

Original Research Article

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## Carbon Sequestration Potential in Oil Palm-Cocoa Cropping System Grown in Andhra Pradesh under Irrigated Conditions

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### ABSTRACT

#### Keywords

Carbon stock, Sequestration, Oil palm, Cocoa and biomass

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A study was carried out in an adult Oil Palm (*Elaeis guineensis*) plantation intercropped with cocoa (*Theobroma cocoa*) grown in sandy loam soil to study the effect of cropping system on above ground carbon sequestration. Non-destructive method for calculating standing biomass of oil palm and cocoa were used. Based on this biomass data carbon stock and CO<sub>2</sub> sequestered from the system were estimated. The standing biomass of Oil Palm, Cocoa and Oil Palm with Cocoa were 95.33 t.ha<sup>-1</sup>, 59.96 t.ha<sup>-1</sup> and 155.29 t.ha<sup>-1</sup>, respectively, while the carbon stock of oil palm, cocoa and oil palm with cocoa were in order of 47.66 t.ha<sup>-1</sup>, 29.98 t.ha<sup>-1</sup> and 77.64 t.ha<sup>-1</sup> and the CO<sub>2</sub> sequestration of oil palm, cocoa and oil palm + cocoa intercropped system were 174.93 t.ha<sup>-1</sup>, 110.02 t.ha<sup>-1</sup> and 284.95 t.ha<sup>-1</sup> respectively. Based on these results, Cocoa could be an ideal intercrop in adult oil palm plantation for enhanced CO<sub>2</sub> sequestration in the system.

### Introduction

Oil palm (*Elaeis guineensis* Jacq.) is perennial vegetable oil yielding crop and it is having a potential of yielding 4-6 t.ha<sup>-1</sup> oil. In oil palm plantation, interspace will be more and it could be effectively used for cropping system for sustainability in oil palm.

Cocoa is the best suited crop and almost all the oil palm growing farmers in Andhra Pradesh are adopting this system in an area of 5000 ha. Forests, cultivated lands and grass lands are source of carbon sequestration apart from soil. Capturing of atmospheric carbon and storing it in the terrestrial biosphere is one

of the options, which have been proposed as a mitigation option for greenhouse gas reduction (GHG) reduction. In united Nations Framework Convention on Climate change (UNFCCC) clean development mechanism, agroforestry (Annon, 2017; Albrecht and Kandji, 2003; Montagnini and Nair, 2004), forestation and reforestation (Shrestha *et al.*, 2005) are designated for carbon trade.

Thus agroforestry as a land use system is receiving wider recognition not only in terms of agriculture sustainability but also in the perspective of climate change. Efforts are on to include some other perennial systems like plantation crops into this mechanism. Once

these systems are approved for carbon trade, one can expect large demand for plantation crop systems in terms of information on carbon sequestration potential and sustainable productivity. Oil palm cocoa mixed crop not only gives a sustainable production, but also serve as a good system for biomass production and carbon accumulation. Agro forestry system of cocoa with shade trees have been reported to be good examples of biomass production in Costa Rica (Beer *et al.*, 1990).

Oil palm is grown either as monocrop or intercropped with other plantation crops like cocoa, lemon, etc., whereas, cocoa is grown only as an intercrop of either coconut or Arecanut or oil palm. These crops provide shade for under-storied cocoa, forming a considerable amount of land use system that provides sustenance to oil palm growers. Demand for the cocoa is ever increasing in India and also at global level, making this plantation crop more remunerative. On the other hand, oil palm is being consumed as edible oil and also bakery product preparation in India. However, the income levels of farmers are highly fluctuating owing to market dynamics. These suggest the importance of stable income from oil palm – cocoa plantation system. Exploiting carbon sequestration potential of this system is important not only for augmented income, but also for mitigating GHG emissions in the perspective of climate change.

