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Biomass and carbon storage potential of teak clonal seed orchards: Implication for climate change mitigating

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ABSTRACT: *Teak (Tectona grandis Linn.f.) is one of the world-famous commercial tree species grown across tropical and sub-tropical countries. For large scale plantations, good quality seeds are required. Thus, under the tree improvement programme, provenance trials, seed production areas, clonal seed orchards, and seedling seed orchards of important tree species including teak had been established in different parts of the country. These research/seed production trials act as long-term conservation plots. Moreover, these plots can act as carbon sinks. Exploring opportunities for linking teak plantations with carbon credit markets is one of the discussion points of 5th World Teak Conference held at Cochin, India during Sept. 2025. Similarly, we can also think of long-term tree improvement trials like CSOs for its use in carbon trading. Thus, a present study was undertaken to estimate the biomass and carbon sequestration potential of teak clones in a 53-year-old clonal seed orchard located at Waghai, Gujarat. Study reveals that DBH, volume, stem biomass, carbon storage and carbon sequestration showed a significant variation among the 18 studied teak clones. Clones such as TC-1, followed by TC-12, TC-2 and TC-8 showed superiority for biomass accumulation and carbon storage potential over other teak clones. Based on the observation, it was estimated that a 53-year-old teak 1 ha clonal seed orchard (CSO) can store about 150 tons of carbon. Therefore, CSO acts as a carbon reservoir and it can be used in the carbon credit programme, depending upon total area available. Considering the clonal potentiality, further screening of clones can be made for large scale clonal plantations to achieve maximum biomass and carbon yield.*

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1. INTRODUCTION

Carbon sequestration, a process of long-term storage of carbon in plants (especially trees), soils, geologic formations and the ocean, play a vital role in mitigating climate change. Forests serve as carbon sinks, where plants absorb carbon dioxide (CO_2) from the atmosphere through photosynthesis and storing it in trees including plants, and soils. As per recent country report, total carbon stock for the year 2023 is estimated to be 7,285.5 Mt with an increase of 81.5 Mt as compared to previous assessment. Considering tropical forests, wet evergreen forests topped in carbon stock accumulation (173.67 t/ha), followed by littoral and swamp forests (125.59 t/ha), and moist deciduous forests (101.20 t/ha); however, it was the least in thorn forests (39.61 t/ha) and dry deciduous forests (78.03 t/ha; ISFR, 2023).

Gujarat Ecological Education and Research (GEER) foundation, Gandhinagar, Gujarat reported the carbon sequestration potential of 51 important tree species in Gujarat. Among them, *Tectona grandis, Eucalyptus globulus, Prosopis juliflora, Azadirachta indica, Casuarina equisetifolia* and *Acacia tortilis* plantation sequestered more carbon content of 3.70, 2.47, 1.67, 1.45, 1.28 and 1.04 lakh tons (http://timesofindia.indiatimes.com). Similarly, Navsari Agricultural University, Navsari, Gujarat also determined the carbon sequestration potential of 12 forest tree species *viz.,* Teak, Arjuna, White Siris, Neem, Eucalyptus, Casuarina, Haldu, Kalam, Bijasal, Subabul, Sapota and Mango. Among them, Casuarina, followed by Bijasal, Eucalyptus, Haldu, Subabul and Teak performed superiority in terms of its biomass and carbon storage potential across different girth classes (Behera *et al.,* 2019).

As per the recent conference report, teak plantations play a major role in carbon sequestration and it could be viable option for Forest Landscape Restoration programme, moreover, additional incentives can be tapped from carbon credit markets, and it may also support the global effort on climate change mitigation (Walter Kollert and Thulasidas, 2025). On the other hand, long term preservation/conservation plots like botanical gardens, arboretums, tree improvement plots such as clonal seed orchards, seedling seed orchards, seed production areas, clonal garden and breeding populations also act as carbon reservoirs. Thus, documentation of carbon storage and

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sequestration potential of tree improvement stands such as seed orchards or seed production areas is necessary (Bhat *et al.,* 2005; Gunaga and Vasudeva, 2005; Gunaga, 2011). Recent report shows that, based on 20 years observation, clonal plantations show considerably higher yields and better timber quality than plantations established from seeds (Walter Kollert and Thulasidas, 2025).

