Original Research Article

EVALUATION OF CARBON SEQUESTRATION POTENTIAL OF DIFFERENT MELIA GERMPLASMS IN EASTERN DRY ZONE OF KARNATAKA

ABSTRACT

The research period should come immediately before the methodology so that there will be a chronological flow of thought. Abbreviations and acronyms should be written in full at first use.

The present research was conducted from April, 2023 to July, 2024 in AICRP on Agroforestry field unit, ZARS, UAS, GKVK, Bengaluru. *Melia dubia* is one of the best agroforestry tree species, which is known for its faster growth rate and biomass accumulation. To maintain ecological balance and sustainability carbon sequestration plays an important role, hence this study aimed at identifying the best suitable Melia germplasm for Eastern dry zone of Karnataka. RBD design was used for the experiment. Evaluation of 15 Melia germplasms revealed that highest tree height was recorded in MD-173 (16.06 m) and lowest in MD-129 (12.31 m). Girth at breast height (GBH) was highest in MTP-3 (97.94 cm) and lowest in MD-135 (60.35 cm). Tree volume was highest in MTP-3 (328.6 m^3 ha^{-1}) and was on par with MTP-1 (314.4 m^3 ha^{-1}) and MD-138 (307.4 m^3 ha^{-1}) whereas, significantly lower tree volume was found in MD-135 (106.0 m^3 ha^{-1}). The above ground biomass, belowground biomass, total biomass and total biomass carbon were found highest in MTP-3 (197.2 t ha^{-1}, 51.3 t ha^{-1}, 248.6 t ha^{-1} and 124.2 t ha^{-1} respectively), and significantly lowest were found in MD-135 (63.6 t ha^{-1}, 16.5 t ha^{-1}, 80.1 t ha^{-1} and 40.1 t ha^{-1} respectively). MTP-3 consistently exhibited the highest biomass CO_2 values across all intervals, reaching a remarkable 455.9 t ha^{-1} at 81 months followed by MTP-1 (436.1 t ha^{-1}). MD-138 (426.4 t ha^{-1}), MD-157 (375.9 t ha^{-1}), and MD-164 (375.7 t ha^{-1}) were found to be intermediate CO_2 accumulators. Lowest carbon sequestration potential was found in MD-135 (147.1 t ha^{-1}), MD-174 (209.8 t ha^{-1}) and MD-129 (236.3 t ha^{-1}). MTP-3 followed by MTP-1 and MD-138 were more suitable for Eastern dry zone of Karnataka.

Keywords: *Biomass, height, carbon sequestration potential, CO_2, Germplasms, girth at breast height, Melia and volume.*

1. INTRODUCTION

Climate change, driven by rising atmospheric carbon dioxide (CO_2) levels~~,~~ has emerged as a critical global challenge requiring immediate attention. Mitigating the adverse effects of this phenomenon calls for innovative and sustainable approaches to reduce CO_2 concentrations in the atmosphere. Among the strategies available, carbon sequestration through afforestation and agroforestry systems ~~has~~ have proven to be an effective and eco-friendly solution. Tree species play a pivotal role in carbon capture~~,~~ as they sequester atmospheric CO_2 into their biomass and soil~~,~~ thereby contributing significantly to carbon stock enhancement and climate change mitigation.

Melia, commonly referred to as Malabar Neem, is a fast-growing tree species native to the Indian subcontinent. Renowned for its adaptability, high biomass production, and multipurpose utility, Melia has gained attention as a promising candidate for afforestation and agroforestry programs (Laxmi et al., 2021). Its ability to thrive under a range of environmental conditions~~,~~ coupled with its considerable carbon sequestration capacity~~,~~ makes it an ideal choice for regions with challenging climatic conditions (Chopra et al., 2023).

The Eastern Dry Zone of Karnataka, characterized by low and erratic rainfall, limited soil fertility~~,~~ and high temperatures~~,~~ presents unique challenges for agricultural productivity and ecological stability. In this context, identifying tree species with high carbon sequestration potential that can also thrive in such adverse conditions is crucial. Evaluating the performance of different germplasms of Melia under these conditions is essential to optimize their role in enhancing carbon stocks, improving soil health~~,~~ and contributing to the socio-economic development of the region.

This study aims to evaluate the carbon sequestration potential of various Melia germplasms in the Eastern Dry Zone of Karnataka. By assessing growth performance and biomass accumulation, this research seeks to identify superior germplasms capable of maximizing carbon storage while ensuring adaptability to the region's climatic and edaphic conditions. The findings of this study are expected to provide valuable insights for policymakers, foresters, and farmers, fostering the adoption of sustainable land-use practices to combat climate change and improve livelihoods.

