**ASSESSMENT OF SOIL ORGANIC CARBON STOCK IN DIFFERENT BLOCK PLANTATION SYSTEMS IN SOUTH GUJARAT CONDITION**

**ABSTRACT:** The study was carried out to assessment the concentration and stock of soil organic carbon (SOC) across nine different types of block plantation systems such as; Sapota- *Manilkara achras* L. (MA), Mango- *Mangifera indica* L. (MI), Teak- *Tectona grandis* L.f. (TG), Killai- *Albizzia procera* (Roxb.)Benth. (AP), Eucalyptus- *Eucalyptus clones* (EC), Casuarina- *Casuarina equisetifolia* L.ex J.R.& C.Fraser (CE), Shisham- *Dalbergia latifolia* Roxb. (DL), Jatropha- *Jatropha curcas* L., (JC) and Arjun- *Terminalia arjuna* (Roxb.ex DC.) Wight & Arn, in South Gujarat, India. Soil samples at different depths (0–10, 10–20 and 20–30 cm) were collected from each of the block plantation under study to estimate SOC content in the laboratory. Hence, bulk density of soil was from 1.28 to 1.42 Mg/m3 as the increased different tree components under block plantation land use systems. Perusal of the plantation of trees data indicate that the available soil organic carbon was found highest (AP; 0.88%) in *A. procera*, which was at par with tree plantation of *T. grandis* (TG; 0.86%), *T. arjuna* (TA; 0.82%), *D. latifolia* (DL; 0.82%) and *M. indica* (MI; 0.81%), *M. achras* (MA; 0.80%). While it was lowest in Eucalyptus clones (EC; 0.77%) respectively. In addition, find out the depth of soil increased the bulk density. From the investigation of this research paper we concluded the top soil surface layer (0-10 cm) showed maximum soil organic carbon content.

***Keywords*:** Block plantation, soil organic carbon, bulk density.

**1. INTRODUCTION:** Soil plays a crucial role in the global carbon cycle due to its active carbon pool (Prentice, *et. al.* 2001). In plantation ecosystems, soil is the largest carbon sink, storing over three times the carbon present in the atmosphere and 3.8 times more than the biotic pool (Zomer, *et al.* 2003). As a result, significant carbon sequestration in soils offers a promising opportunity to mitigate global warming (Singh, *et al.* 2011). Improving the capture and storage of atmospheric CO2 across different land use systems can effectively reduce its concentration while enhancing soil quality. Globally, the top 1 meter of soil holds approximately 1500 Pg of soil organic carbon (SOC), with India contributing about 9 Pg of that total. The Himalayan region accounts for around 33% of India's SOC reserves, largely due to dense forest cover (Bhattacharyya, *et al.* 2008). The amount of SOC can increase or decrease based on various factors such as soil type, climate, topography, and land management practices. However, vegetation has a significant impact on SOC through organic matter input, making land use change a key factor in influencing SOC storage. In natural ecosystems like forests and agroforestry, soils experience minimal disturbance due to fewer cultivation practices, resulting in higher nutrient content and a diverse microbial community compared to agricultural lands. A study from Northeast India found that dense forests had the highest soil organic carbon (SOC) stock at 140.4 Tg, while shifting cultivation had the lowest at 10.7 Tg. The total SOC stock across an area of 10.10 million hectares was 339.82 Tg, with forest soils contributing more than 50%, highlighting the potential for SOC sequestration in the region (Choudhury, *et al.* 2013). Soil carbon sequestration plays a crucial role in maintaining soil health and crop productivity, aiding in climate change mitigation, and enhancing soil physical properties by improving moisture and nutrient retention. However, deforestation and land use changes that remove biomass can accelerate soil erosion, leading to substantial SOC loss from surface soils. Estimating SOC stock across different block plantation land use systems is vital for developing sustainable land management strategies and preventing SOC depletion. Therefore, this study was conducted to estimate SOC stock in various land uses and assess the relationship between SOC and land use types in South Gujarat.