Review showed that age, spacing, types of planting materials, site/ environment, cultural practices, tree x crop ecology, genetic, GxE interaction factors stimuluses the overall biomass and carbon sequestration potential in forest trees including teak (Watanabe *et al.,* 2009, Sreejesh *et al.,* 2013, Nirala *et al.,* 2018, Damayanti *et al.,* 2019, Toppo *et al.,* 2021, Subba and Honnurappa, 2024, Widiyatno *et al.,* 2024, Rathod *et al.,* 2025, Krishnan *et al.,* 2025, Ruiz-Blandon *et al.,* 2025). Documentation of biomass accumulation and carbon sequestration potential of tree species like teak in pure plantations, mixed plantations, agroforestry systems and/or urban plantations are documented in Table 1. Study shows that clonal materials performed better growth and biomass than seedlings of seed origins, which is mainly due to the genetic characteristics of the materials used (Mulyadiana *et al.,* 2020, Saravanan, 2020). Moreover, Subba and Honnurappa (2024) recorded clonal variation for biomass and carbon accumulation among teak clones of Karnataka. However, comparison studies between plantation systems and improved stands such as Seed Production Areas and Seed Orchards for biomass and CO_2 accumulation are scanty in teak. The 5th World Teak Conference also recommends exploring the opportunities of linking teak plantations with carbon credit markets (Walter Kollert and Thulasidas, 2025). The present study focuses the efficiency of older clonal seed orchards for carbon storage potential linking to carbon trading in teak, a world-famous commercial tree species of India.

2. MATERIALS AND METHODS

Study was carried out in a clonal seed orchard of teak. Clonal seed orchards are plantations where clones of different plus trees possibly from different geographic situations are planted at wider spacing (of 5x 5 m to 8 x 8 m) to intermate among the clones to obtain genetic quality seeds in larger quantity, so that quality seedling produced from such seed sources assures the better quality of wood production in the established plantation (Bhat *et al.,* 2005). This stand is entirely different from traditional plantation, where plantations are raised for wood production with initial spacing of 2 x 2m; thereafter, regular thinning was done to get sufficient space for higher growth and productivity (Sreejesh *et al.,* 2013). On other hand, clonal orchards are maintained for a longer period of time for regular seed production, and also serve as an *ex situ* conservation plot. Hence, such orchards can potentially be used for carbon trading programme.

The present investigation was carried out in a clonal seed orchard (CSO) of teak located in the northern most western ghats region, Waghai taluka of the Dangs district, Gujarat. The Dangs area receives rainfall through the South-West monsoon, especially during mid of the June and annual rainfall ranges from 2000 to 2500 mm. Peak rains occur during July to August months. Temperature ranges from 13 to 38 °C; while humidity ranges from 25 to 90 per cent. This area is characterized as undulating topography with hilly slope, valley and plain river beds. Soil is a loamy mixed type (https://rkvy.da.gov.in).

The present investigation was carried out in a 53-year-old clonal seed orchard of teak established during the 1971-72 by the Dungarda Research Range of Gujarat Forest Department (GFD), Rajendrapur, Waghai [20° 46' 33.4056" N and 73° 30' 31.7232" E with an altitude of about 120 meter above the mean sea level]. This orchard consists of 10 blocks with a total area of 10 ha and it is composed of 18 teak clones spaced at 5 x 5m. This seed orchard is maintained for large scale production of genetically superior quality seeds for healthy seedling production in the nursery. Regular weeding and clearing of ground were practiced by the GFD.

In the present study, 18 clones planted in the first block were considered to study the growth and yield attributes. Total 235 ramets were measured; among them, data from 162 trees (18 clones and 9 ramets per clone) were used for the statistical analysis.

In this study, standing tree growth attributes were recorded for individual ramet from all the 18 teak clones. Growth attributes such as height and DBH and yield attributes such as stem volume [V (m^3) = π (D^2/4) x h x FQ], basal area (m^2) [

Clone wise data were collected, entered and processed in the data sheet using MS Excel and preliminary verification was done. Further, these data were subjected to statistical analysis using OP-STAT statistical software (Sheoran *et al.,* 1998). Total 18 teak clones were used as treatments (T=18) with nine ramets (individuals of clones) as replications and ANOVA was constructed following a completely randomized design. The treatment differences were tested by the 'F' test of significance based on the null hypothesis. The data recorded in the present study are summarized in the tables- 2 and 3. Association between DBH with yield parameters were analyzed using linear type regression equation and data were presented in the form of graphical representation (Fig. 1).