2. MATERIAL AND METHODS

The present study was carried out at 'M' block, All India Coordinated Research Project (AICRP) on Agroforestry unit, Zonal Agricultural Research Station (ZARS), Gandhi Krishi Vigyana Kendra (GKVK), University of Agricultural Sciences, Bangalore, Karnataka from April 2023 to July 2024. It is located in the Northern part of Bengaluru between 13º 04' North ~~latitude~~ Latitude and 77º 34' East ~~longitude~~ Latitude at an altitude of 930 m above mean sea level (MSL). The soil of the experimental site was red sandy loam in texture, classified under the order *Alfisols*.

Table 1. Experimental details

A.	**Study site**	**:**	'M' block, Agroforestry unit, ZARS, GKVK, Bengaluru.
B.	**Tree species**	**:**	*Melia dubia*

C.	**Tree spacing**	**:**	5 m × 5 m
D.	**Date of planting**	**:**	21-09-2017
E.	**Number of clones**	**:**	15 HKT-1, MTP-1, MTP-2, MTP-3, MD-129, MD-135, MD-138, MD-148, MD-155, MD-157, MD-164, MD-171, MD-173, MD-174, KGL-1
F.	**Replications**	**:**	3
G.	**Experimental ~~year~~ period**	**:**	April 2023 to July 2024
H.	**Design**	**:**	RBD

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The trees were planted at 5 m X 5 m in the year 2017. Currently, age of the plantation is 7 years. Here, 15 Melia germplasms were brought from different places like Mettupalyam (MTP series), IFGTB, Coimbatore (MD series), Heggada Devanakote (HKT series) and Kollegala (KGL series) and evaluated for the growth and carbon sequestration potential.

2.1 Tree growth observations

The tree biomass was calculated by the non-destructive method by taking the measurements of height and girth at breast height (GBH) of the standing trees and then volume was calculated. The mean girth, height and volume of the tree were recorded at three months interval. The methods used to measure the height, girth and volume are detailed here.

a) Tree height (m)

The total tree height was measured with the help of an altimeter (Chaturvedi and Khanna, 1981) from the ground level to the tip of the tree and it is expressed in meters (m).

b) Tree girth (cm)

The girth at breast height (1.37 m) from the ground level was measured with the help of standard measuring tape and expressed in centimeters (cm).

2.2 Estimation of structural parameters

a) Tree volume estimation

The height of all the trees in each land use system was measured using a Ravi altimeter. GBH was measured at 1.37 m from the ground level over the bark with the help of measuring tape. Non-destructive method of biomass estimation was carried out using volume (tree height, GBH) and wood density. The wood density of different tree species was referred from FAO (2010) and World Agroforestry Centre (WAC). The following formula was used for calculating the standing volume of trees (Bitlerlich, 1984) this reference is too old

$$\text{Volume (m}^3\text{ ha}^{-1}) = \text{Basal Area} \times \text{Height} \times \text{Form factor} \times \text{Tree population per hectare}$$

$$= (G^2/4\pi) \times H \times \text{Form factor} \times \text{Tree population per hectare}$$

Where, π = 3.14, G is the Girth at breast height (GBH; m), and H is the height of the tree (m).

b) Aboveground biomass

To calculate aboveground biomass, volume of the tree is estimated using GBH and height of the tree. The volume (m^3 ha^{-1}) of each tree is then multiplied with its specific wood density (kg m^{-3}) to get above ground biomass (Ravindranath and Ostwald, 2008).

$$\text{AGB (t ha}^{-1}) = \text{Volume (m}^3\text{ ha}^{-1}) \times \text{Wood density (kg m}^{-3}).$$

c) Belowground biomass

Below ground biomass **(**BGB) of the tree includes live root biomass, excluding fine roots and was calculated using 0.26 factor of root: shoot ratio (Ravindranath and Ostwald, 2008).

$$\text{BGB (t ha}^{-1}) = \text{AGB (t ha}^{-1}) \times 0.26$$

d) Total biomass (TB)

Sum of AGB and BGB gives total biomass (TB) of the tree (Ravindranath and Ostwald, 2008).

$$\text{TB (t ha}^{-1}) = \text{AGB (t ha}^{-1}) + \text{BGB (t ha}^{-1})$$

e) Biomass carbon estimation

Carbon estimation is measurement of total carbon accumulated in a tree out of total biomass of the tree. Generally, for any plant species 45-50 per cent of its biomass is considered as carbon (Pearson et al., 2005) *i.e.*,

$$\text{Carbon Storage} = \text{Biomass} \times 50\%$$

f) CO_2 sequestration by trees

The CO_2 in the atmosphere is assimilated by trees in the process of photosynthesis. In order to derive the amount of CO_2 converted into carbon and retained in the biomass. The molecular weight relation between carbon and oxygen is used as follows. Atomic weight of carbon is 12 and oxygen is 16 (Pearson et al., 2005).

$$CO_2 = (12 + (16\times2))/12 = 44/12 = 3.67.$$

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Thus, one molecule of carbon = 3.67 molecules of CO_2 or 1 ton of carbon = 3.67 ton of CO_2.

