Eco. Env. & Cons. 29 (1) : 2023; pp. (96-101)

ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2023.v29i01.014

Oil Palm Plantation: Carbon Sequestration Potential and Effective carbon Management within Serchhip, Mizoram, India

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(Received 2 July, 2022; Accepted 25 September, 2022)

ABSTRACT

Sustainable management of crop plantations to sequester more carbon is a timely strategy to reduce greenhouse gases, as these have been considered to be potent measures for mitigation of climate change. Oil palm (*Elaeis guineensis*) is a proven carbon-sequestering perennial crop by biological means, aiding in the mitigation of global warming and climatic fluctuations. The present study was carried out in Serchhip, Mizoram, India from 5th February to 30th March 2021. All major palm plantation sites located within Serchhip were determined in the study. The carbon store was determined from sample plants of three, six, eight, and ten years. This research adopts a destructive approach to estimate the amount of carbon storage. The investigator surveyed the number of trees and the age of the palm trees with the help of farmers. The results indicates that the trunk stores the largest amount of carbon when compared with other plant parts. However, in a three-year plantation, the fronds store more carbon than the trunk. The study reveals that the amount of carbon sequestered by four, six, eight, and ten-year palm trees were 0.045 t, 0.098 t, 0.276 t and 0.539 t respectively. The total sample surveyed was 1015 standing trees from eight locations, and the carbon stock potential accounting all plantations site within Serchhip was estimated to be 345.1 t/yr. Recently, many farmers are planning of giving up oil palm farming and are likely to replace their oil palm fields with other crops. Uprooting, slashing, and burning is the common practice adopted to clear palm trees, which is believed detrimentally to emit tonnes of carbon into the atmosphere. Therefore, the study will be very helpful in decision-making and, consequently selecting a wiser choice for climate change mitigation within Serchhip and, to a larger extent, Mizoram.

Keywords *: Oil palm, Climate, Carbon sequestration, Serchhip, Atmosphere, Carbon*

Introduction

The carbon concentration in our atmosphere has been found to increase year after year, rising from 270 ppm before the industrial revolution to about 394 ppm in December 2012 (Manua Loa observatory, 2013). The global average atmospheric carbon dioxide in 2020 was further increased to 412.5 ppm, setting a new record high. A steady increase was still recorded at 416.45ppm in 2021, despite the economic slowdown due to the COVID-19 pandemic. Therefore, today's atmospheric carbon management is very crucial. Trees are an important source of carbon storage as they help in sequestering carbon from the environment. The amount of carbon stored in trees may vary depending on species, type of climate, age of the trees, environment, and vegetation of surrounding trees. Tree plantations in nearby towns and cities may act as a good source of carbon pool and, furthermore, a good potential to absorb and store carbon. Management of dead trees and leaves is actually important for sustainably maintaining a good carbon level in the atmosphere. Strategic management of forest resources to sequester CO_2 is a needed plan to reduce greenhouse gases. These have been considered an effective measures for mitigation of current climate change. The tropical forest is a huge reservoir of carbon, storing half of carbon in the world's forests.

Oil palm is presently one of the most valuable cash crops in the world. It is a highly versatile crop that can be processed into a variety of products. On a global scale, oil palm has been largely grown in Malaysia and Indonesia. Despite the fact that only 143 palm tree plantations are ideal on one hectare of land, it is one of the highest biomass and oil yielding plants per unit area among oilseed crops. Oil palm fields in India cover up to 0.35 million ha in 16 states, including Andhra Pradesh, Karnataka, Tamil Nadu, and Kerala (Ministry of Agriculture and Farmerswelfare, 2019).

Oil palm plantations are threatening Mizoram's forest cover, which covers 21081 sq.km. Mizoram has 25,923 ha of palm plantation as of 2017 (Department of Agriculture, 2017). The plantation began in Mizoram on 2005, and Serchhip is the covered districts under Mizoram Oil Palm act, 2004. Serchhip district is one of the most promising districts after Kolasib and Mamitdistrict, with a potential covered land area of 1868 ha. Serchhip is popular in agriculture, particularly in the production of vegetables and seasonal crops. Most commercial crops cultivations are confine to the plains and gentle slope region of Serchhip zawlpui, a region irrigated by the Mat River.