Table 1. Pattern of biomass and carbon accumulation in teak, grown in different land-use systems

S.No.	Land-use systems	Description	Major outcomes on biomass and carbon accumulation	References
1	Natural forest	Studied teak trees growth and yield parameters in Gir National Park and Gir Wildlife Sanctuary, Sasan Gir, Gujarat.	In National Park, total dry biomass (above and below) per tree was 189.07 kg, carbon content per tree was 94.5 with 59.96 tons CO_2 per ha, whereas in Wildlife sanctuary, total dry biomass per tree was 202.42 kg, carbon content per tree was 101.21 kg with 33.44 tons CO_2 per ha.	Goyal *et al.* (2024)
2	Agroforestry systems	Study undertaken in 15-years-old teak plantation established at 2 × 2 m spacing.	Annual carbon sequestration varied from 2.53 (Sole teak) to 4.06 tons per ha (Teak+ Barley) in five teak based agroforestry systems studied along with sole teak.	Jain and Ansari (2013)
3	Farm grown teak	Studied three age groups *viz.*, 5-10 yrs, 10-15 yrs and 15-20-yrs plantations in three agroclimatic zones of Tamil Nadu *viz.*, North eastern zone, North western zone, and Cauvery delta zone (Total nine plantations).	Total carbon equivalent varied from 0.282 to 0.683 Mg/acre in 15-20 yrs age to 0.102 to 0.214 Mg/acre in 5-10 yrs age in three agroclimatic zones.	Krishnan *et al.* (2025)
4	Silvipastoral AF system	12 treatments *viz.*, T1: Teak + Hybrid Napier, T2: Teak + Sudan grass, T3: Gamhar + Hybrid Napier, T4: Gamhar + Sudan grass, T5: Teak + Gamhar + Hybrid Napier, T6: Teak + Gamhar + Sudan grass, T7: Teak, T8: Gamhar, T9: Teak + Gamhar, T10: Sole Hybrid Napier, T11: Sole Sudan grass, T12: Control. At Birsa Agricultural University, Ranchi, Jharkhand.	Total carbon sequestration potential (ton ha-1) of teak based system was T1 (88.64) >T2 (77.68) >T5 (69.55) >T6 (65.36) >T7 (62.90) > T9 (49.77).	Toppo *et al.* (2021)
4	Pure teak plantation	Ages- 5, 10, 15, 20, 30, 40 and 50 years of teak plantations at Nilambur forest division, Kerala.	Wood biomass yields were recorded to be 50.56 <91.50 <112.15 <142.28 <254.34 <480.48 <635.85, respectively from lower to higher age classes. Similarly, carbon content per tree were recorded to be 23.26 <42.09 <51.59 <65.45 <116.99 <221.02 <292.49, respectively from lower to higher age classes.	Sreejesh *et al.* (2013)
5	Plantation system	Six age groups (1.5, 3.5, 7.5, 13.5, 18.5 and 23.5 years) Farm plantations.	Aboveground biomass (kg) recorded by teak was 1.39, 4.94, 12.90, 49.22, 71.78, and 141.39 kg, respectively in 1.5, 3.5, 7.5, 13.5, 18.5 and 23.5 years	Jain and Ansari (2013)
6	Pure teak plantation	Different age group plantations (28 to 48 yrs) of teak at five different compartments of Bhabar and Shivalik regions of Kotdwar Forest Division Uttarakhand.	Both sites and age of plantations affected the growth, biomass and carbon content in teak. Among 27 plantations evaluated, lowest total biomass, carbon and CO_2 was 256.75 128.37 471.13 tons per ha, respectively in Sigaddi-18B plantation, and they were more (858.84 429.42 1575.97 tons per ha, respectively) in Sigaddi-18A plantation.	Nirala *et al.* (2018)
7	Pure teak plantation	20-years-old teak plantation grown outskirts of Burla town of Sambalpur, Odisha, Eastern Ghats (Sampled area of 23 ha with stocking of ~2000 plants per ha).	Total biomass (above + below) and carbon storage varied from 48.83 to 67.20 and 24.41 to 33.60 kg per m^2 (average of 58.17 and 29.09 kg per m^2, respectively).	Singh *et al.* (2020)
8	Pure teak plantation	Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, Konkan region of Maharashtra.	Average biomass and carbon stock of 6 years-old plantation was found to be 31.20 and 15.60 tons/ha, respectively (101.01 kg biomass per tree and 50.51 carbon per tree)	Zagade *et al.* (2022)
9	Clonal seed orchard	Evaluated eight teak clones - MyHaD1, MyHaD4, MyHaV1, MyHaV3, MyHaK2, MySA1, MyHuT1 and MyMK3 established at 40 years old teak clonal orchard, Manchikere, Karnataka.	Biomass ranged from 0.98 (2.93 tons per three ramets, MyHaV1) to 2.57 tons per tree (7.70 tons per three ramets, MySA1), and carbon sequestration potential ranged from 0.49 (1.46 tons per three ramets, MyHaV1) to 1.28 tons per tree (3.85 tons per three ramets, MySA1)	Subba and Honnurappa (2024) Personal communication with Susmita Subba
10	Clonal seed orchard	13 clones of teak established at teak CSO, Orissa.	Among 13 teak clones, ORANP2 accumulated highest biomass of 223.72 tons per ha, while ORANP1 accumulated lowest biomass of 64.05 tons per ha. Total carbon stock ranged from 32.02 to 111.86 tons per ha, respectively in ORANP1 and ORANP2.	Behera and Mohapatra (2015)