2.3 Statistical analysis

The experimental data generated during research was subjected to statistical analysis adopting Fisher's method of analysis of variance as outlined by Gomez and Gomez (1984). The level of significance used in "F" test was at 5 per cent. Critical difference (CD) values were calculated at 5 per cent level of significance whenever "F" test was found significant.

3. RESULTS AND DISCUSSION

The growth parameters *i.e.* tree height and girth at breast height (GBH) were measured at three months interval and the biomass production as well as carbon sequestration were estimated and presented in the following tables.

Table 2. Tree height (m) of Melia germplasms at quarterly interval

Germplasms	Months after planting (MAP)					
	66	69	72	75	78	81
MD-129	9.48	10.06	10.67	11.33	11.73	12.31
MD-135	10.19	10.80	11.39	12.03	12.59	13.09
MD-138	12.12	12.82	13.55	14.23	14.90	15.58
MD-148	10.08	10.64	11.23	11.77	12.47	12.60
MD-155	11.63	12.32	13.04	13.67	14.40	15.77
MD-157	12.09	12.82	13.51	14.17	14.90	15.52
MD-164	10.82	11.48	12.12	12.83	13.33	13.87
MD-171	10.40	10.89	11.50	12.20	12.69	13.19
MD-173	12.44	13.17	13.91	14.67	15.47	16.06
MD-174	11.98	12.63	13.25	13.87	13.87	14.31
MTP-1	12.31	13.03	13.76	14.57	15.00	15.63
MTP-2	11.87	12.61	13.33	13.93	14.72	15.56
MTP-3	12.07	12.79	13.49	14.23	14.90	15.51
HKT-1	10.44	11.03	11.65	12.30	13.33	13.68
KGL-1	11.38	12.05	10.84	13.47	14.13	14.67

S.Em±	1.26	1.26	1.14	1.26	1.28	1.30
CD@ 5%	3.65	3.65	3.29	3.66	3.72	3.76

By the end of eighty-one months after planting, significantly higher tree height (Table 2) was found in MD-173 (16.06 m), and was on par with MD-155 (15.77 m), MTP-1 (15.63 m) whereas, lowest tree height was found in MD-129 (12.31 m). The height of local Melia germplasms *viz.,* HKT-1 (13.68 m) and KGL-1 (14.67 m), which performed better than other non-local Melia germplasms *viz.,* MD-129 (12.31 m), MD-148 (12.60 m), MD-135 (13.09 m) and MD-171 (13.19 m).

Sharma et al. (2019) observed significant differences in the height growth of 17 improved genotypes of *Melia dubia* at the Forest Research Institute in Dehradun. Similarly, Srivastav et al. (2018) investigated the early performance of 19 Eucalyptus clones in Uttar Pradesh, reporting notable height growth variation, which aligns with the findings of the current study. They suggested that this variability might be linked to clonal differences and genetic factors. In the case of *Populus deltoides* clones studied in Himachal Pradesh, Vasudev et al. (2021) noted that environmental factors could also influence height growth variation.

Table 3. Girth at breast height (cm) of Melia germplasms at quarterly interval

Germplasms	Months after planting (MAP)					
	66	69	72	75	78	81
MD-129	66.43	68.16	70.85	72.97	75.33	77.79
MD-135	53.46	54.27	55.66	57.11	58.53	60.35
MD-138	75.33	78.27	81.48	85.86	89.76	93.35
MD-148	67.06	69.50	71.61	74.96	77.47	79.03
MD-155	62.76	64.35	66.08	67.58	69.13	71.43
MD-157	74.12	76.18	78.60	81.74	84.94	88.20
MD-164	74.83	80.61	83.23	86.06	89.80	93.24
MD-171	74.02	77.20	80.47	84.64	88.39	92.34
MD-173	73.71	75.70	78.09	80.42	83.60	86.94
MD-174	63.58	65.38	67.63	69.97	72.62	68.99
MTP-1	76.17	79.04	82.58	86.56	90.65	94.91
MTP-2	60.91	62.39	64.59	66.90	70.79	73.22
MTP-3	83.33	85.49	88.64	92.42	95.69	97.94
HKT-1	64.43	65.31	67.76	70.07	72.27	74.72
KGL-1	70.73	72.12	74.09	76.30	78.45	80.79
S.Em±	3.72	3.82	3.79	3.82	3.86	3.92
CD@ 5%	10.79	11.08	10.97	11.07	11.18	11.36

