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RESEARCH PAPER

Carbon Sequestration of Eleven Oil Palm Hybrids under Irrigated Conditions

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ABSTRACT

Eleven adult oil palm hybrids planted at Directorate of Oil Palm Research, Pedavegi, Andhra Pradesh were selected for studying the carbon sequestration potential. Trunk biomass ranged from 35.3 to 82.6 T ha^{-1} and the leaf biomass ranged from 8.9 to 26.0 T ha^{-1} among the hybrids. Deli x Ghana hybrid recorded the highest trunk biomass as well as the leaf biomass. Among different plant parts, the amount of carbon sequestered in trunk ranged from 15.3 to 35.8 T C ha^{-1} and the carbon sequestered in leaf ranged from 2.6 to 7.7 T C ha^{-1}. The carbon sequestration potential was highest in Deli x Ghana hybrid (43.7 T C ha^{-1}), while it was lowest in 128 x 31323 hybrid. The present study would be useful for developing a comprehensive and accurate database regarding the carbon storage in oil palm plantation crops which are substantially larger sinks for carbon compared to other annual crops grown under irrigated conditions.

Key words : Carbon sequestration, oil palm, plantation, biomass.

INTRODUCTION

Oil palm has been introduced into India under non-traditional environments to meet the vegetable oil demand of the growing Indian population. Good irrigation and fertilizer management with improved planting material, regular maintenance and harvesting are essential to produce higher yields. Established oil palm plantations managed in an environmentally friendly way are sustainable production systems (Basiron and Weng, 2004; Ibrahim, 1992). The higher concentration of green house gases (GHG) in the atmosphere, particularly CO_2, is responsible for 50% of the overall GHG effect (Bergonzini, 2004). The average CO_2 concentration increased from 290 to 380 ppm from 19th to 20th century. Oil palm has major potential for atmospheric CO_2 sequestration and is used for judging the environmental impacts of this perennial crop (Lamade and Bouillet, 2005). The environmental impact of oil palm plantation establishment may be categorised into three principal effects: change in the greenhouse gas balance; erosion and reduction of biodiversity by fragmentation (Hamer, 1981; Maene *et al.*, 1979); disturbance and destruction of natural habitats (Laidlaw, 2000; Robertson and Schaik, 2001).

The input of carbon into the plant is first determined by the rate of net photosynthesis, which in turn is dependent upon the photosynthetically active radiation (PAR), efficiency of photosynthesis and the metabolic reactions that convert carbohydrates to plant biomass and maintain the standing biomass. Decomposition also releases plant nutrients that become available again to plants and emits the carbon contained in the biomass into the atmosphere as carbon dioxide (CO_2). Roots make a relatively large contribution to soil organic matter due to their location in the soil and linkage to soil particles. Differences in root biomass in different areas were obtained according to different soil types which is more difficult to estimate and its measurement requires destructive sampling (Fahmuddin *et al.*, 2009).

Oil palm helps in reduction of CO_2 from atmosphere by sequestration process, which enhances quality of soil, air and wildlife habitat. Based on the eddy covariance technique by Henson (1989), the annual uptake of CO_2 by mature oil palm on coastal soil in Malaysia was estimated to be 46.4 T ha^{-1} yr^{-1} with a net fixation of about 11.0 T ha^{-1}. Enhanced biological storage of carbon has the potential to reduce atmospheric CO_2 considerably (Winjum *et al.,* 1992; Mutuo *et al.,* 2005). The carbon capture and storage technologies provide a potentially valuable set of tools for achieving the magnitude of emissions reduction required for CO_2 stabilization. Lenton and Huntingford (2003) reported that the biosphere may soon become a net source rather than a net sink of atmospheric carbon due to changes in climate. Under the clean development mechanism of the Kyoto protocol, green house gas emissions offsets are measured in tonnes of CO_2 equivalents and are called Certified Emission Reductions (CERs).

There are two methods of measurement of carbon stocks accumulated by a plant *viz.,* destructive method, where in the plant will be uprooted and plant parts are seperated and non destructive method, by measuring specific parameters like diameter, height, wood density etc. This paper focuses on estimating the carbon sequestration potential of eleven oil palm hybrids grown under irrigated conditions by destructive method.

MATERIALS AND METHODS

The study was conducted at Directorate of Oil Palm Research, Pedavegi. Pedavegi is situated in West Godavari district, Andhra Pradesh, India and located at 16°8' N, 81°11' E, with a mean sea level of 13.4 m. The palms were planted with 9 m triangular spacing and standard agronomic practices were followed. Eleven oil palm hybrids grown under uniform management conditions were uprooted and plant parts were separated. Above-ground biomass *viz.*, fresh weights of trunk, leaflets, rachis and spears were recorded and their representative samples were dried in hot air oven at 65°C to attain constant weight and dry weights were recorded. The samples were ground and passed through 0.2 mm sieve for analyzing the total carbon. The estimation of carbon contents in the different samples was done on the basis of dry combustion, with the help of CHNS analyzer (Vario EL III, Elementar, Germany). The total carbon of the system was calculated based on the carbon component and mass of each component of the system.