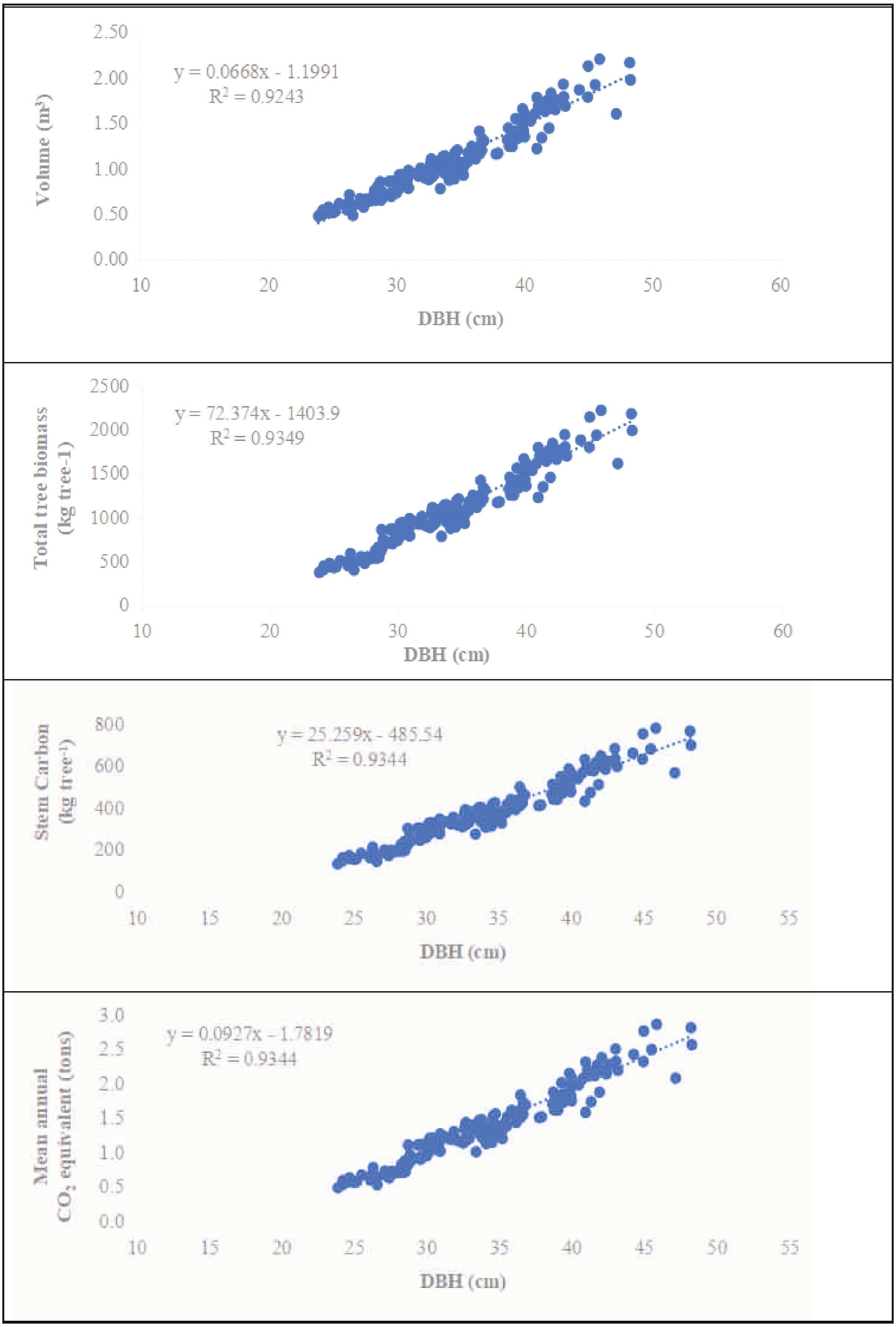

Fig. 1: The relationship between DBH with volume, biomass, carbon storage and carbon sequestration among teak clones

3. RESULTS AND DISCUSSION

Height (m) and DBH (cm): Result shows that the diameter at breast height (DBH) showed a significant variation among 18 teak clones that ranged between 28.27 and 39.27 cm with mean diameter of 34.10 cm (Table 3). However, the height does not vary significantly among the studied clones.

***Yield Attributes*:** Study revealed that the stem volume (0.71 to 1.43 m^3), above ground biomass (512.48 to 1135.82 kg $tree^{-1}$), below ground biomass (133.25 to 295.32 kg $tree^{-1}$), total tree biomass (645.72 to 1431.14 kg $tree^{-1}$), stem carbon storage (230.89 to 504.62 kg $tree^{-1}$), carbon sequestration potential (values of CO_2 equivalent = 0.85 to 1.85 tons $tree^{-1}$) showed a significant variation among teak 18 clones at the age of 53 years (Table 4).

The overall mean values of tree height, DBH, tree volume, above ground biomass, below ground biomass, total tree biomass and stem carbon storage potential of 18 teak clones were 22.15 m, 34.10 cm, 1.08 m^3, 844.19 kg $tree^{-1}$, 219.49 kg $tree^{-1}$, 1063.68 kg $tree^{-1}$ and 375.67 kg $tree^{-1}$, respectively (Table 3 and 4). Interestingly, mean total carbon sequestration potential in terms of CO_2equivalent was 1.38 tons $tree^{-1}$ at the 53 years age (Table 4).

Among the selected clones, TC-1 was found to be superior for growth and yield attributes than the rest of the clones. In fact, TC-1 showed significantly stronger than TC-18 for all these attributes. Other clones such as TC-12 > TC-2 > TC-8 also performed better for higher biomass and carbon storage.