In the last reading, significantly higher tree girth at breast height (Table 3) was found in MTP-3 (97.94 cm), and was on par with MTP-1 (94.91 cm), MD-138 (93.35 cm) and MD-157 (88.20 cm) whereas, the lowest tree GBH was found in MD-135 (60.35 cm). The GBH of local Melia germplasms *viz.,* HKT-1 (74.72 cm) and KGL-1 (88.20 cm), ~~which~~ performed better than other non-local Melia germplasms *viz.,* MD-135 (60.35 cm), MD-174 (68.99 m), MD-155 (71.43 cm) and MTP-2 (73.22 cm).

The rapid girth increment of MTP-3 is influenced by a combination of genetic, environmental~~,~~ and management factors. Several studies indicate that MTP-3 has a high photosynthetic efficiency~~,~~ which contributes to its fast growth rate~~,~~ particularly in regions with optimal temperature and rainfall (Laxmi et al., 2021). Its deep-rooting system allows it to access nutrients and water more effectively~~,~~ thereby enhancing its resilience to drought and supporting faster growth (Sharma et al., 2019).

Table 4. Wood volume (m^3 ha^{-1}) of Melia germplasms at quarterly interval

Germplasms	Months after planting (MAP)					
	66	69	72	75	78	81
MD-129	96.8	108.0	122.9	138.1	152.6	170.3
MD-135	64.6	70.7	78.4	87.3	96.0	106.0
MD-138	157.1	179.2	205.0	238.4	272.6	307.4
MD-148	101.9	115.3	129.1	148.6	168.1	176.4
MD-155	102.7	114.3	127.5	139.8	153.9	179.6
MD-157	149.4	167.5	187.7	212.6	241.3	271.0
MD-164	135.8	167.9	188.8	214.1	241.8	270.8
MD-171	128.2	146.0	167.3	196.1	222.3	252.2
MD-173	149.3	166.9	187.7	210.2	239.5	269.2
MD-174	108.6	120.9	135.8	152.2	163.9	151.2
MTP-1	160.2	182.4	210.2	244.2	275.5	314.4
MTP-2	99.4	110.8	125.3	140.2	165.3	186.7
MTP-3	185.3	206.9	234.7	269.4	302.3	328.6
HKT-1	102.1	110.3	125.3	140.8	161.0	176.8
KGL-1	133.8	146.9	134.7	182.6	202.1	222.0
S.Em±	**22.4**	**24.3**	**23.6**	**28.8**	**31.1**	**32.3**
CD@ 5%	**64.8**	**70.3**	**68.3**	**83.4**	**90.2**	**93.5**

When tree density ~~is~~ was considered for estimating the wood volume of Melia germplasms, the results of last readings showed ~~that~~ a significantly higher tree volume (**Table 4**) ~~was~~ as found in MTP-3 (328.6 m^3 ha^{-1}) and was on par with MTP-1 (314.4 m^3 ha^{-1}) and MD-138 (307.4 m^3 ha^{-1}), whereas, significantly lower tree volume was found in MD-135 (106.0 m^3 ha^{-1}).. The tree volume of local Melia germplasms *viz.,* HKT-1 (176.8 m^3 ha^{-1}) and KGL-1 (222.0 m^3 ha^{-1})~~, which~~ performed better than other non-local Melia germplasms *viz.,* MD-135 (106.0 m^3 ha^{-1}), MD-174 (151.2 m^3 ha^{-1}) and MD-129 (170.3 m^3 ha^{-1}).

The rapid increase in basal area and volume of the MTP-3 clone of *Melia dubia* compared to other clones can be attributed to its superior genetic traits, efficient resource utilization, and enhanced adaptability to environmental conditions. Sharma et al. (2018) investigation ~~have~~ has shown that MTP-

3 exhibits a higher growth rate due to its genetic selection for fast-growing characteristics, including increased photosynthetic capacity and better carbon assimilation. Additionally, this clone has been found to possess a more extensive and deeper root system, enabling efficient nutrient and water uptake, which supports faster growth even under suboptimal conditions (Chopra et al., 2023; Satya et al., 2018). The MTP-3 clone also demonstrates a higher resistance to pests and diseases, which reduces stress and allows more energy to be directed towards growth (Sinha et al., 2019). These factors collectively contribute to the accelerated increase in basal area and volume observed in MTP-3 compared to other *Melia dubia* clones.

