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Studies on carbon sequestration potential of farm grown casuarina clones

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Abstract
Plantation forestry in India is playing a crucial role in meeting the wood requirement of the country. The productivity of plantations can be enhanced through the selection and deployment of site-specific clones with desirable traits and suitable silvicultural practices.
Among the different fast-growing species, Casuarinas are preferred for environmental and commercial planting since the species have the adaptability to a wide range of climatic and edaphic conditions and has also gained importance as major pulpwood species. The efficient clones can be recommended for particular end uses by assessment of different clones. Thus, the present study was conducted to assess the growth performance and carbon sequestration potential of Casuarina clones in clonal trials located at Forest College and Research Institute, Mettupalayam. At the age of three years, the growth indicators-GBH, height, basal area, volume, and total biomass-were estimated. There was a significant difference in quantitative and qualitative growth traits among the five clones.

Keywords: Biomass of trees, carbon stocks, casuarina clones

Introduction
Recent years have seen an increase in the number of intellectuals paying attention to the vital and delicate environmental issue of climate change. According to the IPCC (2001, 2007), the atmosphere's rising carbon dioxide levels are thought to have played a substantial role in the climate change. Global warming is one of the most dreaded threats of the new millennium that is creating climate change. It is assumed that carbon emissions are the main cause of global warming. As a result, one of today's major issues is the increase in carbon emissions, which the Kyoto Protocol appropriately addresses. The most practical and immediate solution for storing and sequestering atmospheric carbon was found to be the use of perennial woody vegetation, which is effective, economical, and environmentally friendly. In order to protect and improve terrestrial carbon stores, the United Nations Framework Convention on Climate Change (UNFCCC) has acknowledged the significance of plantation forestry as a greenhouse gas mitigation approach. The capacity of short rotation plantations to reduce pressure on timber extraction from wild forests and hence support forest conservation makes them useful as farm forestry or agroforestry systems. Additionally, trees are crucial for enhancing soil C sequestration by increasing soil C content. In this regard, the genus Casuarina is viewed as one of the top choices among the rapidly growing tree species that are widely planted in the tropics, primarily for grown for pulpwood and plywood and are used as the multi-purpose tree species, especially in the agricultural and forestry industries (L. K. Behera, 2016). Interspecific hybrids of *C. equisetifolia* and *C. junghuhniana* have shown faster growth and better stem straightness and disease resistance than the parent species in South India. The relative performance of these hybrids differs with respect to clones and different environments, because of the possible presence of genotype × environment interaction. The information on these interactions can be utilized for identifying clones which are superior in one or more desirable combination of traits.

The plantations established with these clones will have the potential to increase the productivity, carbon storing capacity and value of plantations.

Materials and Methods

The current study was carried out in 2023. The summer typically starts in mid-March and peaks by the May-June and the harsh winter months of December and January. The place experiences an average annual rainfall of 913.9 mm, with the most of the rains occurring during the monsoon when it merges with the north east monsoon. Winter showers typically don't last very long. Five Casuarina clones were planted with a spacing of 1.2 x 1.2 m. The girth of the tree was measured by the measuring tape at a height of 1.37 meters above the ground. The height of planted tree species was measured from the ground level to the leading terminal tip using Haga altimeter and it is expressed in metre.

Estimation of biomass

- **Girth** at breast height (GBH): This was measured at 1.37 m height from the base of the tree using measuring tape.
- **Diameter** at breast height (DBH) was calculated as follows DBH = GBH/3.14
- **Basal area (BA)** of the tree was calculated using the formula given by Chaturvedi and Khanna.

  BA = πd 2 /4, where d is the diameter

- **Volume:** To calculate volume of the tree, basal area was multiplied by height of the tree. Volume (m^3 /ha) = Basal area (m^2 /ha) x height (m) x Form factor. The form factor was assumed to be 0.5.
- **Aboveground biomass (AGB):** To estimate this, volume was multiplied by the wood density of the tree. Aboveground biomass (kg/ha) = Volume (m^3 /ha) x wood density (kg/m^3). The wood density of tree species was unavailable standard average value 0.6 gm/m^3.
- **Belowground biomass (BGB):** This was estimated by multiplying the aboveground biomass with 0.26. Belowground biomass (kg/ha) = Aboveground biomass (kg/ha) x 0.26.
- **Total Biomass** is the summation of aboveground biomass and belowground biomass. Total Biomass (kg ha^{-1}) = AGB (kg/ha) + BGB (kg/ha).