***Association study*:** Regression study shows that DBH was found to be significant and it directly influences the volume (V= 0.0668*D - 1.1991, R^2 = 0.924), Total tree biomass (TTB= 72.374*D - 1403.9, R^2 = 0.934), Carbon storage (CS= 25.259*D - 485.54, R^2 = 0.934) and CO_2 equivalent value (CO_2e= 0.0927*D - 1.7819, R^2 = 0.934) and they are presented in figure 1. In fact, r^2

Table 2. Specific gravity and wood carbon content estimates for teak trees of different diameter classes used in the study (Behera *et al.*, 2019)

Sr. No.	Teak Girth classes	Basic density value (kg m^{-3})	Wood carbon value (%)
1	G: 60-75 cm	620.19	44.95
2	G: 75-90 cm	653.85	45.67
3	G: > 90 cm	798.08	44.38

Table 3. Variation among 18 teak clones for growth attributes in a clonal seed orchard (Values are Mean ± SE)

Sr. No.	Clonal ID	Tree height (m)	DBH (cm)
1	TC-1	22.27±0.51	39.27±2.21
2	TC-2	22.80±0.36	37.21±1.18
3	TC-3	21.38±0.83	33.86±1.84
4	TC-4	22.53±0.92	34.82±2.28
5	TC-5	22.21±0.63	35.25±2.02
6	TC-6	22.27±0.66	34.97±1.91
7	TC-7	21.76±0.83	32.84±1.35
8	TC-8	22.60±0.83	36.84±1.62
9	TC-9	21.90±0.45	33.20±1.44
10	TC-10	23.43±0.75	34.95±1.34
11	TC-11	21.42±0.55	30.85±1.79
12	TC-12	22.84±0.81	37.23±2.16
13	TC-13	21.67±0.85	33.74±2.38
14	TC-14	22.17±0.73	33.57±1.55
15	TC-15	22.41±0.61	31.32±1.82
16	TC-16	21.49±0.32	32.58±1.62
17	TC-17	21.87±0.84	32.95±1.35
18	TC-18	21.64±0.47	28.27±1.03
	Grand Mean	22.15	34.10
	SEm (±)	0.69	4.92
	C.D. @ 5%	NS	1.76