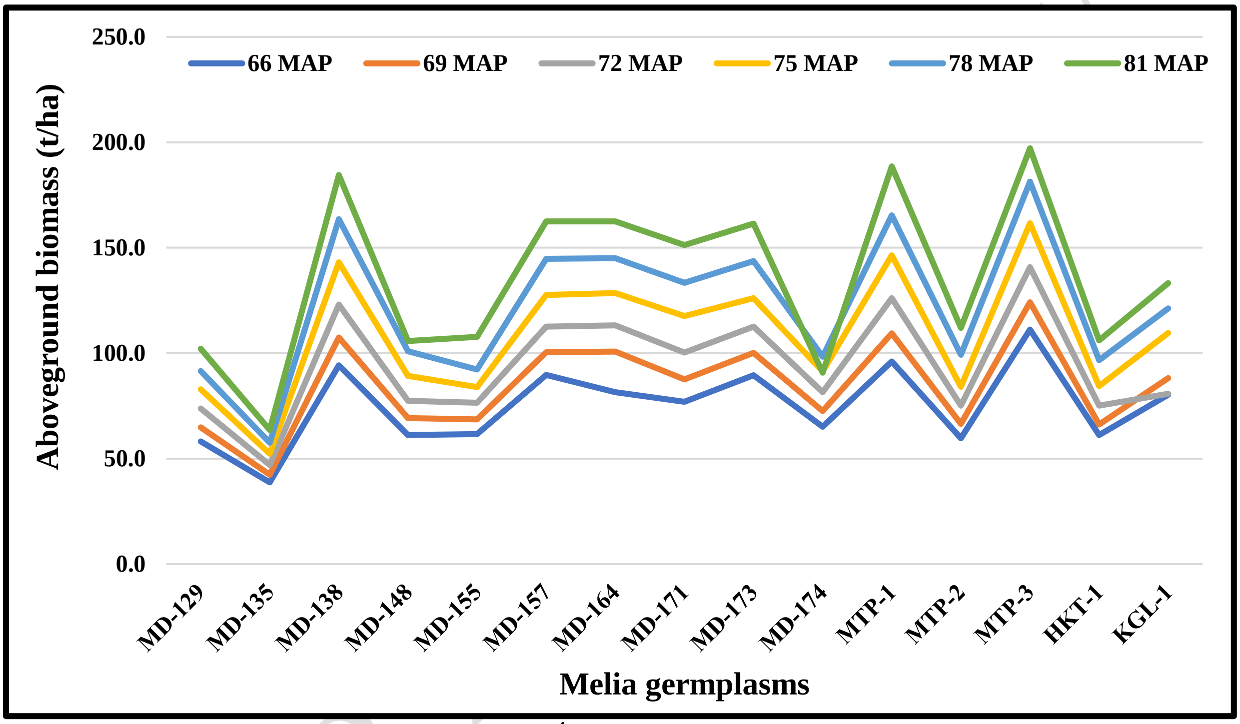

Fig. 1. Aboveground biomass (t ha^{-1}) of Melia germplasms at quarterly interval

Aboveground biomass was estimated by using tree volume of Melia germplasms, where the results of latest observations showed that significantly higher aboveground biomass (**Fig. 1**) was found in MTP-3 (197.2 t ha^{-1}), and was on par with MTP-1 (188.6 t ha^{-1}) and MD-138 (184.4 t ha^{-1}) whereas, significantly lower aboveground biomass was found in MD-135 (63.6 t ha^{-1}). The aboveground biomass of local Melia germplasms *viz.,* HKT-1 (106.1 t ha^{-1}) and KGL-1 (133.2 t ha^{-1}), which performed better than other non-local Melia germplasms *viz.,* MD-135 (63.6 t ha^{-1}), MD-174 (90.7 t ha^{-1}) and MD-129 (102.2 t ha^{-1}).

Belowground biomass was estimated by using aboveground biomass of Melia germplasms, where the latest observations showed that significantly higher belowground biomass (**Fig. 2**) was found in MTP-3 (51.3 t ha^{-1}), and was on par with MTP-1 (49.1 t ha^{-1}), MD-138 (48.0 t ha^{-1}) whereas, significantly lower belowground biomass was found in MD-135 (16.5 t ha^{-1}). The belowground biomass of local Melia germplasms *viz.,* HKT-1 (27.6 t ha^{-1}) and KGL-1 (34.6 t ha^{-1}), which performed better than other non-local Melia germplasms *viz.,* MD-135 (16.5 t ha^{-1}), MD-174 (23.6 t ha^{-1}) and MD-129 (26.6 t ha^{-1}).