Beginning in 2010, oil palms were commercially cultivated by farmers in Serchhip. The plantation was considered to be profitable until 3F business, the sole Fresh Fruit Bunch (FFB) buyer within the district, pulled out. As a result, farmers in Serchhip have to sell their gathered FFB at the same rate to the Godrej enterprise, located in Bukvannei of Kolasib district. This mill is 250 kilometres away from Serchhip. Moreover, there has not been a price increase since 2014, which still remains constant at 5.50INR. As a consequences, many farmer have given up and decided to uproot palm trees from their field and replace them with other cash crops such as rubber trees or vegetable crops. The leftover palm residues are often burned before other crops are introduced. This is believed to emit tonnes of carbon to the atmosphere. Palms as a cash crop are also a significant source of carbon sink and therefore management of palm resources to maximise atmospheric carbon emission is crucial. Changing land use and replacing existing plantations practices often result in an increased carbon concentration in the environment. The purpose of the study is to measure the amount of carbon stored in different ages of *Elaeisguineensis* and further estimate the amount of carbon sequestered by standing oil palm trees within Serchhip.

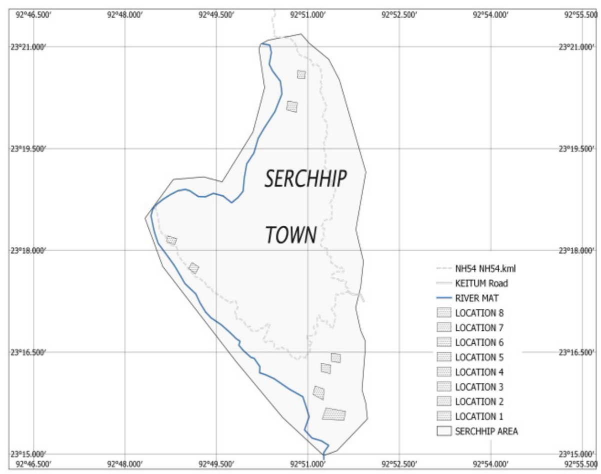

Fig. 1. Location of the study site

Materials and Methods

Researchers have estimated the above-ground and below-ground carbon stock of oil palm trees using allometric equations and other non-destructive standard procedures. However, the current research adopts a destructive approach to estimate the above-ground carbon stock. The destructive method is chosen over non-destructive as one oil palm field containing different ages of plantation is to be cleared and replaced by another crop plantation. All felling and sample collection was done from that site (L2). There are eight plantation fields within the vicinity of Serchhip where the carbon content of all palm trees is to be measured in the study. The study was carried out at Serchhip, Mizoram, India and the field work start 5th February to 30th March, consequently followed by laboratory analysis. All major palm plantation sites located near and around Serchhip town were surveyed in the study.

The palm trees of 3 yrs, 5 yrs, 7 yrs, 8 yrs, and 10yrs were randomly selected from L2 to determine their carbon content. In order to measure the biomass and carbon content, selected sample tree was first grounded using a chainsaw. Fronds were removed from the trunk and leaves were stripped from all the fronds. All the leaves collected from the fronds were placed in a plastic bag and weighed on the field using a digital weighing machine. Fronds were also cut into smaller pieces, placed in a plastic bag, and collectively weighted at the collection site. The frond that remains attached to the main trunk was weighed once the trunk was cut and split. After grounding, the trunk was cut into smaller slices for the convenience of weighing. The length and diameter of the trunk base and tip were recorded in all tree samples.

Fig. 2. Main trunk after removal of fronds

The fresh weight of each plant part, i.e, fronds, trunk, leaves, fruits, and flowers were recorded. A sample weight of one kilogram from each plant part was collected and taken to Botany Research laboratory, Pachhunga University College for oven drying and further analysis.The samples were oven-dried four days and five days of air drying. The air-dried sample was finally weighed once the weight of the sample is constant. The dry biomass value for all plant part is calculated initially after the biomass percentage is calculated as follows:

Dry Biomass percentage = (Dry Biomass Weight / Wet Biomass Weight) x 100

The total biomass of the oil palm tree was then estimated by summing the biomass values derived for each of the plant parts: trunk, fronds, leaves, flowers, and fruits. To determine the percentage of carbon contained in each part of the palm, a default carbon value was used. The amount of carbon stored in plant parts were determined by multiplying the biomass values with the derived percentage of carbon: Leaves 45.2 %, Frond 41.2%, Trunk 40.8%, Fruit 46%, Flower 45.7%.