Table 4: Variation among 18 teak clones for yield attributes in a clonal seed orchard (Values are Mean ± SE)

Sr. No.	Clonal ID	Stem Volume (SV) (m^3)	Above Ground Biomass (AGB) (kg $tree^{-1}$)			Stem carbon storage (SCS) (kg $tree^{-1}$)	CO_2 equivalent [Carbon sequestration] (tons $tree^{-1}$)
			Above Ground (AGB)	Below Ground (BGB)	Total (TTB) (AGB+BGB)		
1	TC-1	1.43±0.16	1135.82±135.62	295.32±35.26	1431.14±170.88	504.62±59.81	1.85±0.22
2	TC-2	1.28±0.09	1027.25±69.58	267.09±18.09	1294.34±87.67	455.90±30.88	1.67±0.11
3	TC-3	1.03±0.13	796.82±112.67	207.17±29.29	1003.99±141.96	355.32±49.27	1.30±0.18
4	TC-4	1.17±0.18	920.73±152.94	239.39±39.77	1160.11±192.71	409.41±67.54	1.50±0.25
5	TC-5	1.15±0.14	921.70±114.25	239.64±29.71	1161.33±143.96	409.05±50.71	1.50±0.19
6	TC-6	1.14±0.14	892.59±121.94	232.07±31.71	1124.66±153.65	397.34±53.54	1.46±0.20
7	TC-7	0.97±0.10	769.59±85.63	200.09±22.26	969.68±107.90	342.04±37.70	1.26±0.14
8	TC-8	1.27±0.14	1015.30±110.50	263.98±28.73	1279.28±139.23	450.59±49.04	1.65±0.18
9	TC-9	0.99±0.08	785.28±72.25	204.17±18.79	989.45±91.03	349.01±31.69	1.28±0.12
10	TC-10	1.17±0.10	933.32±75.51	242.66±19.63	1175.98±95.15	414.21±33.51	1.52±0.12
11	TC-11	0.86±0.12	647.13±105.84	168.25±27.52	815.39±133.36	289.65±46.39	1.06±0.17
12	TC-12	1.32±0.17	1043.83±139.30	271.40±36.22	1315.23±175.52	463.91±61.48	1.70±0.23
13	TC-13	1.01±0.11	789.44±97.69	205.26±25.40	994.70±123.09	351.36±42.79	1.29±0.16
14	TC-14	1.03±0.11	810.37±89.08	210.69±23.16	1021.06±112.24	360.39±39.23	1.32±0.14
15	TC-15	0.93±0.13	704.68±116.17	183.22±30.20	887.91±146.37	315.02±50.81	1.16±0.19
16	TC-16	0.94±0.10	725.55±93.26	188.65±24.25	914.19±117.51	323.87±40.67	1.19±0.15
17	TC-17	0.96±0.07	763.55±62.92	198.52±16.36	962.08±79.27	339.40±27.51	1.24±0.10
18	TC-18	0.71±0.06	512.48±60.40	133.25±15.70	645.72±76.11	230.89±26.05	0.85±0.10
	Grand Mean	1.08	844.19	219.49	1063.68	375.67	1.38
	SEm (±)	0.34	291.70	75.84	367.54	128.38	0.47
	C.D. @ 5%	0.12	104.24	27.10	131.35	45.88	0.17

values for these traits were found to be higher; hence, the same equation may be used to determine the volume, biomass, carbon storage and CO_2 equivalent based on DBH in teak, especially grafted clones of about 50 years of age group. Jain and Ansari (2013) also documented that age, height and DBH exhibited positive relationship with above ground biomass in a teak plantation established at Tropical Forest Research Institute, Jabalpur, Madhya Pradesh. Similarly, Ruiz-Blandon *et al.* (2025) also recorded the positive relationships between stem and total biomass with DBH, while roots showed positive relationship with belowground development and diameter increment.