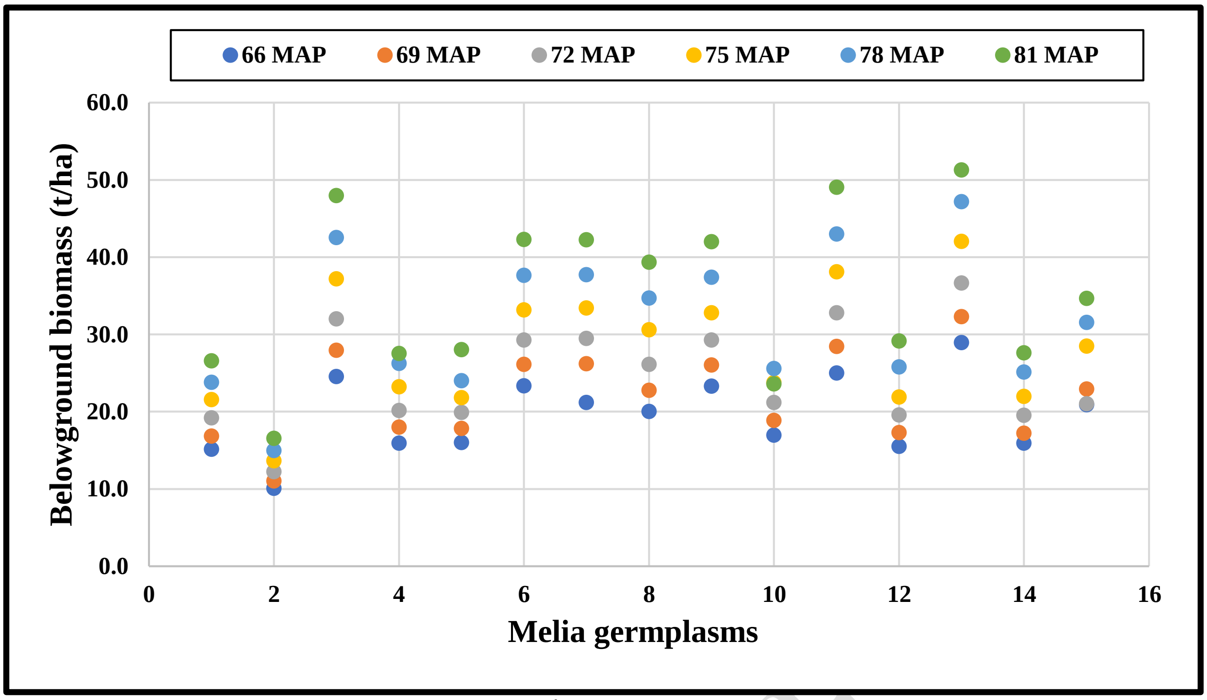

Fig. 2. Belowground biomass (t ha^{-1}) of Melia germplasms at quarterly interval