**2. MATERIALS AND METHODS:**

**2.1 Study site:** Geographically, Navsari is situated at 20.95o North latitude, 75.90o East longitude and at an altitude of 12.0 meters above mean sea level (MSL) (Fig.1). According to agro-climatic condition, Navsari is placed in South Gujarat heavy rainfall zone-I (Agro-ecological situation-III). The College instructional farm is located 12 km away in the east from the Arabian Seashore, Dandi. This region belongs to tropical climate characterized by fairly hot summer, moderately cold winter and more humid and warm monsoon with heavy rain. The average annual precipitation is 1355 mm. The soil of the experimental site is dark grayish brown type with flat topography. The soil is characterized by medium to poor drainage and good water holding capacity. The predominant clay mineral is montmorillonite. The present investigation was carried out during 2014-15 in Navsari district of Gujarat by choosing Nine tree plantation Sapota- *Manilkara achras* L. (MA), Mango- *Mangifera indica* L. (MI), Teak- *Tectona grandis* L.f. (TG), Killai- *Albizzia procera* (Roxb.)Benth. (AP), Eucalyptus- *Eucalyptus clones* (EC), Casuarina- *Casuarina equisetifolia* L.ex J.R.& C.Fraser (CE), Shisham- *Dalbergia latifolia* Roxb. (DL), Jatropha- *Jatropha curcas* L.,(JC) and Arjun- *Terminalia arjuna* (Roxb.ex DC.) Wight & Arn. were selected for comparison their soil organic carbon potential.Table 1;showed the detail of block plantation with 3 replication, number of tree/hectare, were taken for observations.

 **Fig 1: Map of Navsari district of Gujarat, India(Red circles show the research area)**

**2.2 Procedure of soil sample collection and preparation:**

From the different land use system, soil were collected from different soil depth such as-0-10 cm, 10-20 cm, 20-30 cm in triplicates. The composite soil samples for each depth were obtained by mixing three samples. For analysis of soil physio-chemical, sample were air dried in shade, ground with wooden pestle, passed through 2 mm sieve and stored in cloth bags (Walkley and Black, 1934).

**Table 1: Details of different block plantation land use systems.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S.no** | **Block plantation Land use systems** | **Tree spacing (m)** | **Planting Year** | **No of trees (Per hectare)** |
| 1 | Sapota- *Manilkara achras* L. (MA),  | 8 x8 | 1994 | 156 |
| 2 | Mango- *Mangifera indica* L. (MI) | 8 x8 | 1990 | 156 |
| 3 | Teak- *Tectona grandis* L.f. (TG),  | 3 x3 | 1990 | 1111 |
| 4 | Killai- *Albizzia procera* (Roxb.)Benth. (AP) | 3 x3 | 1995 | 1111 |
| 5 | Eucalyptus- *Eucalyptus clones* (EC),  | 2 x2 | 2009 | 2500 |
| 6 | Casuarina- *Casuarina equisetifolia* L.ex J.R.& C.Fraser (CE),  | 2x 2 | 2009 | 2500 |
| 7 | Shisham- *Dalbergia latifolia* Roxb. (DL),  | 3 x 3 | 1991 | 1111 |
| 8 | Jatropha- *Jatropha curcas* L.,(JC)  | 2 x 2 | 2006 | 2500 |
| 9 | Arjun- *Terminalia arjuna* (Roxb.ex DC.) Wight & Arn. (TA)  | 4 x 4 | 1990 | 400 |

The samples were air dried and used for determining organic carbon. Soil bulk density was measured by core method (Allen *et al*., 1974). Soil OC stock (Mg ha-1) at different soil depths in different agroforestry systems were calculated using the formula given by Nelson and Sommers (1996):

**SOC stock (Mg ha-1) = SOC (%) × bulk density (Mg m-3) ×soil depth (m) × 100
2.3 Data analysis:** The experimental data were subjected to the statistical analysis as per the procedure suggested by Gomez and Gomez (1984). The treatment differences were tested by ‘F’ test of significance based on null hypothesis. The appropriate standard error (S.Em.±) was calculated in each case and critical difference (C.D.) at 5 percent level of probability was worked out to compare the treatment means, where the treatment effects were significant.

