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CARBON SEQUESTRATION POTENTIAL OF OIL PALM IN MITIGATING CLIMATE CHANGE- AN OIL PALM GROWER'S PERSPECTIVE

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ABSTRACT

Oil Palm has emerged as the highest vegetable oil yielding perennial crop (4-5 t oil ha^{-1} yr^{-1}) and has been introduced in India to bridge the demand and supply of vegetable oil of the country. Various Expert Committees constituted by Government of India, have identified 10.36 lakh hectares in the country as suitable for oil palm cultivation and Till 2016, an area of 2.50 lakh ha has been covered. Standing crops like oil palm could serve as net accumulators of carbon, thereby offsetting carbon emissions arising mainly from fossil fuel consumption. The aim of this study is to quantify the potential of carbon sequestration in a twenty year old oil palm grower's plantation grown under irrigated conditions in Andhra Pradesh. Two studies were undertaken during the present investigation. One study involved analysis of annual dry matter production and carbon contents in the system using non destructive sampling techniques, while the other study involved estimation of standing biomass and carbon sequestered by oil palm through destructive methods. Results indicated that the annual dry matter production and carbon sequestered by oil palm were 36.25 t ha^{-1} y^{-1} and 11.63 t ha^{-1} y^{-1} respectively. Leaves or fronds of oil palm plantations possessed the maximum carbon sequestration ability (40 per cent) followed by trunk, bunches and roots. The standing biomass and carbon sequestered in the plantation were of the order of 79.05 and 30.97 t ha^{-1}. The above study emphasizes that oil palm has a huge potential in mitigating climate change since it sequesters substantial quantities of carbon. The carbon credits accrued due to cultivation of oil palm could add additional income to the oil palm grower. The findings could help policy and decision makers in drafting climate change mitigation programmes and policies in India.

Key words: Carbon sequestration, climate change, dry matter production, irrigated conditions

INTRODUCTION

It is generally perceived that there is a link between the increase in average temperature at the earth's surface during the 20th century (0.6 °C +/– 0.2 °C) and higher concentration of greenhouse gasses (GHG) in the atmosphere, which is responsible for 50 per cent of the overall GHG effect. Under United Nations Framework Convention on Climate Change (UNFCCC) in 1992 in Rio de Janeiro (UNFCC), the Kyoto Protocol, signed in 1997 and implemented since February 2005, calls for a reduction in GHG emissions in industrialized countries "to at least 5 per cent below the 1990 levels during the commitment period (2008 to 2012)". Among the provisions proposed, the CDM (Clean Development Mechanism), provides for establishment of carbon sinks, through reforestation or afforestation. It should be noted that, although only forest species are eligible during the first phase, tropical tree plantations may subsequently be involved (www.irrdb.com; www.energybulletin.net).

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In this context, Oil Palm has emerged as the highest vegetable oil yielding perennial crop (4-5 t oil ha^{-1} yr^{-1}) and has been introduced in India to bridge the demand and supply of vegetable oil of the country. Various Expert Committees constituted by Government of India, have identified 10.36 lakh hectares in the country as suitable for oil palm cultivation and Till 2016, an area of 2.50 lakh ha has been covered. Measurements of dry matter production in oil palms belonging to different ages in West Africa and Malaysia have been estimated by several workers (Rees, 1962a; Rees and Tinker, 1963; Ng *et al*. 1968, Henson, 1989, Henson, 1995a; Lamade and Setyo, 1996a, Pulhin *et al*. 2014, Haniff *et al*. 2016). Henson (1998) showed that the annual uptake of carbon dioxide by mature oil palm on coastal soil in Malaysia was 46.4 t ha-1 yr-1 with a net fixation of 11.0 t ha based on the eddy covariance technique. Despite the potential and advantages of oil palm plantations in mitigating global climate change, studies have been undertaken on carbon sequestration under irrigated conditions (Suresh and Arulraj, 2010; Suresh and Kochu Babu, 2010; Suresh *et al*. 2011; Suresh, 2012, 2013; Suresh and Behera, 2014). Despite the above studies, the present study has been undertaken to understand the carbon sequestration potential of twenty year old adult oil palm plantation in mitigating global climate change under irrigated conditions with an oil palm grower's perspective.