Improved plantations such as seed stand/seed production area, provenance stand, seed orchards and breeding stands contribute genetic quality seeds for large scale seedling production. Among these, seeds collected from the clonal seed orchard play a vital role in terms of maintaining genetic quality and diversity of seed source. CSO refers to a plantation consisting of clones from selected trees usually of proven genetic quality, and it is isolated to control pollination from foreign pollens, and managed for early and abundant seed production (Schmidt, 1997). On other hand, clonal plantation generally exhibits faster, uniform, and superior growth, better stem form, and uniform wood quality as compared to plantation raised from seedling source (Smit and Oestreich, 2014, Walter Kollert and Michael Kleine, 2017, Mulyadiana *et al.,* 2020, Widiyatno *et al.,* 2024). This is mainly due to the selection of genetically superior trees for propagation. Moreover, plantations established from seedlings raised from CSO are performing better than traditional seedling plantations raised from unknown seed sources (Walter Kollert and Michael Kleine, 2017, Olivier and Doreen, 2017, Widiyatno *et al.,* 2024).

CSOs are mainly regulated for a longer period of time, especially state forest department and research institutions, to obtain genetic quality seeds in large quantities; thus, CSOs can be considered as long-term Conservation Stands. In the present study, the DBH and various yield attributes such as biomass, carbon storage and carbon sequestration showed a significant variation among the 18 teak clones, which shows the genetic superiority of clones for biomass accumulation and carbon storage potential. Similarly, Lyngdoh *et al.* (2012) found significant variation among teak clones established in Clonal Seed Orchard at Karnataka for DBH, height and volume. Further, Subba and Honnurappa (2024) recorded clonal differences for growth and carbon sequestration among teak clones in 40 year's clonal teak orchard at Manchikere, Karnataka and they have identified eight best clones that sequester more carbon *viz.,* MyHaD1, MyHaD4, MyHaV1, MyHaV3, MyHaK2, MySA1, MyHuT1 and MyMK3. Behera and Mohapatra (2015) studied clonal variation in growth, biomass and carbon accumulation among 13 clones of teak, where clone-ORANP2 exhibited better, followed by ORANP2, ORANP3, ORANP6, ORANP7 and ORANR3 clones. Similarly, in the present study, teak clones such as TC-1>TC-12>TC-2>TC-8 accumulated more biomass and more carbon sequestration. This could be due to genetic factors. Kaosa-ard *et al.* (1998) reported an estimated gain of 17% when seeds were collected from selected clones from a clonal seed orchard of teak. Kjaer and Foster (1996) also reported genetic gain in terms of economics, where 50-year-old teak trees grown from improved planting stock fetched more money as compared to trees grown from unimproved material. Hence, clonal materials play a vital role in higher carbon sequestration potential. On the other hand, the carbon sequestration potential of different species is highly dependent upon the photosynthetic rate, transpiration rate and other eco-physiological activities throughout the day (Hari Prasath *et al.,* 2016). Physiological attributes may also influence the growth and carbon assimilation in different genotypes. Sharma and Bakshi (2014) compared the growth attributes with physiological and biochemical attributes in *Dalbergia sissoo* clones, where total chlorophyll content and chlorophyll fluorescence influenced the growth among different clones. Thus, there is a need to consider physiological attributes while studying the CO_2 sequestration in forest tree species.

Parthiban (2025) has documented productive potential of tree genetic resources, where teak clone-MTP TK 07 yielded about a productive potential of 300-350 MT ha^{-1}. From the result, it was estimated that a CSO of 1 ha area can store about 150 tons of carbon, which sequesters about 550 tons of carbon (CO_2 equivalent) at the age of 53-years of planting; it is corresponding to 550 carbon credits. The range of variation in carbon storage (230.89 to 504.62 kg $tree^{-1}$) and CO_2 equivalent value (0.85 to 1.85 tons $tree^{-1}$) among teak clones illustrates that there is a lot of scope for further selection and multiplication of superior clones for large scale clonal plantation in order to accumulate more biomass and carbon sequestration in teak. Henceforth, to achieve higher biomass and wood carbon, teak clones such as TC-1, TC-2, TC-8 and TC-12 are suggested for large scale plantations programme and further breeding activity.

4. CONCLUSION

Study summaries that there was a significant variation among clones for growth and yield attributes in teak. Among 18 clones studied, TC-1, followed by TC-12, TC-2 and TC-8 clones showed significantly superior over other clones. CSO acts as a carbon reservoir and it can be used in the carbon credit programme, depending upon the total extents, age, *etc*. Further, study indicates that potential clones can be suggested for large scale clonal forestry programmes.

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