan *et al.,* 2012)

$$\text{Carbon stock} = BD \times OC \times Depth \times Area$$

Where,

BD- Bulk density of soil.

OC- Organic Carbon of soil.

The rate of photosynthesis is limited by the atmospheric CO_2 level in almost all plants with C3 photosynthetic pathway including coconut. Higher the CO_2 level, greater the photosynthetic production. In an experiment conducted by Hebbar and Chaturvedi (2015) in open top chamber (OTC), reported increased coconut seedlings growth and biomass at elevated CO_2 level. At 550 and 700 ppm CO_2, the biomass increased by 8 per cent and 25 per cent respectively, against ambient CO_2 concentration of 380 ppm (Table 1). This is due to the maintenance of membrane stability with increased activity of superoxide dismutase, catalase and peroxidase.

Cropping system and carbon sequestration

The carbon sequestration potential of coconut varies with intercropping system. Kumar and Maheswarappa (2019) carried out a study to investigate the carbon stores above the soil of coconut-based cropping systems with vegetable crops (M1: Okra -fallow, M2: Green manure-Cucumber, M3: Babycorn-Gherkin, Control: Coconut monocropping) in Hassan, Karnataka. Carbon sequestration by coconut was enhanced under intercropping. In monocultures, it was 12.18 t C ha^{-1} and in intermediate crops it was 13.12 t C ha^{-1}. It is mainly attributed to the increase in the palm's biomass, such as the number of functional leaves and the height of the palm. A field experiment was conducted by Bhagya *et al*. (2017) in coconut garden (50 years) intercropped with several fruit crops (5 years). Among these, coconut (*Cocos nucifera*) + Jamun (*Syzygium cumini*) stored significantly higher amount of above ground carbon (60.93 C t ha^{-1}), while the coconut monocropping had sequestered only 51.14 C t ha^{-1}. The underground storage of carbon (60 cm deep rhizosphere) was significantly the highest in coconut+ mango system (82.47 C t ha^{-1}) followed by Jamun and Garcinia intercropped in coconut. The lowest was reported in coconut monoculture (47.06 C t ha^{-1}). The correct stage of density and harvest interval of intercrops are also important to maximize carbon sequestration potential. Joy *et al.* (2018) reported that intercropping of Calliandra in coconut plantation with a tree density of 27,777 trees ha^{-1} and the forage harvest at an interval of 12 weeks showed a maximum yield of dry forage and total carbon content.

Soil carbon storage is an indicator of the carbon sequestration potential of the soil. The root exudates from coconut are rich in sugars, aminoacids, natural acids, phenols, vitamins and other organic compounds. In the rhizosphere soil of a multi-storeyed cropping system of coconut, organic compounds like aminoacid, phenol and total sugar content were significantly higher when compared

Table 1: Performance of coconut seedling in OTC with variable CO_2 level.

Climate variable	Root length (cm)	Volume (cm^3)	Root weight (kg)	Stem weight (kg)	Leaf weight (kg)	Biomass (kg)
Ambient 380 ppm CO_2	94	752	0.218	0.406	0.398	1.022
500 ppm CO_2	98	875	0.27	0.446	0.433	1.126
700 ppm CO_2	105	992	0.269	0.487	0.460	1.216

Table 2: Comparison between multistoreyed and monocropping system in total sugar, reducing sugar, amino acid and phenol content of the soil.

Cropping system	Total sugar (µg /g)	Reducing sugar (µg /g)	Amino acids (µg /g)	Phenols (µg /g)
Multistoreyed	27.59±2.39	4.19±0.38	1.47±0.38	0.24±0.08
Monocropping	20.08±1.89	4.65±0.58	1.24±0.18	0.12±0.04
CD (p=0.05)	7.57	1.66	0.90	0.19

to monocrop (Bopaiah and Shetty, 1991) (Table 2). The organic compounds can affect the root zone microbiota and thus enhance the organic carbon content of the soil. Thomas (2003) has confirmed the same assumption and found that organic carbon was more under coconut based multitier system than the monocropping. Sudha and George (2011) 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.

Homestead-potential sink for atmospheric Co_2

Coconut cultivation plays an important role in Kerala's agricultural economy. In Kerala, homestead farming systems form a common land use practice and coconut is the main crop in homestead farming systems. While most agroforestry systems have a high potential for carbon sequestration, home gardens are unique in this regard. Home garden can capture carbon in biomass and soil and thus helps to scale down fossil fuel combustion by stimulating the use of firewood and preserving agricultural biodiversity (Kumar and Nair, 2004). This helps to conserve natural forests by reducing the pressure on these areas (Kumar, 2006). In addition, there is no complete removal of biomass from homesteads, which means that the system is permanent. Roshetko *et al*. (2002) conducted studies on the carbon sequestration potential of 19 homegardens (12 to 17 years) and reported that 89 per cent of home gardens grow coconuts and the rest grows bananas, mangoes, cocoa, coffee, *etc*. The homegardens had 35 t C ha^{-1} (48 times higher) when compared to Imperata-cassava systems and 21 t C ha^{-1} (1.5 times higher) than young rubber agro forests. A survey conducted by Dey *et al*. (2014) to study the contribution of palm species to carbon sequestration in Bangladesh home garden revealed the highest carbon content in coconut (12.48 t ha^{-1}), followed by Arecanut (4.20 t ha^{-1}), *Borassus flabellifer* (3.02 t ha^{-1}) and *Phoenix sylvestris* (0.59 t ha^{-1}).The homestead was able to store a total of 20.28 t Cha^{-1}.

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. Most of these are perishable and are decomposed by microbes to convert them into soil organic matter. Coconut plantation could act like a tropical evergreen broad leaf forest, which has got high potential to sequester carbon. 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.

Conflict of interest

All authors declare that they have no conflict of interest.

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