**3. RESULTS AND DISCUSSION:**

**3.1 Bulk density:** The bulk density (BD) of fine soil (<2 mm) across different land use types and varying soil depths ranged from 1.28 to 1.42 Mg m-3 (Figure 2). On average, the bulk density in the 0–30 cm soil profile was lowest in *Albizzia procera* (Roxb.)Benth. (AP, 1.28 Mg m-3) block plantation and highest in *Manilkara achras* L. (MA, 1.42 Mg m-3). The relatively higher soil bulk density observed in *Terminalia arjuna* (TA) and *Jatropha curcas* L.,(JC) compared to other land uses, may be attributed to cultivation practices such as tillage, which can lead to soil compaction. Numerous studies have suggested that as soil depth increases, the bulk density tends to rise as well. In this context, the soil bulk density across all the land use types examined was consistently found to be well below the critical threshold, indicating the absence of severe soil compaction. The bulk density increased as the depth of soil sampling increased. Plantation of trees under different land use systems directly correlated to soil bulk density level decreasing due to the more organic matter which leads to better soil structure and hence more porosity of soil. Halvorson *et al*. (2002), Baruah & Barthakur, (1997) also reported the bulk density inversely related to tillage intensity. Christine, 2006 supported the finding of tree component increased the area for tillage decreases and decrease in bulk density with increase in soil depth.

**3.2 Soil organic carbon:** The mean data regarding variation in soil organic carbon under different Plantation land use systems are presented in Fig.3. Soil organic carbon content of different soil samples (depth) collected from different Plantation land use system was compared in the study

for the soil organic carbon was found amongst the systems, the top 0-10 cm soil layer in to be highest in *A. procera* (AP; 0.88%), which was at par with tree plantation of *T. grandis* (TG; 0.86%), *T. arjuna* (TA; 0.82%), *D. latifolia* (DL; 0.82%) and *M. indica* (MI; 0.81%), *M. achras* (MA; 0.80%). While it was lowest in Eucalyptus clones (EC; 0.77%) respectively. In the second sub surface layer (10-20 cm), the results showed similar trends as observed in upper surface layer. This may happen because of enhanced stock of leaf litter in the tree based land use systems. The abundant leaf litter or pruned biomass returns to soil, combined with decay of roots contribute to the improvement of organic matter under complex land use systems (Kumar *et al*. 2001 and Bhalawe *et. al.* 2013).Our findings are also supported by Tandel (2003). From the agroforestry land use system combined crops and trees practices shows that maximum ( 0.76%) available soil organic carbon in (RTG) *O.sativa* grown with *T.grandis,* which was at par with *M.paradisiaca* grown with *T.grandis* (BTG;0.70%) and *S.officinarum* grown with *C.equisetifolia* (SCE;0.69%), respectively (Bhalawe *et. al.* 2024). This may be due to abundant tree leaf litter biomass returns to soil, combined with decay of roots contribute to the improvement of organic matter. Similar observations were recorded by Pandey *et al.* (2000) in *Acacia nilotica* based agroforestry systems and opined that tree canopy contribute toward nutrient conservation, soil amelioration and nutrient availability.