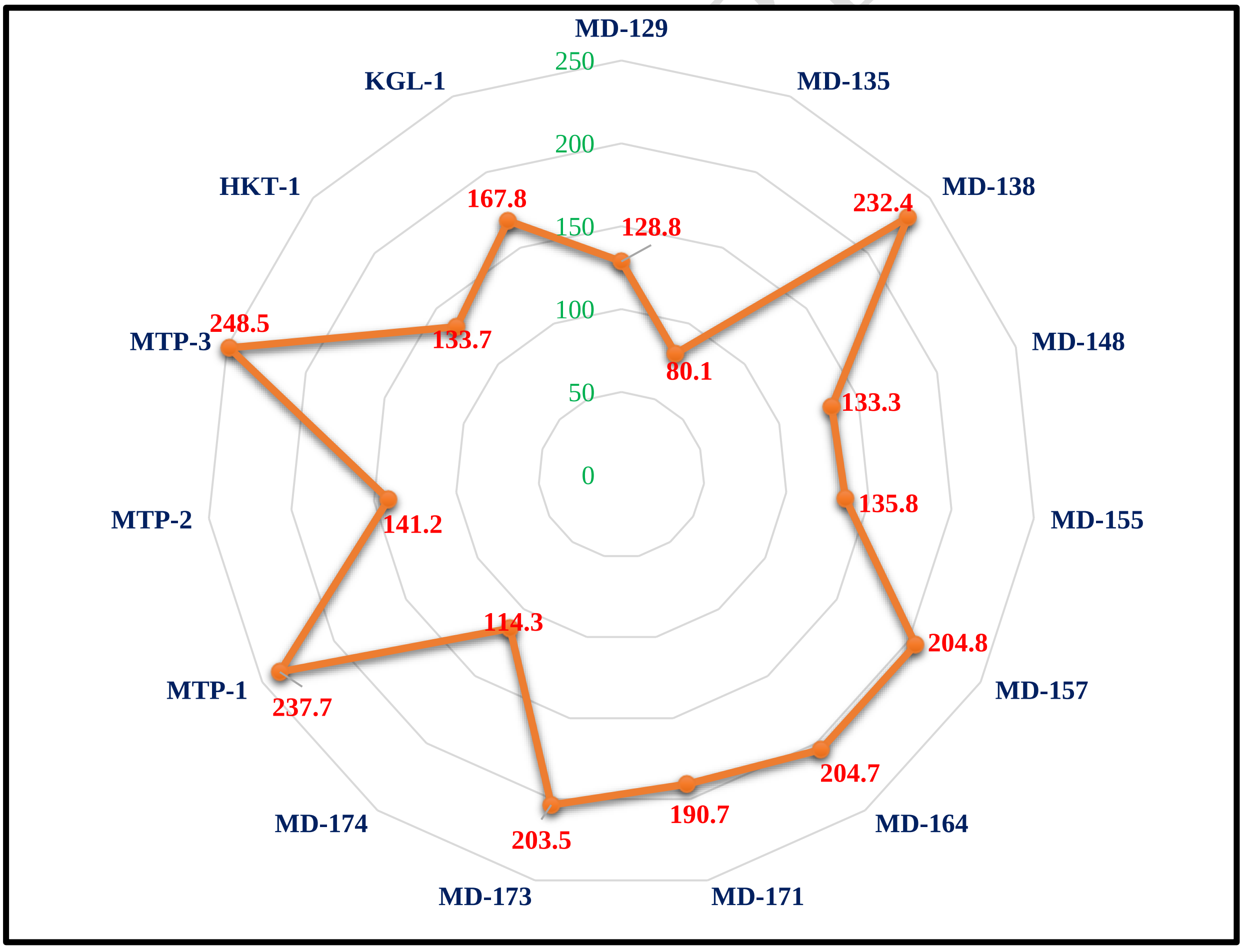

Fig. 3. Total biomass (t ha^{-1}) of different Melia germplasms at 81 months after planting

Total tree biomass was estimated by adding aboveground biomass and belowground biomass of Melia germplasms, where the results showed that a significantly higher total tree biomass

(Fig. 3) was found in MTP-3 (248.6 t ha^{-1}) (Fig. 3), and was on par with MTP-1 (237.7 t ha^{-1}) and MD-138 (232.4 t ha^{-1}) whereas, significantly lower total tree biomass was found in MD-135 (80.1 t ha^{-1}). The total tree biomass of local Melia germplasms *viz.,* HKT-1 (133.7 t ha^{-1}) and KGL-1 (167.8 t ha^{-1}), which performed better than other non-local Melia germplasms *viz.,* MD-135 (80.1 t ha^{-1}), MD-174 (114.3 t ha^{-1}) and MD-129 (128.8 t ha^{-1}).

Table 5. Total biomass carbon (t ha^{-1}) of Melia germplasms at quarterly interval

Table 5: Quarterly total biomass carbon (t ha^{-1}) of Melia germplasms

Germplasms	Months after planting					
	66	69	72	75	78	81
MD-129	36.6	40.8	46.5	52.2	57.7	64.4
MD-135	24.4	26.7	29.6	33.0	36.3	40.1
MD-138	59.4	67.7	77.5	90.1	103.1	116.2
MD-148	38.5	43.6	48.8	56.2	63.5	66.7
MD-155	38.8	43.2	48.2	52.9	58.2	67.9
MD-157	56.5	63.3	70.9	80.4	91.2	102.4
MD-164	51.3	63.5	71.4	80.9	91.4	102.4
MD-171	48.5	55.2	63.2	74.1	84.0	95.3
MD-173	56.4	63.1	70.9	79.4	90.5	101.7
MD-174	41.0	45.7	51.3	57.5	62.0	57.2
MTP-1	60.6	68.9	79.5	92.3	104.2	118.8
MTP-2	37.6	41.9	47.4	53.0	62.5	70.6
MTP-3	70.1	78.2	88.7	101.8	114.3	124.2
HKT-1	38.6	41.7	47.3	53.2	60.9	66.8
KGL-1	50.6	55.5	50.9	69.0	76.4	83.9
S.Em±	**8.5**	**9.2**	**8.9**	**10.9**	**11.8**	**12.2**
CD@ 5%	**24.5**	**26.6**	**25.8**	**31.5**	**34.1**	**35.3**

Total tree biomass carbon was estimated by using total tree biomass of Melia germplasms, where the results showed that by the end of eighty-one months after planting, significantly higher total tree biomass carbon (**Table 5**) was found in MTP-3 (124.2 t ha^{-1}), and was on par with MTP-1 (118.8 t ha^{-1}) and MD-138 (116.2 t ha^{-1}) whereas, significantly lower total tree biomass carbon was found in MD-135 (40.1 t ha^{-1}). The total tree biomass carbon of local Melia germplasms *viz.,* HKT-1 (66.8 t ha^{-1}) and KGL-1 (83.9 t ha^{-1}), which performed better than other non-local Melia germplasms *viz.,* MD-135 (40.1 t ha^{-1}), MD-174 (57.2 t ha^{-1}) and MD-129 (64.4 t ha^{-1}).