Fig. 3. Removing frond from its base

Below ground biomass production (kg/palm) = Aboveground biomass (kg/palm) × 0.26.

Below ground Carbon sequestered (kg/palm) = Below ground biomass (kg/palm) × 0.50

The number of palm trees was surveyed from all eight plantation sites and recorded. The ages of the plants were determined by the assistance of farmer. Transect and other method could not be exploited due to irregular planting and gap filling. Some farmers do not follow the 9m triangular spacing and therefore thinning has to be done later to facilitate space for growth. Carbon storage was determined both from sample trees and total tree surveyed. The amount of carbon stored in all plant parts was determined by multiplying the biomass values with the derived percentage of carbon. Total organic carbon of a tree = total dry biomass x carbon factor.

Results

Most of the carbon store was contributed by the trunk and frond. The trunk stores the largest carbon compare to other plant parts except in 3years where the frond has larger carbon stock as compared to the trunk. The frond and trunk carbon content is almost the same in five years, however, the difference in the carbon content of the frond and trunk is very large in eight and ten years. As the trunk increases, the biomass of the frond also increases. However, it was also observed that fronds were previously removed from older plantation, as removing of frond is essential from 4/5 years crop to collect fruit bunch from the standing crop. The previous removed frond cannot be weighed in the present study as they have usually been dry and burnt out.

Table 1 gives the biomass and carbon stock of different age of palm trees along with their plant parts. The table shows that sample palm trees are distinguish into four age groups. The total biomass of three, six, eight and ten years sample was measure to be 82.25 kg, 178.75 kg, 505.55 kg and 311.05 kg respectively. As shown in Table 1, the amount of biomass is directly proportional to its carbon content. Table 2 gives the above ground and below ground carbon content of the sample. The carbon content of three and six years shows a small difference, 0.045 t to 0.098 t respectively. The carbon content of eight years and ten years increase enormously to 0.276 t and 0.529 respectively, as compare to the five and three years.

Table 1. Biomass and carbon content (± = standard deviation) of plant parts.

Age	Parts	Above Ground Biomass (kg)	Carbon content (kg)
3yrs	Trunk	23.5 ±2.40	9.58±0.98
	Frond	44±1.41	18.13±0.58
	Leaves	14.2±1.70	6.42±0.77
	Fruits	0	0
	Flower	0.55±0.01	0.25±0.01
	Total	82.25±0.78	34.38±0.34
5yrs	Trunk	71.35±3.32	29.11±1.35
	Frond	67.9±3.11	27.97±1.28
	Leaves	20±1.13	9.04±0.51
	Fruits	18±1.41	8.28±0.65
	Flower	1.5±0.28	0.69±0.13
	Total	178.75±	75.09±1.90
8yrs	Trunk	264±9.90	107.71±4.04
	Frond	168±11.313	69.22±4.66
	Leaves	28±1.13	12.66±0.51
	Fruits	42±1.41	19.32±0.65
	Flower	3.5±0.35	1.6±0.16
	Total	505.55±0.85	210.51
10yrs	Trunk	630±15.56	257.04±6.35
	Frond	265±8.49	109.2±3.50
	Leaves	39.2±1.70	17.72±0.77
	Fruits	38.9±4.67	17.9±2.15
	Flower	3.95±0.21	1.81±0.10
	Total	977.05±4.10	403.67

Table 2. Age wise total carbon content.

Age of tree (yrs)	Carbon Content (t) AB	Carbon Content (t) BG	Total C Content(t)
3	0.034	0.011	0.045
5	0.075	0.023	0.098
8	0.21	0.066	0.276
10	0.402	0.127	0.529

AB-Above Ground, BG-Below Ground

The total area, number of standing palm crop and the potential carbon storage fromeight location surveyed is given in Table 3. The age of palm and the number of palm tree differ from different locations as shows in Table 1. Older plants sequester more carbon and therefore made significant contribution to carbon stock potential of plantation field. L4 plantation site has an area of 1.25 ha, contains maximum number of ten years crop and has total carbon stock of 61.92 t. Location one has the largest area, number of standing tree and the highest carbon stock of 62.90 t.