With this view, this study on carbon sequestration was taken up in oil palm cocoa cropping system. In this paper, use of models to calculate biomass, the net primary productivity in terms of biomass production and carbon stock and CO<sub>2</sub> sequestration in the system are discussed. The objective of this paper is to analyze carbon sequestration and storage in oil palm-cocoa agroforestry system and discuss the role they can play in reducing the concentration of CO<sub>2</sub> in the atmosphere.

## Materials and Methods

A field study was carried out in an adult oil palm (*Elaeis guineensis* Jacq.) – cocoa (*Theobroma cocoa*) cropping system grown in sandy loam soil of west Godavari district, Andhra Pradesh and planted in 9 m triangular spacing with 143 palms/hectare and cocoa were planted in between palm rows at a spacing of 7.65 x7.65 m which could accommodate 170 plants/ha. Ten replications were used in the study. Standard agronomic package of practices were followed. Biometric observations like height (m) of palm up to crown from the base were taken by marked aluminium pole and canopy area (m<sup>2</sup>) of cocoa was measured in two directions of canopy spread (East-West and North –South) and average of these two directions were considering for biomass calculation of cocoa, stem girth (cm) of cocoa at 50 cm height from the base, stem height (m) of cocoa upto base of crown from the base were taken. Non-destructive methods in the form of regression model were followed for calculating above ground biomass of oil palm and cocoa.

The standing biomass of cocoa is calculated as per Balakrishna and Nair (1989).

$$\text{Total dry weight} = -8.41 + 0.47 \text{CA} + 0.28\text{SG} + 2.69\text{SH}$$

Where, CA-Canopy area (m<sup>2</sup>), SG- Stem girth (cm), SH- Stem height (m) upto base of crown

The standing biomass of oil palm is calculated as per regression model (Khalid *et al.*, 1999)

$$W = 725 + 197H \text{ ----- (1)}$$

Where, W- Total fresh weight (kg), H- Height (m), Fresh to dry weight=  $W \times 0.27$

Based on biomass obtained from the non-destructive methods, carbon stocks and CO<sub>2</sub>

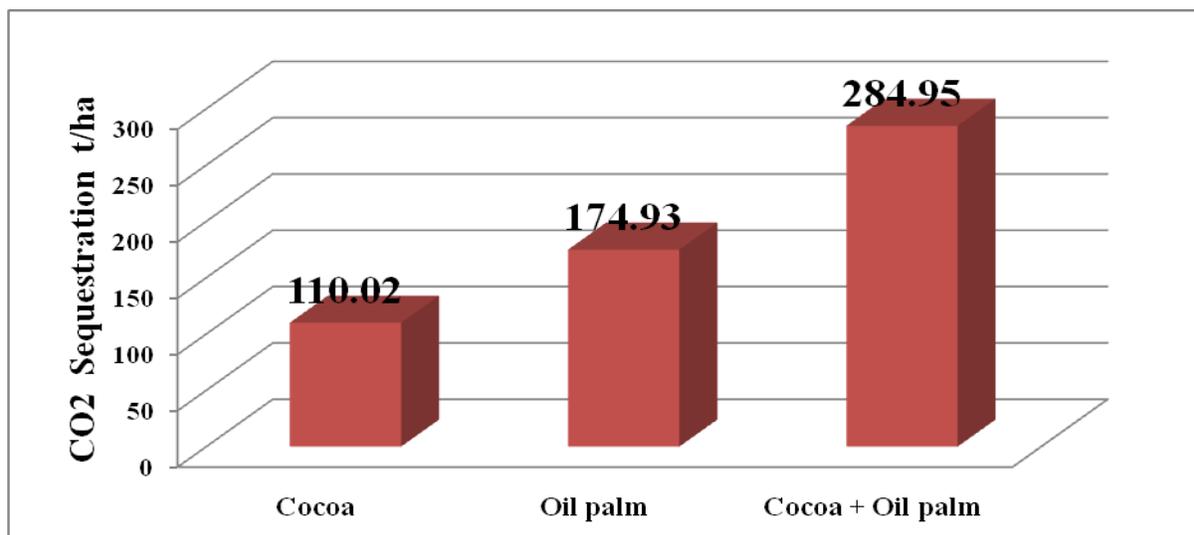
sequestered from the system was estimated. The biomass to carbon stock conversion factor was 0.5 as per IPCC, 2003. The CO<sub>2</sub> sequestration was calculated by using a factor of 3.67 as per Balakrishna, 2011. Statistical analyses were performed using Statistical Analysis System 9.3 computer software (SAS Institute Inc., 13).

