International Journal of Research in Agronomy 2024; SP-7(9): 498-503

E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; SP-7(9): 498-503
Received: 06-07-2024
Accepted: 11-08-2024

Lokhande Sunil J
M.Sc. Scholar, Department of soil science and agricultural Chemistery, College of Agriculture, Dhule, Maharashtra, India

Bhalerao Vikrant P
Associate Professor, Department of soil science and agricultural Chemistery, College of Agriculture, Dhule, Maharashtra, India

Jagdhani Anil D
Assistant Professor, Department of soil science and agricultural Chemistery, College of Agriculture, Pune, Maharashtra, India

Bhusari Rushikesh M
Ph.D. Scholar Department of Horticulture (Fruit science), PGI, MPKV Rahuri, Maharashtra, India

Landge Amrsinh P
M.Sc. Scholar, Department of soil science and agricultural Chemistery, College of Agriculture, Dhule, Maharashtra, India

Corresponding Author:
Lokhande Sunil J
M.Sc. Scholar, Department of soil science and agricultural Chemistery, College of Agriculture, Dhule, Maharashtra, India

Estimation of terrestrial carbon stock as influenced by mango orchard at Dhule region

Lokhande Sunil J, Bhalerao Vikrant P, Jagdhani Anil D, Bhusari Rushikesh M and Landge Amrsinh P

DOI: https://doi.org/10.33545/2618060X.2024.v7.i9Sg.1526

Abstract
The present research investigation has been carried out at the Horticulture Farm, College of Agriculture, Dhule, throughout the years 2021-2022. The trial used a randomised block design, with nine treatments replicated three times. Treatments T_1–T_8 are plants taken from a 19-year-old orchard, whereas T_9 is the control.T_5 had a higher tree height (527.33 cm), while T_8 had a higher diameter at breast height (88.39 cm), tree volume (3206.37 m2), above ground biomass (2180.33 kg tree-1), below ground biomass (566.89 kg tree-1), and total plant biomass (2757.8 kg tree-1), resulting in a higher accumulation of plant carbon (1373.61 kg tree-1). Higher total organic carbon (TOC) 0.94%, 0.83% and 0.58%, water soluble carbon (WSC) -173.15 mg kg^{-1}, 150 mg kg^{-1} and 90.67 mg kg^{-1}, soil microbial biomass carbon (SMBC) 480.61 mg kg^{-1}, 402.27 mg kg^{-1} and 318.31 mg kg^{-1}, permanganate oxidizable soil carbon (POSC) 1213.50 mg kg^{-1},965.24 mg kg^{-1} and 798.40 mg kg^{-1}, fulvic acid carbon 21.63 mg kg^{-1}, 19.48 and 12.28 mg kg^{-1}, humic acid carbon 13.70 mg kg^{-}1, 11.22 mg kg^{-}1, 7.75 mg kg^{-1}, Soil organic carbon (SOC) stock content in mango orchard soil is 36.42 mg ha^{-1}, 32.91 mg ha^{-1}, 23.44 mg ha^{-1} recorded at the depth of 0-30 cm, 30-60 cm and 60-90 cm, respectively. On an average, 1116.31 kg $tree^{-1}$ *i.e.* 111.63 t ha^{-1} plant carbon has been sequestered in 19 years old mango orchard.

Keywords: Organic carbon, soil microbial biomass carbon, carbon stock, permanganate etc.

Introduction
Information on the dynamics of soil organic carbon in agricultural soils is becoming more essential due to the consequences for climate change and crop yield. Expanding forests, forest understory plants, litter, and forest soils retrieve almost two-thirds of terrestrial carbon.
The global production of greenhouse gases (GHGs; CO2, CH4, N2O) is increasing by the day, but there are several methods for reducing these emissions, the most common of which is the cultivation and protection of trees such as fruit orchards or agroforestry. This strategy, often known as "climate-smart farming," might significantly decrease harmful gasoline emissions and has various beneficial environmental consequences. The cultivation of fruits is viewed as a potential tool for improving agricultural practices that may be harmed by climate change. The combination of trees, frequently in different systems, promotes productivity, improves the nutrient cycle, and assists in ecological balance due to the "biological carbon sequestration potential".
Carbon sequestration in terrestrial ecosystems refers to the process of removing carbon sources from the environment, such as CO2, or reducing CO2 emissions from terrestrial ecosystems and storing them productively. Natural vegetation has a significant influence on soil organic carbon concentration, showing a sink capacity for tree cultivation. Increased carbon emissions are a major cause of anxious across the world, and the Kyoto Protocol does an excellent job of tackling them. Carbon sequestration is the long-term storage of carbon in the oceans, soils, plants (especially forests), and geological formations.
India serves as a wide variety of soil types and climates that are perfect for growing horticulture and agricultural items. As a result, these fields may be planted with permanent horticultural crops to ensure lucrative and effective commercial horticulture. Mango (*Mangifera indica*) is regarded as "king of fruits" and is the leading fruit crop of India. Mango accounts for