MATERIALS AND METHODS

The investigation was conducted in a progressive oil palm grower's plantation (Mr. V.Venkata Rao) at T.Gokavaram. T.Gokavaram is situated in the West Godavari district of Andhra Pradesh province in India and located at 16^0 5675' latitude and 81^0 6359' longitude with a mean sea level of 13.41 m. The average rainfall in the region is around 1221 mm. A twenty year old adult oil palm plantation was taken for the study. Standard agronomic practices were followed. Irrigation and fertilizers were applied as per Indian Institute of Oil Palm Research (IIOPR) recommendations. The average fresh fruit bunches yield was 25.6 t ha^{-1}. Two studies were undertaken during the present investigation. One study involved analysis of annual dry matter production and carbon contents in the system using non-destructive sampling techniques, while the other study involved estimation of standing biomass and carbon sequestered by oil palm through destructive methods. In the first study, annual increments in dry matter production and yield components were monitored as per the methods described by Hardon *et al.* 1969 and Corley *et al.* 1971a. Leaf dry weight [kg] was calculated by using the formula leaf dry weight = 0.1023 P + 0.2062 where P is petiole width × depth [cm^2]. Trunk dry weight was calculated as sum of volume (V) and density (S). Volume was determined by the formula $V = \pi [d/2]^2 * h$ (where d is diameter, h is height). Density (S) is estimated as S = 7.62T + 83 (where T is age of palm in years after planting). Trunk dry weight (D) was estimated as D = 0.5275 F (where F is fresh bunch weight in kg). Dry weight of roots was done by core sampling. The auger was used to extract circular soil cores with a diameter of 10 cm in six consecutive 10 cms depth to a total depth of 60 cms as described by Chan (1977). Later the samples were oven dried and ground for estimation of carbon. The carbon contents in the leaf, trunk, roots and bunches were estimated with the help of CHNS analyzer (Elementar, Germany). The annual CO_2 sequestered was arrived by multiplying carbon sequestered with a factor of 3.66 (molecular weight of CO_2 divided by atomic weight of carbon).

In the other study for estimating standing biomass, the palms were uprooted and total biomass of the harvested trees were weighed and samples were drawn from different plant components viz., fronds, trunk, roots, inflorescence, bunches, cabbage and spear and subsequently weighed. Later the samples were oven dried and ground for estimation of carbon. The carbon contents in the different plant parts were estimated using CHNS analyzer (Elementar, Germany). Total carbon of system was calculated based on carbon content and mass of each component of the system. The CO_2 sequestered by the standing crop was arrived by multiplying carbon sequestered with a factor of 3.66 (molecular weight of CO_2 divided by atomic weight of carbon).

RESULTS AND DISCUSSION

A perusal of the data indicates that annual dry matter production of different plant parts of oil palm viz., leaves, trunk, roots and bunches were of the order of 15.85, 6.12, 0.83, 13.45 t ha^{-1} y^{-1} (Table 1). Leaves (fronds) contributed about 43.72 per cent of the total dry matter production followed by bunches (36.25 per cent) and trunk (6.12 per cent). Roots contributed the lowest dry matter. Similar results were obtained by Suresh and Kiran Kumar (2011). Oil palm produces high biomass which is mainly due to more longevity of the leaf *ie.,* leaf area duration, which means a complete ground cover throughout the year resulting in more light interception and total biomass production. Similar findings have been reported by Rees (1962a). The findings of Corley *et al*. (1971a) also indicate that when the source is limited, vegetative growth takes priority in the process of assimilation in oil palm plantations.

The annual carbon sequestered by oil palm is given in Table 1. The annual carbon sequestered by oil palm was 11.63 t C ha^{-1} y^{-1}. In this study, leaves or fronds sequestered more carbon followed by bunches, trunk and roots. Similar findings were obtained by Suresh and Kiran Kumar (2011). They have also reported that the amount of C sequestered by roots under rainfed conditions were twice compared to that of irrigated conditions. The total amount of CO_2 sequestered by the twenty year old plantation was 42.58 t CO_2 ha^{-1} y^{-1} (Table 1). Leaves were the biggest sinks for atmospheric CO_2 followed by bunches and trunk.

The data regarding standing biomass along with carbon sequestration and CO_2 sequestration in a twenty year old oil palm plantation is being given in Table 2. The data reveals that the standing biomass in spear leaves, leaves, trunk, roots and bunches are 0.40, 14.25, 54.17, 6.46, 3.77 t ha^{-1} respectively. The total standing biomass of the twenty year old oil palm plantation was 79.05 t ha^{-1}. The contribution of different plant parts ie., spear leaves, leaves, trunk, roots and bunches are of the order of 0.51, 18.02, 68.53, 8.17 and 4.77 per cent to the total biomass. Trunk contributes nearly 68.53 per cent of the total standing biomass of the palm.