**Table 2: Different block plantation land use systems and soil depth on soil organic carbon stock (t/ha).**

|  |  |  |  |
| --- | --- | --- | --- |
| S.no. | **Treatments****(Land use systems** | **Soil depth** | **Average** |
| **( 0-10 cm)** | **( 10-20 cm)** | **( 20-30 cm)** |
| **1** | **Tree plantation land use systems**  |
| a | Sapota-*Manilkara achras* L. (MA),  | 14.10 | 11.95 | 9.80 | 11.95 |
| b | Mango- *Mangifera indica* L. (MI) | 14.88 | 12.64 | 10.20 | 12.57 |
| c | Teak- *Tectona grandis* L.f. (TG),  | 17.42 | 14.50 | 12.80 | 14.91 |
| d | Killai- *Albizzia procera* (Roxb.)Benth. (AP) | 18.5 | 17.20 | 16.35 | 17.35 |
| e | Eucalyptus- *Eucalyptus clones* (EC),  | 11.50 | 10.45 | 9.20 | 10.38 |
| f | Casuarina- *Casuarina equisetifolia* L.ex J.R.& C.Fraser (CE),  | 12.98 | 11.10 | 9.50 | 11.19 |
| g | Shisham- *Dalbergia latifolia* Roxb. (DL),  | 15.95 | 13.60 | 11.20 | 13.58 |
| h | Jatropha- *Jatropha curcas* L.,(JC)  | 13.50 | 11.40 | 10.10 | 11.67 |
| i | Arjun- *Terminalia arjuna* (Roxb.ex DC.) Wight & Arn. (TA)  | 16.10 | 13.64 | 12.10 | 13.95 |

Note: CD (p=0.05), land use-1.62, soil depth-0.65, interactions: land use x soil depth 1---n  -1.84, soil depth x land use 1---n  -2.24

**3.3 Soil organic carbon stock:** Soil organic carbon stock decreased with increase in soil depth, signifying the importance of upper layer in storing soil organic carbon Table 2. Similarly the highest average soil carbon stock was 17.35 t/ha in block plantation land use systems of *Albizzia procera* (AP), which was followed by tree plantation land use systems  *Tectona grandis* (TG), *Terminalia arjuna* (TA), *Dalbergia latifolia* (DL) and least in *Eucalyptus clones* (EC) 10.38 t/ha. The upper soil layer (0-10cm) of *Albizzia procera* stored (AP; 18.50.42 t/ha) soil organic carbon stock, which was at par with *Tectona grandis* (TG; 17.42 t/ha), *Terminalia arjuna* (TA; 16.10 t/ha), *Dalbergia latifolia* (DL; 15.95 t/ha) and least in *Eucalyptus clones* (EC;11.50 t/ha). In the sub-layer of soil profile found similar trend with top layer (0-10 cm). It was observed that the top soil layer (0-10 cm) depth showed significantly highest soil organic carbon stock compared to lower layer of soil depth. Higher the soil organic carbon in tree plantation land use systems is due to the return of more organic matter to the soil in the form of leaves, bark, fruits and flowers (Bhalawe *et al.* 2019). The study of different land use systems are conformity with the results obtained by Ladegaard *et al.* 2005, Singh *et al.* 2018 and Jha *et al.* 2003 reported the soil organic carbon stocks differed significantly among tree species.

**Correlation regression between soil organic carbon and bulk density:** Soil organic carbon (SOC) and soil bulk density (BD) are two important soil properties that are closely related. Soil organic carbon and bulk density are typically negatively correlated, meaning that BD increase, SOC tends to decrease due to the greater soil compaction which can lead to reduced soil aeration and water infiltration, making it less favorable for organic matter accumulation and limit root growth and microbial activity (Fig 4). Similar result reported by Raju singh *et al.* (2019), Baishy and Sharma (2017), Kalita *et al.* (2016) and Das (2014).

**4. CONCLUSION:** In conclusion, the study on soil organic carbon stock in different block plantation systems under South Gujarat conditions provides valuable insights into the impact of plantation practices on soil health. Among the studied block plantation systems, those dominated by native species such as *Albizzia procera* (AP), *Tectona grandis* (TG) *and Terminalia arjuna* (TA)tended to accumulate more SOC than those with exotic species *Eucalyptus clone* (EC) as well as old block plantation and those with minimal disturbance (e.g. reduced tillage, no fertilizers) generally showed higher SOC stocks than younger plantation or those with more intensive management. Soil organic carbons were negatively correlated with soil bulk density. Additionally the study areas subtropical climate with distinct wet and dry seasons, likely influenced SOC dynamics.

**COMPETING INTERESTS DISCLAIMER:**

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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