approximately 36% of total fruit area (2019-20), covering 2.3 million hectares and producing 20.44 million tonnes, accounting for 40.50% of total global mango output (National Horticultural Board, 2022). Major mango producing states area wise are Andhra Pradesh (16.5%), Uttar Pradesh (12.1%), Odisha (8.3%), Karnataka (7.7%) and production wise Uttar Pradesh (23.4%) ranks first closely followed by Andhra Pradesh (23.1%). In Telangana mango is cultivated in 1, 28, 000 ha with productivity of 992 kg ha^{-1} (Horticulture Statistics Division, DAC&FW, 2021). It is estimated that, total C sequestered per mango tree across the country varied from 446.2 to 934.7 kg tree–1 and, grafted mangoes sequestered 733.03 kg C tree–1, thus Indian mango orchards had carbon sequestration potential of 285.005 m t of carbon (Ganeshamurthy *et al*., 2019) [16].

In terms of nutrient supply, dissolved organic N (DON), labile organic nitrogen (LON) and light fraction organic matter (LFOM) respond more quickly to management than SOM content (Biederbeck *et al*. 1994) [4] and they are believed to play a role in regulating N mineralization patterns in various soils (Bonde and Rosswall, 1988) [7]. Soil organic carbon sequestration is influenced by several factors, including climatic and soil conditions (Chabbi *et al.* 2009) [10] soil erosion, vegetation types, cropping systems (Jagadamma *et al.* 2010) [21] and managements including tillage (Ogle *et al.* 2005) [33] and fertilization (Bhattacharyya *et al.* 2008) [5].

Keeping the factors mentioned above in mind, study was conducted at the College of Agriculture, Dhule to better understand soil organic carbon sequestration after mango planting, with the following objectives. To estimate the soil carbon storage in a mango orchard.

Materials and Methods

At a height of 250 meter above mean sea level. Field is located at $20^0$53'59" N latitude and $74^0$46'11" E longitude. Field experiment was undertaken at the Horticulture Farm, College of Agriculture, Dhule, in Agro climatic Zone-6, *i.e*. the scarcity zone condition of Northern Maharashtra.

Total 75 soil samples were collected from all the various location throughout the experimental area with depth i.e. 0-30 cm, 30-60 cm and 60-90 cm. Then the samples were dried under shade to remove the moisture content and crushed with the help of wooden mortar and pestle. After that the soil was sieved through 2 mm sieve to obtain a uniform sample. Total carbon content of soils is determined by Nelson and Somner method (1982). The height and diameter at breast height (DBH) are two main biophysical measurements which measured for each tree sample. The mango tree height measured by measuring tape and bamboo stick. The tree diameter was measured at breast height (DBH) by using measuring tape (at 1.3 meters height from ground).

Estimation of above and below ground biomass

The above ground biomass (ABG) has been calculated by multiplying volume of tree and wood density (Ravindranath and Ostwald, 2008) [43]. The volume was calculated based on diameter and height.

$$AGB (kg) = Volume of tree (m^3) x wood density (kg m^{-3})$$

The below ground biomass (BGB) has been calculated by multiplying above ground biomass taking 0.26 as the root to shoot ratio (Ravindranath and Ostwald, 2008) [43].

$$BGB (kg) = AGB (kg) x 0.26$$

Volume of tree was estimated by using diameter at breast height (DBH) of tree and computed as per the standard formula (Ravindranath and Ostwald, 2008) [43].

$$Volume of tree (V) (m^3) = \pi x r^2 x H$$

Where,
V = volume of tree in cubic centimetres or cubic metre
r = radius of the tree 1.3 m above ground = DBH / 2
H = height of the tree in centimetres or metres.

Total plant biomass is the sum of the above and below ground biomass (Chavan and Rasal 2011) [11].

TPB=AGB+BGB (All values are in kilogram)

Generally, for any plant species 50% of its biomass is considered as carbon (Chavan and Rasal 2011) [11].

Plant Carbon = total plant biomass x 50% or Biomass / 2

Estimation of Soil organic carbon stock

Soil organic carbon stock at two depths i.e. 0-30, 30-60 and 60-90 cm were estimated by using following standard formula (Jasmine, Wagner and Abbott 2021) [22].

SOC Stock= TOC x BD x D

Where,
TOC = Total organic carbon
BD = Bulk density of soil
D = Depth of soil layer

Total Organic Carbon (TOC)

Total carbon content of soils is determined by dry combustion at high temperatures in a furnace with the collection and detection of evolved CO_2 (Nelson and Sommer, 1982) [32].

Water Soluble Carbon (WSC)

Water soluble carbon at three depths were analysed by following Water extraction method given by Mc Gill *et al.* (1986) [28].

Soil Microbial Biomass Carbon (SMBC)

The soil microbial biomass carbon from soil was determined by the fumigation-extraction technique in fresher incubated soil samples at 27 °C described by Vance *et al.* (1987) [44].

POSC

Permanganate oxidizable soil carbon at three depths was analysed by following Permanganate oxidation method given by Blair *et al.* (1995) [6].