Estimation of carbon stock in trees

Biomass was converted into carbon by multiplying it with carbon fraction (0.50) of dry matter. The calculation of carbon from biomass by the following formula:

Carbon stock (t ha^{-1}) = Total tree biomass (t ha-1) x 0.5

Statistical analysis: The experimental data were subjected to statistical analysis for the possible relationship between the different parameters. Karl Pearson's correlation coefficient was worked out by using SPSS (Statistical Package for the Social Sciences).

Result and Discussion

In Forest College and Research Institute, the highest girth at breast height for the clones ranged in between 7 cm and 51.50 cm (Figure 2). The highest GBH was recorded in the clone CH 2 with 51.50 cm followed by clone CH 1 (48 cm, 45.5 cm) and clone THAMAN (42 cm). The lowest GBH among the tested clones in Forest College and Research Institute was recorded in the clone CH 2 with 7 cm followed by the clone CH 1 and clone CJ 1 with 10.70 cm and 10.8 cm respectively. The height of the 5 Casuarina clones ranged in between 21 m to 4.5 m (Figure 1). The maximum height was recorded in the clones CH 1 and CH 2 with a recorded height of 21 m followed by the clones CH 5 and THAMAN (20 m). The clone CJ 1 with 4.50 m height recorded the lowest height followed by clone CH 2 (6 m). On an average the clone CH 1 had better growth results compared to other with mean height of 18.8 m and mean GBH of 31.14 cm. The least performed was clone CJ 1 with mean height of 13.17 m and GBH of 19.7 cm.

This kind of result is because Casuarina hybrids grow as well as or better than their parents, and large changes in growth across hybrid clones can be linked to both genetic and environmental variables and management, especially the weeding frequency and the protection of the seedlings from pests and diseases, drought and seedling handling during planting period. The means for basal area of the tested clones showed that the basal area in the zone ranged in between 0.0055 m^2 /ha and 0.0134 m^2 /ha (Figure 3).

The highest basal area was recorded in the clone CH 1 with 0.0134 m^2 /ha followed by clone EC 4 (0.0120 m^2 /ha) and clone CH 5 (0.0102 m^2 /ha). The lowest basal area was recorded in the clone CJ 1 with 0.055 m^2 /ha and clone THAMAN (0.0080 m^2 /ha). The Total biomass per hectare ranged in between 39.55 ton/ha and 128.58 ton/ha. The highest total biomass was recorded in the clone CH 1 with 128.58 ton/ha followed by the clone CH 2, clone CH 5 and clone THAMAN with 112.50 ton/ha, 89.73 ton/ha and 69.53 ton/ha respectively. The lowest total biomass was recorded in the clone CJ 1 with a biomass of 39.55 ton/ha. The carbon stocks in the zone ranged in between 19.77 ton/ha and 64.29 ton/ha. The clone CH 1 with 64.29 ton/ha recorded carbon stocks outperformed the other clone followed by the clone CH 2 with 56.25 ton/ha, clone CH 5 with 44.86 ton/ha and clone THAMAN with 34.76 ton/ha. The lowest total carbon biomass was recorded in the clone CJ 1 with 19.77 ton/ha.

With all the biometric traits the superior clone over the others was clone CH 1 with better growth performance and carbon storage capacity followed by CH 2 and CH 5. The least performed one was clone CJ 1. Similar results were obtained by Deepthi *et al.* (2020) [2] that the performance of clone CH 1 outperformed other clones in all traits such as height (4.33 m), DBH (2.84 cm) and Volume (927.20 cm^3). In many studies CH 2 showed better performance than others. Among the best performing clones under study, the clone IFGTB CH 2 possessed desirable characteristics *viz.* high growth performance, more increment, biomass production and stem straightness. The interspecific hybrids possess the desirable combination of parental characters and can perform well in comparison with intraspecific hybrid families (Kannan *et al.*,2012; Nicodemus *et al.*,2013) [6, 21, 11].