It was recorded from the survey that there are 1005 oil palm within Serchhip and it was also found that no new plantation is established recently, and three year crop was the youngest plantation recorded. The total number of three years palm was 85 while that of five years crop is 121. The number of eight years and ten years palm tree from all the locations was also estimated to be 387 and 422 respectively. The carbon stock potential of oil palm accounting all plantation site within Serchhip area was estimated to be 345.41 t/yr.

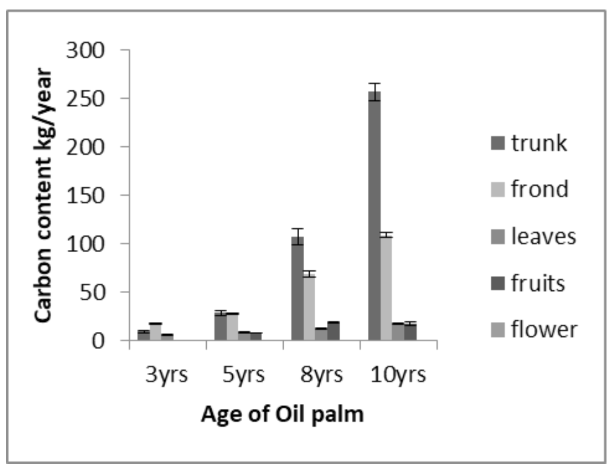

Fig. 1. Carbon distribution in plant parts

Discussion

The clearing of oil palm fields and the introduction of new crops can have adverse consequences due to the potential of oil palm fields to act as a carbon sink

Table 3. Total number of standing oil palm crop and estimated carbon stock from all plantation sites within Serchhip.

Location	Area	3yrs		5yrs		8yrs		10yrs		Total	
Site	(ha)	NP	CC	NP	CC	NP	CC	NP	TCC	NP	CC(MT)
L1	1.70	50	2.25	42	4.12	167	45.94	20	10.58	279	62.90
L2	0.75		0	32	3.14		0	63	33.33	85	36.467
L3	1.28	20	0.90	29	2.84	21	5.78	52	27.51	122	37.03
L4	1.25		0		0	52	14.31	90	47.61	142	61.92
L5	0.40		0		0		0	46	24.33	46	24.33
L6	0.60		0		0	53	14.59	37	19.57	90	34.16
L7	1.26	15	0.68	18	1.77	60	16.51	74	39.15	167	58.10
L8	0.94		0		0	34	9.354	40	21.16	74	30.51
Total	8.18	85	3.83	121	11.87	387	106.48	422	223.24	1005	345.41

(Value in parentheses: NP-Number of palm, CC-Carbon content, ha- Hectare).

in Serchhip. It is estimated from the study that the carbon stored in all standing crops is approximately 345.41 t. To clear palm plantations, the plants are normally uprooted by machine, slashed, and burnt. This devastation process further acts as a major driver for carbon emissions. When it comes in managing atmospheric CO_2, giving up oil palm farming may not be a wiser choice if the field is to be cleared and exploited again for other types of cultivation. There would be more carbon debt if the secondary areas were utilized for other cultivation and not converted back to forest. If all the carbon stored in this palm plantation field are released, it would emit tonnes of carbon to the atmosphere. However, palm oil cultivation may have negative impact to the soil microbial environment. A significant decrease in soil dehydrogenase enzyme activity was observed in 10 years crop while only an unnoticeable decrease was observed in soil of 15 years crop. Among the 1005 palm trees in Serchhip, 422 palm trees were 10 years old, and therefore, oil palm farmers need to have a strategic plan to determine the right time for giving up palm cultivation, considering different aspects in terms of economic, environmental, and ecological impact it is evident from the present study that more carbon will be stored by the palm tree after 10 years or more. Abandoning plantation at an early age may benefit the farmer economically and upto an extent a wiser ecological option. Once it age 10 years or more, giving up of the cultivation at any period may require same efforts to restore soil quality consequently from clearing the plantation at its productive end year, which is normally around 30 years. Further research may be suggested to validate and provide additional information to farmers in Serchhip. The findings in the present study will act as an important aid in decision making by farmers, policymakers, and other stakeholders.

Acknowledgements

The authors would like to thank all the oil palm farmers in Mizoram for their cooperation and assistance. We would also like to thank the Principal, faculty and staff of Pachhunga University College, Mizoram for aiding the present study with unlimited resources.

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