Humic Acid and Fulvic Acid Carbon

The principal extraction procedure (Stevenson, 1994) was followed by separation after extracting with freshly prepared sodium hydroxide (0.5 *M* NaOH) at pH 13.0 with acid wash (0.1 *M* HCl, pH 2.0).

The results of the experiment were statistically examined using RBD, according to Panse and Sukhatme (1967) [34].

Results and Discussion

Table 1. Shows the impact of the various mango trees on total plant biomass and plant carbon.

In comparison to the treatment in the mango orchard treatment T_8 was found higher volume of tree (3206.37 m^2) above ground biomass (AGB) *i.e*. (2180.33 kg $tree^{-1}$), below ground biomass

(BGB) *i.e.* (566.89 kg tree^{-1}), total plant biomass (TB) *i.e.* (2757.80kg tree^{-1}), and plant carbon (PC) *i.e.* (1373.61 kg tree^{-1}). Maximum tree height and maximum diameter recorded in T_5 (527 cm) (88.39) respectively.

Furthermore, on the other side lower data on plant biomass was found in treatment T_1 *e.g.* volume of tree (1969.02 m^2), above ground biomass (ABG) (1338.94 kg tree^{-1}), below ground biomass (BGB) (348.12 kg tree^{-1}), total plant biomass (TB) (1687.06 kg tree^{-1}) and plant carbon (PC) (843.53 kg tree^{-1}) and their height and diameter at breast height was (470 cm) and (72.13 cm) respectively

Among the different treatments, above ground biomass, below ground biomass, and total plant biomass were greater than the rest of the treatments, and on the basis of these biometric observations, higher plant carbon were reported after calculation than the rest of the treatments. It might be owing to increased leaf fall or litter fall over a nineteen-year period, its genetic makeup, and successful adaptation to climate circumstances. Similar observations were also be recorded by Kaur *et al.* (2002) [24] and Chavan and Rasal (2012) [12].

Table 1: Total plant biomass content in 42 year old orchard

Treat.	Tree height (cm)	Diameter at breast height (in cm.)	Volume of tree (m^2)	Above ground biomass (kg tree^{-1})	Below ground biomass (kg tree^{-1})	Total plant biomass (kg tree^{-1})	Plant Carbon (kg tree^{-1})
T_1	470	72.13	1969.02	1338.94	348.12	1687.06	843.53
T_2	506	83.29	2783.47	1892.76	492.12	2384.87	1192.44
T_3	519	78.23	2528.92	1719.66	447.11	2166.78	1083.39
T_4	455	82.29	2424.48	1648.64	428.65	2077.29	1038.65
T_5	527	79.23	2600.70	1768.48	459.80	2228.28	1114.10
T_6	467	88.33	2849.01	1937.33	503.70	2441.03	1220.51
T_7	488	80.29	2484.36	1689.37	439.24	1759.89	1064.30
T_8	525	88.39	3206.37	2180.33	566.89	2757.80	1373.61
S.E.±	29.29	3.11	297.93	202.59	52.67	255.67	127.63
CD 5%	NS	9.52	NS	NS	NS	NS	NS

Total Organic Carbon

According to the findings in Table 2, the total organic carbon content of orchard soil was measured at depths of 0 to 30 cm, 30 to 60 cm, and 60 to 90 cm. Carbon accounts for a sizable component of soil organic matter, which also contains nutrients, cations, and trace elements essential to the growth of plants.

At a depth of 0 to 30 cm, where treatment T8 (0.94%) was significantly superior however, it was at par with treatments T_4 **(**0.91%), T_5 (0.90%), T_7 (0.89%), T_1 (0.88%), T_3 (0.88) and T_2 (0.87%). At depth 30-60 cm, treatment T_8 (0.83%) was superior to other treatments while it was at par with treatments T_2 (0.79%), T_3 (0.79%), T_7 (0.78%), and T_5 (0.77%). Significant observations were recorded at a depth of 60 to 90 cm, where treatment T_8 (0.58%) was significantly superior to other treatments, however, it was at par with treatments T_1 (0.57%), T_2 (0.56%), T_6 (0.56%), T_3 (0.55%), T_5 (0.55%) and T_7 (0.55%). On the other side in all treatment T_9 i.e. control shows minimum organic carbon. Due to organic matter addition from natural vegetation, top soil has the highest total organic carbon concentration when compared to subsurface soils (Ingram and Fernandes 2001). As the depth of the soil increases, it decreases (Dar *et al.* 2017) [20, 13].

Water Soluble Carbon

According to the data represented in Table 2 water-soluble carbon content of orchard soil recorded from a depth of 0 to 30 cm, 30 to 60 cm and 60 to 90 cm. It regulates the turnover of nutrients and the expansion of microbe and it provides energy for soil organisms.