The biometric traits of five Casuarina clones were measured at 3 years. Based on the observed data, Karl Pearson's correlation coefficient was worked out between biometric traits and biometric biomass carbon. The biometric traits are Height and Girth. The study result of the correlation is explained here under at Table 4.

The correlation estimation of selected tree clones revealed that, among three characters subjected for correlation, significant positive correlation of 0.988 was exhibited between girth VS biomass carbon. However, height VS biomass carbon showed

some less level correlation compared to girth VS biomass of 0.913. The significant positive correlation was observed between biometric traits and biometric biomass carbon.

Table 1: Height (m) of tree clones at 39 MAP

S. No.	CH1	CJ1	CH2	THAMAN	CH5
1	19.50	9.00	19.00	20.00	18.00
2	21.00	8.00	21.00	19.00	8.00
3	18.00	16.00	21.00	19.00	16.00
4	21.00	16.00	18.00	17.50	19.00
5	20.00	13.00	13.00	18.50	18.50
6	21.00	17.00	17.00	17.00	18.00
7	20.50	18.00	6.00	18.00	17.00
8	13.50	15.50	17.50	12.00	20.00
9	15.50	13.00	18.00	17.00	19.00
10	16.50	14.00	20.00	20.50	17.50
11	18.00	16.50	18.50	9.50	18.00
12	19.00	16.00	20.00	18.00	20.00
13	20.00	4.50	17.50	18.00	20.00
14	18.50	12.00	19.50	20.00	19.00
15	20.00	9.00	21.00	9.00	20.50
Mean	18.80	13.17	17.80	16.87	17.90
SD	2.202272	3.940027	3.858201	3.671642	3.007134
Sed	0.568624	1.01731	0.996183	0.948014	0.776439
CD (0.05)	1.194111	2.136352	2.091985	1.990829	1.630521

Table 2: Girth (cm) at breast height of tree clones

S. No.	CH1	CJ1	CH2	THAMAN	CH5
1	42.00	24.50	51.50	42.20	41.30
2	48.00	15.50	42.00	28.00	32.20
3	40.00	20.60	36.00	23.60	14.80
4	45.50	16.80	28.00	24.40	29.00
5	30.00	15.00	22.00	34.00	17.00
6	34.50	24.00	24.50	25.60	28.50
7	46.50	20.50	7.00	24.50	20.40
8	26.80	18.00	25.20	12.60	30.50
9	16.50	15.00	26.50	20.80	36.30
10	18.80	18.00	36.00	19.80	21.20
11	27.30	31.50	38.00	21.50	20.00
12	26.50	41.30	30.50	24.60	30.60
13	30.00	10.80	20.00	29.10	35.00
14	10.70	11.80	27.50	19.50	36.20
15	24.00	12.20	29.40	18.40	23.50
Mean	31.14	19.70	29.61	24.57	27.77
SD	11.4243	8.1181	10.3831	7.0077	7.9129
Sed	2.9498	2.0961	2.6809	1.8094	2.0431
CD (0.05)	6.1945	4.4018	5.6299	3.7997	4.2905

Table 3: Mean of Basal area (m^2 /ha), Volume (m^3 /ha), AGB (t/ha), BGB (t/ha), Total biomass (t/ha), Total biomass carbon (t/ha) at 39 MAP

S. No.	Clone	Basal Area	Volume	ABG	BGB	Total Biomass	Total Biomass Carbon
1	CH1	0.0134	0.1230	102.0507	26.5332	128.5839	64.2919
2	CJ1	0.0055	0.0378	31.3911	8.1617	39.5528	19.7764
3	CH2	0.0120	0.1076	89.2917	23.2158	112.5075	56.2538
4	Thaman	0.0080	0.0665	55.1840	14.3478	69.5318	34.7659
5	CH5	0.0102	0.0858	71.2164	18.5163	89.7326	44.8663
SD		0.0031	0.0336	27.8877	7.2508	35.1386	17.5693
Sed		0.0016	0.0149	12.3513	3.2113	15.5626	7.7813
CD (0.05)		0.0033	0.0313	25.9377	6.7438	32.6815	16.3408