RESULTS AND DISCUSSSION

Among different plant parts, trunk biomass ranged from 35.3 to 82.6 T ha^{-1} (Table 1). The highest trunk biomass was recorded in Deli x Ghana hybird, while lowest trunk biomass was recorded in 128 x 31323 hybrid. The leaf biomass ranged from 8.9 to 26.0 T ha^{-1}. Deli x Ghana hybrid recorded highest leaf biomass and 9C x 1001 recorded lowest. The total biomass was highest in Deli x Ghana hybrid (109.4 T ha^{-1}) and was lowest in 128 x 31323 hybrid (50.7 T ha^{-1}). Dufrene (1989) also observed that the above ground biomass accumulation in trunk was about 40 T dry matter ha^{-1} or more in palms older than 20 years where as Lamade and Setiyo (1996) found only 14.1 T ha^{-1} and 9.7 T ha^{-1} in Indonesia. Estimation of above ground biomass in adult palms indicated higher biomass accumulation in trunk followed by leaf and roots, under both irrigated and rainfed conditions (Suresh and Kiran, 2011). Oil palm produces large quantities of dry matter mainly due to larger surface area, complete

Table 1: Above ground biomass (T ha^{-1}) of different plant parts in oil palm hybrids

Hybrid	Spear dry wt	Trunk dry wt	Leaf dry wt	Total dry wt
Deli x Ekona	0.6	50.3	14.5	65.3
128 x 31323	0.5	35.3	14.9	50.7
Deli x Ghana	0.7	82.6	26.0	109.4
1M-0069 D x P	1.0	52.7	25.1	78.8
12 x 313	0.5	43.0	14.6	58.1
Deli x Lame	1.0	66.4	20.5	87.9
12 x 266	0.6	40.0	12.1	52.7
65D x 111	1.0	38.7	14.8	54.6
Deli x Avros	1.1	58.7	13.5	73.3
18 C x 2501	0.5	49.4	12.2	62.1
9C x 1001	0.5	43.5	8.9	52.8

ground cover during the whole year resulting in higher light interception and total dry matter production (Rees, 1962) compared to annual crops. The typical biomass accumulation in tree plantations follows a curve of quick initial growth and thereafter a minor increase (Sanchez, 2000). Carbon loss from atmosphere (around 89%) is mainly because of loss of living biomass of total carbon stored in both vegetation and soil (Houghton, 2005). One important shortcoming lies in the fact that, it is not always clear, whether the biomass includes the leaf bases attached to the trunk (Corley and Tinker, 2003).

Among different plant parts, highest carbon was sequestered in the trunk which ranged from 15.3 to 35.8 T C ha^{-1} (Table 2). Deli x Ghana hybrid sequestred highest carbon in trunk, while lowest was in 128 x 31323 hybrid. The carbon sequestered in leaf ranged from 2.6 to 7.7 T C ha^{-1}. Deli x Ghana hybrid sequestered the highest carbon while it was lowest in 9C x 1001 hybrid. Total carbon sequestered was highest in Deli x Ghana hybrid and lowest in 128 x 31323 hybrid. The balance between emission and absorption of CO_2 during the growth cycle of oil palm depends upon growth rate, green manure and organic waste management and fertilizer practices (Dewi *et al*., 2009). Syahrinudin (2005) reported that biomass carbon of oil palm system in Indonesia increased persistently with plantation age and ranged from 16.6 to 84.6 Mg ha^{-1} in 3 to 30 year old plantations respectively. The amount of carbon sequestered was more in trunk followed by leaves according to the findings of Suresh *et al.* (2008) who reported a carbon sequestration of 17.98 to 35.44 T C ha^{-1}. The carbon contents were found to be low in younger leaves and higher in older leaves. Loss of standing biomass may be offset by long-term carbon storage, either as harvested material (oil palm fruit bunches) or carbon sequestered in soil organic matter. Carbon storage in the biomass elaborates each year primarily with the age and secondarily on agro-ecological conditions. The total amount and proportion of carbon storage varies depending on soil fertility, climate, and land use types (Fahmuddin *et al.,* 2009).

To conclude, plantation crops like oil palm act as larger sinks for carbon than annual crops under irrigated conditions. Effective management of plantation crops like oil palm in India is paramount to meet demand for agricultural products by retaining high biodiversity and ecosystem service delivery. Hence standing perennial crops like oil palm serve as net accumulators of carbon, thereby offsetting carbon emissions, arising from the consumption of fossil fuels and also help in financial gains through carbon trading under the Kyoto Protocol. It also seems to be a prime candidate for storing carbon in which oil palm is grown and is eligible for the clean development mechanism. The findings of the study can be used to develop a comprehensive and accurate database regarding the carbon storage in oil palm which judges the environmental impacts.

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Table 2 : Carbon sequestered (C T ha^{-1}) by different plant parts in oil palm hybrids

Hybrid	Spear	Trunk	Leaf	Total Carbon
Deli x Ekona	0.2	21.8	4.3	26.2
128 x 31323	0.1	15.3	4.4	19.9
Deli x Ghana	0.2	35.8	7.7	43.7
1M-0069 D x P	0.3	22.8	7.4	30.5
12 x 313	0.2	18.6	4.3	23.1
Deli x Lame	0.3	28.8	6.1	35.1
12 x 266	0.2	17.3	3.6	21.1
65D x 111	0.3	16.7	4.4	21.4
Deli x Avros	0.3	25.4	4.0	29.7
18 C x 2501	0.1	21.4	3.6	25.2
9C x 1001	0.1	18.8	2.6	21.6

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