Significant observations were found at a depth of 0 to 30 cm, where treatment T_8 (173.15 mg kg^{-1}) was showed numerically higher and it was at par with treatments T_7 (171.45 mg kg^{-1}), T_3 (170.42 mg kg^{-1}), T_2 (147.33 mg kg^{-1}), T_6 (147.33 mg kg^{-1}) and T_4 (146.75 mg kg^{-1}).. At a depth of 30 to 60 cm, significant observations were recorded, showing that treatment T_8 (150.00 mg kg^{-1}) was found numerically higher over all other treatments and it was at par with treatments T_4 (124.67 mg kg^{-1}), T_6 (118.12 mg kg^{-1}), T_2 (118.08 mg kg^{-1}) and T_7 (117.33 mg kg^{-1}). Significant observations were found at a depth of 60 to 90 cm, where treatment T_8 (90.67 mg kg^{-1}) was significantly superior. Whereas however, it was at par with treatments T_3 (87.33 mg kg^{-1}), T_6 (71.00 mg kg^{-1}), T_2 (70.41 mg kg^{-1}), T_1 (70.08 mg kg^{-1}). The decrease in water soluble carbon concentration in deep soil strata may be due to the water soluble carbon's adsorptive interaction with the mineral matrix's reactive surface (Kalbitz *et al.* 2000 and Brar *et al.* 2013) [23, 2]. Similar results depth wise distribution of water soluble carbon content was observed by Thangavel *et al.* (2015) [42].

Soil Microbial Biomass Carbon

Table 2 shows the soil microbial biomass carbon content of orchard soil at depths of 0-30 cm, 30-60 cm, and 60-90 cm. It is the living portion of soil organic material and is necessary for nutrient cycling, soil organic matter decomposition, and soil organic matter transformation (Liang *et al.* 2012) [26].

Significant observations were recorded at a depth of 0 to 30 cm, where the treatment T_8 (480.61 mg kg^{-1}) was recorded numerically higher over all the treatments however, it was at par with treatments T_3 (476.78 mg kg^{-1}), T_2 (472.71 mg kg^{-1}), T_4 (466.23 mg kg^{-1}), T_1 (450.59 mg kg^{-1}), T_6 (430.34 mg kg^{-1}) and T_7 (423.35 mg kg^{-1}). At a depth of 30 to 60 cm treatment T_8 (402.27 mg kg^{-1}), was markedly higher than other treatments however, it was at par with treatments T_3 (379.74 mg kg^{-1}), T_2 (373.13 mg kg^{-1}) and T_1 (362.19 mg kg^{-1}). At a depth of 30 to 60 cm, treatment T_8 (318.31 mg kg^{-1}) showed numerically higher and it was at par with treatments T_3 (308.19 mg kg^{-1}), T_2 (307.76 mg kg^{-1}), T_1 (290.96 mg kg^{-1}), T_4 (286.96 mg kg^{-1}), T_6 (274.06 mg kg^{-1}) and T_7 (273.26 mg kg^{-1}). Similar result on Soil microbial biomass carbon content depth also decrease was reported by Purakayastha *et al.* (2007) [35]. Result is close confined with (Ramesh *et al.* 2013) [36].

Permanganate Oxidizable Soil Carbon

According to the findings in Table 3. the permanganate oxidizable soil carbon content of orchard soil from a depth of 0 to 30 cm, 30 to 60 cm and 60 to 90 cm. different amounts of soil organic carbon, this fraction is thought to be a useful method for characterizing that carbon (Liang *et al.* 2012) [26].

Significant observations were recorded at a depth of 0 to 30 cm, where treatment T_3 (1350.67 mg kg^{-1}) was significantly superior and treatments T_8 (1213.50 mg kg^{-1}) was found numerically higher over all the treatments however, it was at par with treatments T_5 (1203.00 mg kg^{-1}), T_7 (1175.55 mg kg^{-1}), T_2 (1148.25 mg kg^{-1}), T_3 (1146.75 mg kg^{-1}), T_1 (1103.25 mg kg^{-1}) and T_6 (1085.25 mg kg^{-1}). At a depth of 30 to 60 cm, significant observations were recorded, showing that treatment T_8 (965.24 mg kg^{-1}) was recorded numerically higher over all the treatments however, it was at par with T_7 (962.25 mg kg^{-1}), T_5 (958.50 mg kg^{-1}), T_2 (929.25 mg kg^{-1}), T_1 (909.08 mg kg^{-1}), T_4 (908.08 mg kg^{-1}) and T_6 (900.00 mg kg^{-1}). At a depth of 60 to 90 cm, where treatment T_8 (798.40 mg kg^{-1}) was found numerically higher over all the treatments however, it was at par with treatments T_3 (769.07 mg kg^{-1}) and T_1 (728.29 mg kg^{-1}). Similar results on mango orchard's POSC was substantially higher compared to conventionally cultivated soil (Naik *et al*. 2016) [29]. Sofi *et al.* (2012) [39], who found that cover plant root exudates and decaying residues improved carbon content, which stimulated microbial population responsible for improved nutrient retention and cycling.