However, Dufrene (1989) observed that the main above ground biomass accumulation occurs in trunk with 40 t dry matter ha^{-1} or more in palms older than 20 years. He found a total root biomass of 31.5 t ha^{-1} for 10 year old palms in Ivory Coast, whereas Lamade and Setiyo (1996a) found only 14.1 t ha^{-1} for one family and 9.7 t ha^{-1} for another in Indonesia. Root biomass may be greater in dry climates of West Africa than that of Malaysia and Indonesia.

The carbon sequestered by oil palm standing crop along with its CO_2 sequestration is given in Table 2. The total carbon sequestered by standing oil palm crop was 30.97 t ha^{-1} y^{-1}. Trunk (23.55 t ha^{-1} y^{-1}) sequestered more carbon followed by leaves, roots, bunches and spear leaves. The total amount of CO_2 sequestered by the standing crop was to the tune of 113.36 tCO_2 ha^{-1} y^{-1} (Table 2). Suresh and Kiran Kumar (2011) also reported the amount of C sequestered was 21.18 and 12.39 t ha-1 respectively under irrigated and rainfed conditions respectively. The amount of C sequestered was more in trunk followed by leaves and roots under both the situations. The results also confirm to the findings of Suresh and Kochu Babu (2008), who reported carbon sequestration of about 17.98 - 35.44 T C ha^{-1} by an adult oil palm hybrids under irrigated conditions. Another study under irrigated conditions indicated that the carbon contents in the different fronds of a mature palm ranged from 0.413 to 1.314 kg (Suresh *et al*. 2008). The carbon contents were low in the younger leaves and did not show any pattern among the middle and lower whorls. Kho and Jepsen (2015) reviewed the carbon stocks of oil palm plantations and tropical forests in Malaysia and opined that conversion of forest fallows to oil palm plantations may sustain or even increase the standing carbon stock in the system.

To conclude, the above study emphasizes that oil palm has a huge potential in mitigating climate change since it sequesters substantial quantities of carbon. The carbon credits accrued due to cultivation of oil palm could add additional income to the oil palm grower. The environmental knowledge generated would be relevant to policy makers dealing with Clean Development Mechanism proposed by the Kyoto Protocol, and will contribute in increased understanding of the effects of human induced land use change on green house gas emissions. Lastly, the findings could play an important role in helping policy and decision makers in drafting climate change mitigation programmes and policies in India.

Table 1. Annual dry matter production (t ha^{-1} y^{-1}), carbon sequestration (t ha^{-1} y^{-1}) and CO_2 sequestered (t C ha-^{1}) of twenty year old oil palm plantation (n=12). (Figures given below are in means ± standard error).

Plant part	Dry matter production (t ha^{-1} y^{-1})	Carbon sequestration (t C ha^{-1} y^{-1})	CO_2 sequestration (t CO_2 ha^{-1} y^{-1})	Per cent contribution
Leaves	15.85 ± 1.06	4.69 ± 0.76	17.17 ± 1.19	43.72
Trunk	6.12 ± 0.52	2.66 ± 0.35	9.74 ± 0.64	16.88
Roots	0.83 ± 0.06	0.25 ± 0.06	0.92 ± 0.12	2.30
Bunches	13.45 ± 0.54	4.03 ± 0.78	14.75 ± 0.86	37.10
Total	36.25 ± 3.74	11.63 ± 0.89	42.58 ± 2.57	

Table 2. Standing biomass (t ha^{-1}), carbon sequestered (t C ha^{-1}) and CO_2 sequestered (t C ha^{-1}) by different plant parts in a twenty year oil palm plantation (n=12). (Figures given below are in means ± standard error).

Plant part	Standing biomass (t ha^{-1})	Carbon sequestration (t C ha^{-1})	CO_2 Sequestration (t CO_2 ha^{-1})	Per cent contribution
Spear leaves	0.40 ± 0.01	0.12 ± 0.01	0.44 ± 0.02	0.51
Leaves	14.25 ± 0.94	4.22 ± 0.54	15.45 ± 2.61	18.02
Trunk	54.17 ± 2.46	23.55 ± 2.47	86.19 ± 3.54	68.53
Roots	6.46 ± 0.63	1.95 ± 0.64	7.14 ± 0.52	8.17
Bunches	3.77 ± 0.44	1.13 ± 0.08	4.14 ± 0.34	4.77
Total	79.05 ± 4.47	30.97 ± 3.62	113.36 ± 5.51	

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