### Results and Discussion

Oil palm- cocoa is known to be an ideal cropping system as cocoa effectively utilizes the space and add lots of biomass to the system. As shown in table 1, the standing biomass of cocoa was 59.96 t/ha with carbon stock of 29.98 t/ha and it sequestered 110.02 t/ha CO<sub>2</sub> from the atmosphere. In Arecanut plantation estimated standing biomass of cocoa has been about 3 t/ha in third year of field plantation to about 27 t/ha by the time plantation attained 15 years age after field planting (Balasimha, 2011). Cocoa with oil palm plantation possesses more carbon stock as compared to cocoa with arecanut plantation due to the variation in planting density. In standing biomass of oil palm was 95.33t/ha with 47.66 t/ha carbon stock and CO<sub>2</sub> sequestration of 174.93 t/ha. Similar results in

oil palm above ground biomass ranging from 25 t C/ha to over 50 tC/ha has been recorded by Germer and Sauereborn (2008); Khalid *et al.*, 1999 found 85.3 t biomass (42.65 Ct/ha) with 136 palms per hectare. These results were closely related with Corley *et al.*, (1971) and Suresh and Kiran Kumar (2011). As shown in Figure 1 oil palm cocoa cropping system recorded highest biomass 155.29 t/ha with 77.64 t/ha C stock and 284.95 t/ha C-sequestration. Studies by Sohrabi *et al.*, 2016 reported more carbon storage in above ground than below ground other plantation crops. The higher carbon storage in above ground components in Elder pine (*Pinus eldarica*) is 50.62 Mg/hm<sup>2</sup> followed by Arizona cypress (25.72 Mg/hm<sup>2</sup>). Bhagya *et al.*, 2017 reported that coconut based fruit cropping system (50 year coconut with 7 year old fruit crops) with above ground carbon storage *viz.* Coconut + Jamun (60.93 t/ha), coconut + mango (56.45 t/ha), coconut + Garcinia (53.02 t/ha) and coconut monocropping (51.14 t/ha). Oil palm with cocoa sequestered more carbon stock compared to that of coconut and fruit cropping systems which might be due to contribution of more carbon stock by cocoa in the oil palm cocoa cropping system.

**Fig.1** Oil palm based cocoa cropping system CO<sub>2</sub> sequestration t/ha



**Table.1** Estimated biomass, C stock and CO<sub>2</sub> sequestered (t/ha) in oil palm, cocoa and oil palm + cocoa cropping system

| Treatments       | Biomass (t/ha) | Carbon stock (t/ha) | CO <sub>2</sub> sequestered (t/ha) |
|------------------|----------------|---------------------|------------------------------------|
| Cocoa            | 59.96          | 29.98               | 110.02                             |
| Oil palm         | 95.33          | 47.66               | 174.93                             |
| Cocoa + Oil palm | 155.29         | 77.64               | 284.95                             |
| CV (%)           | 5.55           | 5.55                | 5.55                               |
| SE (d)           | 2.57           | 1.29                | 4.71                               |
| LSD at 5 %       | 5.4            | 2.7                 | 9.9                                |

To conclude, cocoa could be an ideal intercrop in oil palm- cocoa based cropping system as it could sequester more carbon than sole oil palm crop.

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