Fulvic Acid Carbon

According to the results in Table 3, the fulvic acid carbon content of orchard soil at depths of 0 to 30 cm, 30 to 60 cm, and 60 to 90 cm. Although fulvic acids are commonly regarded as humic acid precursors, they may also be humic acid breakdown products.

Significant observations were recorded at a depth of 0 to 30 cm, where treatment T_8 (21.63 mg kg^{-1}) was significantly superior to all treatments however treatment T_5 (21.28 mg kg^{-1}) and T_3 (21.26 mg kg^{-1}) were observed at par with T_8. At a depth of 30 to 60 cm, treatment T_8 (19.48 mg kg-1) was markedly higher than all treatment. Whereas treatment T_3 (18.85 mg kg^{-1}) and T_5 (18.59 mg kg^{-1}) were at par with treatment T_8. At a depth of 60 to 90 cm, where treatment T_8 (12.28 mg kg^{-1}) was significantly superior to all treatment however, it was at par with T_3 (11.25 mg kg^{-1}), T_6 (10.94 mg kg^{-1}), T_7 (10.44 mg kg^{-1}), T_5 (10.22 mg kg^{-1}) and T_4 (9.85 mg kg^{-1}). Due to continuous supply of fresh organic matter and litter fall in forest soil in surface layer as compare to subsurface layer caused high proportion of fulvic acid carbon at surface layer than lower layer (Aswathy *et al.* 2018) [1].

Humic Acid Carbon

According to the findings in Table 3. the humic acid carbon content of orchard soil from a depth of 0 to 30 cm, 30 to 60 cm and 60 to 90 cm. Significant observations were recorded at a depth of 0 to 30 cm, where treatment T_8 (13.70 mg kg^{-1}) was found numerically higher over all the treatments however, it was at par with T_1 (13.28 mg kg^{-1}), T_5 (13.20 mg kg^{-1}), T_6 (13.01 mg kg^{-1}), T_4 (12.69 mg kg^{-1}) and T_2 (12.55 mg kg^{-1}). At a depth of 30 to 60 cm, treatment T_8 (11.22 mg kg^{-1}) was showed numerically higher over all the treatments and it was at par with treatments T_2 (10.27 mg kg^{-1}), T_1 (10.24 mg kg^{-1}), T_3 (10.20 mg kg^{-1}), T_5 (10.16 mg kg^{-1}) and T_4 (10.04 mg kg^{-1}). At a depth of 60 to 90 cm, where treatment T_8 (7.75 mg kg^{-1}) was markedly higher whereas treatments T_1 (5.72 mg kg^{-1}), T_4 (6.09 mg kg^{-1}) and T_9 (3.62 mg kg^{-1}) *i.e.* control. Other all rest treatments T_2 (7.60 mg kg^{-1}), T_7 (7.41 mg kg^{-1}) T_3 (6.91 mg kg^{-1}), T_5 (6.65 mg kg^{-1}) and T_6 (6.42 mg kg^{-1}) were found at par with the treatment T_8 (7.75 mg kg^{-1}). Humic acid carbon levels may have decreased with depth due to a slower rate of humification or decomposition. Similar results were noticed by Aswathy *et al.* (2018) [1].

Soil Organic Carbon stock (SOC) in Orchard

According to the findings in Table 4. The Soil Organic Carbon stock sample from orchard varied from a depth of 0 to 30 cm, 30 to 60 cm and 60 to 90 cm.

Significant observations were recorded at a depth of 0 to 30 cm, where treatment T_8 (36.42 Mg ha^{-1}) was found numerically higher over all the treatments however, it was at par with T_4 (34.50 Mg ha^{-1}), T_3 (33.29 Mg ha^{-1}) and T_5 (33.07 Mg ha^{-1}). at a depth of 60 to 90 cm, where treatment T_8 (23.44 Mg ha^{-1}) was found numerically higher over all the treatments and it was at par with treatments T_1 (22.31 Mg ha^{-1}), T_6 (22.11 Mg ha^{-1}), T_3 (21.58 Mg ha^{-1}), T_4 (21.11 Mg ha^{-1}), T_5 (21.10 Mg ha^{-1}) and T_7 (21.01 Mg ha^{-1}). In comparison to subsurface soil (30–60 cm), the surface soils (0–30 cm) displayed larger content SOC stock, which may be explained by the higher organic matter at the surface soil (Bhat *et al.* 2017) [3]. Similar results have been reported by Gupta and Sharma (2011) [17] and Gupta and Negi (2012) [18].