Table 4: Karl Pearson's correlation coefficient of biometric traits and biometric biomass carbon at 39 MAP

	Height	Girth	Biomass Carbon
Height	1		
Girth	0.957	1	
Biomass Carbon	0.913	0.988**	1

** Correlation is significant at 0.01 level
* Correlation is significant at 0.05 level

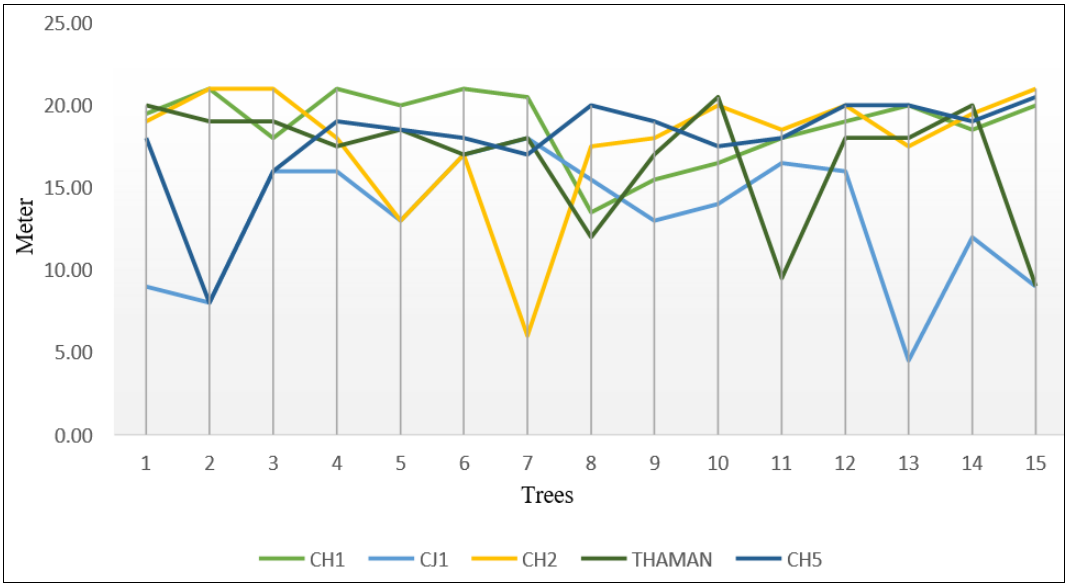

Fig 1: Height (m) of tree clones at 39 MAP

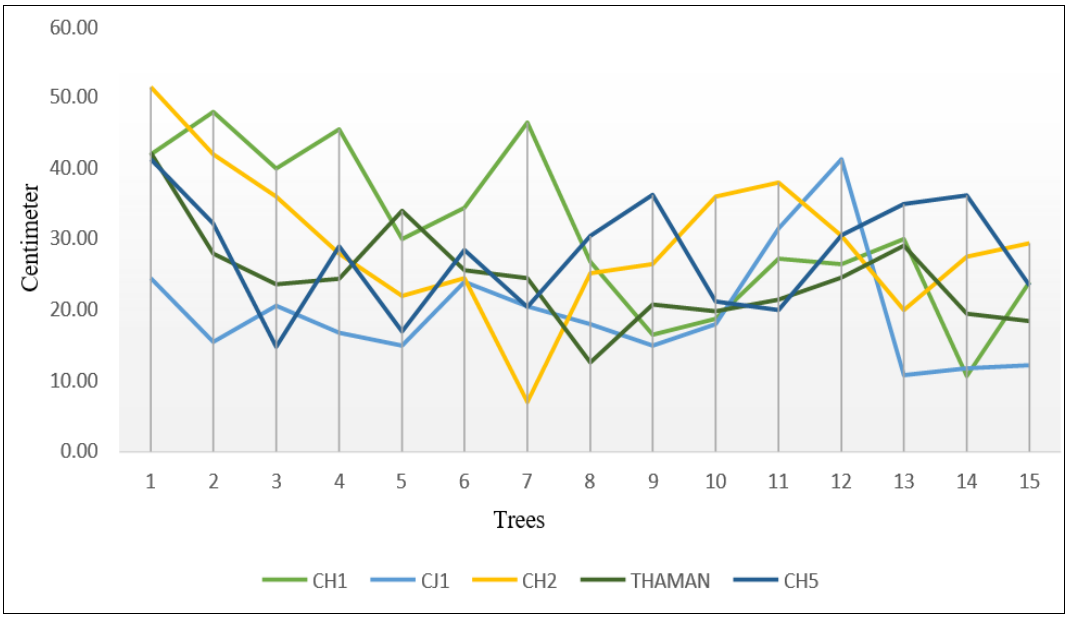

Fig 2: Girth (cm) of tree clones at 39 MAP

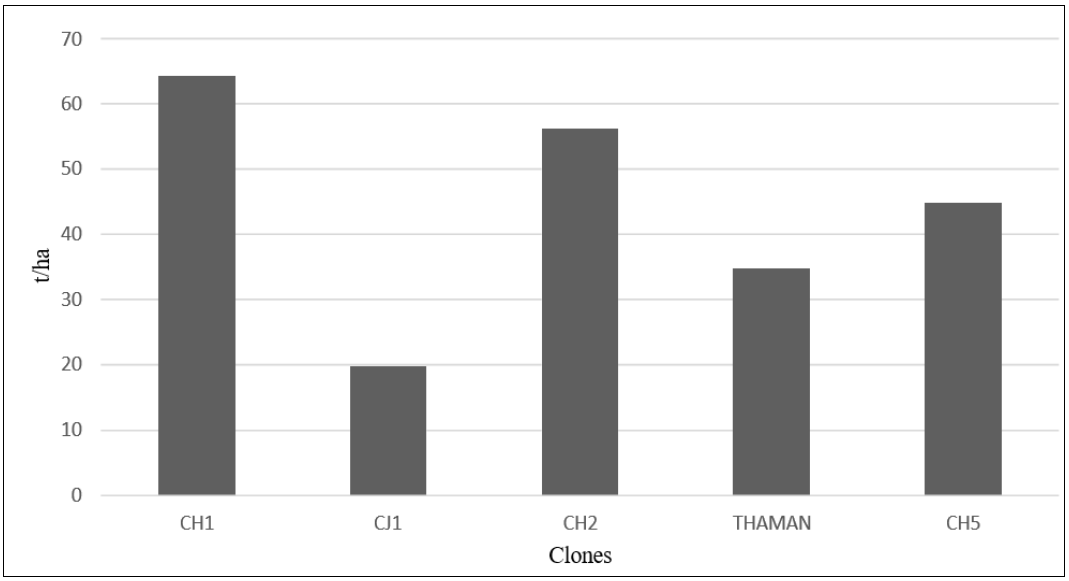

Fig 3: Mean Total biomass carbon(t/ha) of tree clones at 39 MAP

Conclusion

The five Casuarina clones, namely CH 1, CJ 1, CH 2, THAMAN and CH 5, were examined for their capacity to store carbon in the experiment. The clone CH 1 and clone CJ 1 were found to be the best and worst performing clones, respectively, based on the observed values for total biomass and biomass carbon. To validate the evaluation of prospective clones across the areas, growth monitoring must be continued in this trial series. Additionally, the current data may not be sufficient to rank the clones as these were early growth findings at the age of 3 years with low juvenile mature correlations projected. The evaluation of the performance of Casuarina clones will aid in the selection of potential clones for the given location, allowing planting stock of desirable clones to be raised for further cultivation in the field. The increase of Casuarina plantings in agroforestry will aid in lessening forest pressure and expanding trees outside of forests fetching good economic returns in the short span of time**.**

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