Table 2: Depth wise TOC, WSC, SMBC after 19 year of plantation

Treat.	Depth wise total organic carbon TOC (%)			Depth wise water soluble carbon (WSC) (mg kg^{-1})			Depth wise soil microbial biomass carbon SMBC (mg kg^{-1})		
	0-30cm	30-60cm	60-90cm	0-30cm	30-60cm	60-90cm	0-30 cm	30-60 cm	60-90 cm
T_1	0.88^{ab}	0.74^{b}	0.57^{ab}	124.65^{b}	97.32^{b}	70.08^{abc}	450.59^{ab}	362.19^{ab}	290.96^{ab}
T_2	0.87^{ab}	0.79^{ab}	0.56^{ab}	147.33^{ab}	118.08^{ab}	70.41^{abc}	472.71^{ab}	373.13^{ab}	307.76^{a}
T_3	0.88^{ab}	0.79^{ab}	0.55^{ab}	170.42^{a}	112.00^{b}	87.33^{ab}	476.78^{ab}	379.74^{ab}	308.19^{a}
T_4	0.91^{ab}	0.76^{b}	0.52^{b}	146.75^{ab}	124.67^{ab}	70.05^{abc}	466.23^{ab}	343.17^{b}	286.96^{ab}
T_5	0.90^{ab}	0.77^{ab}	0.55^{ab}	124.67^{b}	97.33^{b}	60.15^{c}	417.09^{b}	339.11^{b}	258.17^{b}
T_6	0.84^{b}	0.75^{b}	0.56^{ab}	147.33^{ab}	118.12^{ab}	71.00^{abc}	430.34^{ab}	336.47^{b}	274.06^{ab}
T_7	0.89^{ab}	0.78^{ab}	0.55^{ab}	171.45^{a}	117.33^{ab}	61.19^{bc}	423.35^{ab}	330.33^{b}	273.26^{ab}
T_8	0.94^{a}	0.83^{a}	0.58^{a}	173.15^{a}	150.00^{a}	90.67^{a}	480.61^{a}	402.27^{a}	318.31^{a}
T_9 Control	0.69^{c}	0.56^{c}	0.42^{c}	90.32^{c}	58.35^{c}	32.12^{d}	253.30^{c}	231.48^{c}	155.58^{c}
SE.±	0.03	0.02	0.02	13.13	11.65	8.77	20.69	19.25	15.34
C.D. 5%	0.08	0.06	0.05	39.69	35.24	26.52	62.58	58.48	46.37

Table 3: Depth wise POSC, Fulvic acid carbon, Humic acid carbon, after 19 year of plantation

Treat.	Depth wise permanganate oxidizable soil carbon POSC (mg kg^{-1})			Depth wise fulvic acid carbon (mg kg^{-1})			Depth wise humic acid carbon (mg kg^{-1})		
	0-30 cm	30-60 cm	60-90 cm	0-30 cm	30-60 cm	60-90 cm	0-30 cm	30-60 cm	60-90 cm
T_1	1,103.25^{ab}	909.08^{ab}	728.29^{ab}	7.26^{e}	6.13^{e}	5.47^{bc}	13.28^{ab}	10.24^{a}	5.72^{c}
T_2	1,148.25^{ab}	929.25^{ab}	715.85^{b}	11.34^{d}	10.45^{d}	6.85^{b}	12.55^{abc}	10.27^{a}	7.60^{a}

T_3	$1,146.75^{ab}$	892.50^{b}	769.07^{ab}	21.26^{a}	18.85^{a}	11.25^{a}	11.48^{c}	10.20^{a}	6.91^{abc}
T_4	$1,050.58^{b}$	908.08^{ab}	712.99^{b}	17.75^{bc}	16.42^{b}	9.85^{a}	12.69^{abc}	10.04^{a}	6.09^{bc}
T_5	$1,203.00^{a}$	958.50^{ab}	710.05^{b}	21.28^{a}	18.59^{a}	10.22^{a}	13.20^{ab}	10.16^{a}	6.65^{abc}
T_6	$1,085.25^{ab}$	900.00^{ab}	716.08^{b}	18.76^{b}	16.91^{b}	10.94^{a}	13.01^{abc}	8.25^{b}	6.42^{abc}
T_7	$1,175.55^{ab}$	962.25^{ab}	701.18^{b}	16.56^{c}	15.13^{c}	10.44^{a}	11.91^{bc}	8.35^{b}	7.41^{ab}
T_8	$1,213.50^{a}$	965.24^{a}	798.40^{a}	21.63^{a}	19.48^{a}	12.28^{a}	13.70^{a}	11.22^{a}	7.75^{a}
T_9 Control	825.75^{c}	636.75^{c}	563.21^{c}	6.54^{e}	5.44^{e}	3.62^{c}	8.26^{d}	6.32^{c}	3.62^{d}
SE.±	44.53	29.11	23.74	0.47	0.37	0.91	0.55	0.48	0.45
C.D. 5%	134.66	88.04	71.78	1.41	1.12	2.77	1.67	1.45	1.36

Table 4: Soil organic carbon (SOC) stock in 19 year old orchard soil

Treatment	SOC stock (Mg ha^{-1})		
	0-30 cm	**30-60 cm**	**60-90 cm**
T_1	32.90^{bc}	28.41^{b}	22.31^{ab}
T_2	31.32^{bc}	29.04^{b}	20.71^{b}
T_3	33.29^{abc}	30.48^{ab}	21.58^{ab}
T_4	34.50^{ab}	29.18^{b}	21.11^{ab}
T_5	33.07^{abc}	28.44^{b}	21.10^{ab}
T_6	30.96^{c}	28.28^{b}	22.11^{ab}
T_7	32.90^{bc}	29.17^{b}	21.01^{ab}
T_8	36.42^{a}	32.91^{a}	23.44^{a}
T_9 Control	26.98^{d}	22.40^{c}	16.97^{c}
SE.±	1.12	0.87	0.82
C.D. @ 5%	3.39	2.64	2.47

Conclusion

Among the treatments used in the orchard, T8 was found to be the most effective for improving carbon fractions, carbon stock, and carbon sequestration at depths of 0-30, 30-60, and 60-90 cm, with the exception of T5, which is suitable for tree height. On an average, 1116.31 kg $tree^{-1}$ *i.e.* 111.63 t ha^{-1} plant carbon has been sequestered in 19 years old mango orchard.

Acknowledgement

Author wish to thank Dr. V. Bhalerao Associate Professor and Rushikesh Bhusari (Ph.D. Scholar) for their untiring guidance, constant support and much needed suggestions to improve the quality of this manuscript.

References

1. Aswathy KV, Balachandran B, Sasi SA, Mohan M. Litter degradation and soil carbon fractions in a tropical mountain cloud forest, Western Ghats, India. Trop Ecol. 2018;59(3):515–24.
2. Brar BS, Singh KD, Dheri GS, Kumar B. Carbon sequestration and soil carbon pools in rice-wheat cropping system: effect of long-term use of inorganic fertilizers and organic manure. Soil Till Res. 2013;128:30–6.
3. Bhat ZA, Akhtar FA, Padder SA, Ganale AQ, Rehman HU, Dar NA, Gill RK. Nutrient status of grape orchard soils of Jammu and Kashmir, India. J Ecol Environ Sci. 2017;2(5):12–9.
4. Biederbeck VO, Janzen HH, Campbell CA, Zentner RP. Labile soil organic matter as influenced by cropping practices in an arid environment. Soil Biol Biochem. 1994;26:1647–56.
5. Bhattacharyya T, Pal DK, Chandran P, Ray SK, Mandal C, Telpande B. Soil carbon storage capacity as a tool to prioritize areas for carbon sequestration. Curr Sci. 2008;95:4.
6. Blair GJ, Lefroy RD, Lisle L. Soil carbon fractions based on their degree of oxidation and development of carbon management index for agricultural systems. Aust J Agric Res. 1995;46:1459–66.
7. Bonde T, Schnurer J, Rosswall T. Microbial biomass as a fraction of potentially mineralizable nitrogen in soils from long-term field experiments. Soil Biol Biochem. 1988;20(4):447–52.
8. Brown S, Sathaye J, Cannell M, Kauppi PE. Management of forests for mitigation of greenhouse gas emissions. Cambridge: Cambridge University Press; 1995.
9. Canadell JG, Raupach MR. Managing forests for climate change mitigation. Science. 2008;320(5882):1456–7. doi:10.1126/science.1155458.
10. Chabbi A, Rumpel C. Organic matter dynamics in agro-ecosystems - the knowledge gaps. Eur J Soil Sci. 2009;60(2):153–7.
11. Chavan BL, Rasal GB. Potentiality of carbon sequestration in six years ages young plant from university campus of Aurangabad. Glob J Res Eng. 2011;11(7):15–20.
12. Chavan B, Rasal G. Total sequestered carbon stock of Mangifera indica. J Environ Earth Sci. 2012;2:2224–3316.
13. Dar MA, Rasool R, Maqbool M, Wani JA, Bhat MY, Ramzan S. Depth wise distribution of primary nutrients in pear orchard soils of Kashmir, India. Int J Curr Microbiol Appl Sci. 2017;6(6):2526–39.
14. Dikaran J, Krishnayya NSR. Variation in type of vegetative cover and heterogeneity of soil organic carbon in affecting sink capacity of soils. Curr Sci. 2008;94:1144–50.
15. Dharmesh G, Jaiswal V, Maheta YB, Patel *et al.* Carbon stock estimation of major tree species in Attarsumba range, Gandhinagar forest division, India. Ann Biol Res. 2014;5(9):46–9.
16. Ganeshamurthy AN, Ravindra V, Rupa TR. Carbon sequestration potential of mango orchards in India. Curr Sci. 2019;117(12):2006–13.
17. Gupta MK, Sharma SD. Soil organic carbon in different land uses and land covers in Bageswar District of Uttarakhand. Ann For. 2011;19(2):237–44.
18. Gupta MK, Negi SS. Carbon sequestration through soil organic carbon pool under different forest covers in Chamoli District of Uttarakhand. Indian Forester. 2012;138(3):207–11.
19. Horticulture Statistics Division, DAC & FW, Department of Agriculture and Cooperation, Farmers Welfare. Horticulture

statistics. 2021.
20. Ingram JS, Fernandes ECM. Managing carbon sequestration in soils: concept and terminology. Agric Ecosyst Environ. 2001;87:111–7.
21. Jagadamma S, Lal R. Distribution of organic carbon in physical fractions of soils as affected by agricultural management. Biol Fertil Soils. 2010;46(6):543–54.
22. Jasmine E, Black T, Wagner GD, Abbott G. Assessing lignin decomposition and soil organic carbon contents across a tropical savannah-rainforest boundary in Guyana. Front For Glob Change. 2021;(4):600–29.
23. Kalbitz K, Solinger S, Park JH, Michalzik B, Matzner E. Controls on the dynamics of dissolved organic matter in soils: a review. Soil Sci. 2000;165:277–304.
24. Kaur B, Gupta SR, Singh G. Carbon storage and nitrogen cycling in silvopastoral systems on a sodic soil in northwestern India. Agrofor Syst. 2002;54(1):21–9.
25. Kumar A, Sharma MP. Assessment of carbon stocks in forest and its implications on global climate changes. J Mater Environ Sci. 2015;6:3548–64.
26. Liang Q, Chen H, Gong Y, Fan M, Yang H, Lal R, Kuzyakov Y. Effects of 15 years of manure and inorganic fertilizers on soil organic carbon fractions in a wheat-maize system in the North China Plain. Nutr Cycl Agroecosyst. 2012;92(1):21–33.
27. Lakaria BL, Patne MK, Jha P, Biswas AK. Soil organic pools and indices under different landuse systems in vertisols of central India. J Indian Soc Soil Sci. 2012;60(2):125–31.
28. McGill WB, Cannon KB, Robertson JA, Cook FD. Dynamics of soil microbial biomass and water soluble organic carbon in Breton L after 50 years of cropping two rotations. Can J Soil Sci. 1986;66:1–9.
29. Naik SK, Maurya S, Bhatt BP. Soil organic carbon stocks and fractions in different orchards of eastern plateau and hill region of India. Agrofor Syst. 2016;91(3):541–52.
30. Nair PR, Nair VD, Kumar BM, Showalter JM. Carbon sequestration in agroforestry systems. Adv Agron. 2010;108:237–307. doi:10.1016/S0065-2113(10)08005-3.
31. National Horticultural Board. National horticulture board. Department of Agriculture and Cooperation; 2022.
32. Nelson DW, Sommer LE. Total carbon, organic carbon and organic matter. In: Page AL, editor. Methods of analysis: part II. Agronomy. Madison (WI): American Society Agronomy; 1982. p. 539–79.
33. Ogle SM, Breidt FJ, Paustian K. Agricultural management impacts on soil organic carbon storage under moist and dry climatic conditions of temperate and tropical regions. Biogeochemistry. 2005;72(1):87–121.
34. Panse VG, Sukhatme PV. Statistical Methods for Agricultural Workers. New Delhi: ICAR; 1967.
35. Purakayastha TJ, Chhonkar PK, Bhadraray S, Patra AK, Verma V, Khan MA. Long-term effect of different land use and soil management on various organic carbon fractions in an Inceptisol of subtropical India. Aust J Soil Res. 2007;45:33–40.
36. Ramesh T, Manjaiah KM, Tomar JMS, Ngachan SV. Effect of multipurpose tree species on soil fertility and CO2 efflux under hilly ecosystems of northeast India. Agrofor Syst. 2013;87:1377–88.
37. Rana VS, Rana NS. Studies on fruit growth and organic metabolites in developing kiwifruit. Indian J Plant Physiol. 2003;8:138–40.
38. Sarkar PK, Sarkar P, Kumar A, Pala AN, Kumar M. Carbon storage potential of a waterlogged agroforestry system of Tripura, India. Water Air Soil Pollut. 2021;232(4). doi:10.1007/s11270-021-05098-z.
39. Sofi JA, Rattan RK, Datta SP. Soil organic carbon pools in the apple orchards of Shopian district of Jammu and Kashmir. J Indian Soc Soil Sci. 2012;60(3):187–97.
40. Stevenson FJ. Humus Chemistry: Genesis, Composition, Reactions. 2nd ed. New York: John Wiley & Sons; 1994. p. 196.
41. Thakur U, Bisht NS, Kumar M, Kumar A. Influence of altitude on diversity and distribution pattern of trees in Himalayan temperate forests of Churdhar Wildlife Sanctuary, India. Water Air Soil Pollut. 2021;232:205. doi:10.1007/s11270-021-05162-8.
42. Thangavel R, Manjaiah KM, Mohopatra KP, Rajasekar K, Ngachan SV. Assessment of soil organic carbon stocks and fractions under different agroforestry systems in subtropical hill agroecosystems of north-east India. Agrofor Syst. 2015;89:677–90.
43. Ravindranath NH, Somashekhar BS, Gadgil M. Carbon flow in Indian forests and climate change. In: Kluwer Academic Publishers; 1997. p. 279–320.
44. Vance ED, Brookes PC, Jenkinson DS. An extraction method for measuring soil microbial biomass carbon. Soil Biol Biochem. 1987;19:703–7.
45. William HS. Carbon and agriculture: carbon sequestration in soils. Science. 1999;284(2223):2095.