Table 6. Total biomass CO_2 (t ha^{-1}) of Melia germplasms at quarterly interval

Germplasms	Months after planting					
	66	69	72	75	78	81
MD-129	134.3	149.8	170.5	191.6	211.7	236.3

MD-135	89.6	98.1	108.7	121.1	133.1	147.1
MD-138	218.0	248.6	284.4	330.7	378.2	426.4
MD-148	141.4	159.9	179.1	206.2	233.2	244.7
MD-155	142.4	158.6	176.8	194.0	213.5	249.1
MD-157	207.3	232.4	260.4	295.0	334.8	375.9
MD-164	188.4	232.9	261.9	297.0	335.4	375.7
MD-171	177.9	202.5	232.1	272.1	308.4	349.9
MD-173	207.1	231.5	260.4	291.6	332.3	373.4
MD-174	150.6	167.7	188.3	211.1	227.4	209.8
MTP-1	222.2	253.0	291.6	338.7	382.2	436.1
MTP-2	137.9	153.7	173.8	194.5	229.3	259.1
MTP-3	257.1	287.1	325.6	373.7	419.3	455.9
HKT-1	141.6	153.1	173.8	195.3	223.4	245.3
KGL-1	185.7	203.8	186.9	253.3	280.4	307.9
S.Em±	**31.0**	**33.7**	**32.7**	**40.0**	**43.2**	**44.8**
CD@ 5%	**89.9**	**97.5**	**94.7**	**115.8**	**125.1**	**129.7**

The total biomass CO_2 (t ha^{-1}) accumulation of various *Melia* germplasms, evaluated quarterly from 66 to 81 months after planting, showed significant differences, highlighting the diverse carbon sequestration potential among the tested germplasms (**Table 6**). MTP-3 consistently exhibited the highest biomass CO_2 values across all intervals, reaching a remarkable 455.9 t ha^{-1} at 81 months. This indicates its exceptional potential for carbon sequestration, is likely attributable to its superior growth rate and efficient utilization of resources under the given environmental conditions (Vasudev et al., 2021; Sharma et al*.,* 2019). MTP-1 followed closely, achieving 436.1 t ha^{-1} at 81 months, further underscoring its utility in afforestation and carbon offset programs.

Intermediate performers such as MD-138 (426.4 t ha^{-1}), MD-157 (375.9 t ha^{-1}), and MD-164 (375.7 t ha^{-1}) demonstrated steady and robust biomass accumulation, making them promising candidates for semi-arid regions where top-performing germplasms may not always thrive. These germplasms, with consistent growth and carbon storage trends, could complement high-performing varieties in agroforestry systems to diversify planting strategies and optimize carbon sequestration.

In contrast, MD-135, MD-148, and MTP-2 recorded relatively lower biomass CO_2 values, with MD-135 accumulating only 147.1 t ha^{-1} by 81 months. This suggests limited growth potential or suboptimal adaptability to the Eastern Dry Zone of Karnataka, possibly due to genetic constraints or environmental factors (Chopra et al., 2023; Satya et al., 2018). Interestingly, MD-174 showed a decline in biomass CO_2 accumulation after reaching 227.4 t ha^{-1} at 78 months, dropping to 209.8 t ha^{-1} at 81 months. This trend may be indicative of physiological stress, resource limitations, or disease susceptibility, warranting further investigation. Statistical analysis confirmed significant differences among the germplasms, as indicated by the high CD values at all intervals.

The results highlight the critical role of genetic variation in influencing carbon sequestration potential. The superior performance of MTP-3, MTP-1, and MD-138 suggests that these germplasms are ideal candidates for large-scale afforestation initiatives aimed at maximizing biomass and mitigating climate change. Incorporating intermediate-performing germplasms like MD-157 and MD-164 into planting programs can further enhance ecological and economic sustainability by accommodating diverse site conditions.

These findings underscore the importance of selecting high-performing germplasms tailored to specific environmental conditions to optimize carbon sequestration efforts in semi-arid regions like the Eastern Dry Zone of Karnataka.

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4. CONCLUSION

MTP-3, MTP-1 and MD-138 germplasms were found to have higher carbon sequestration potential and ~~were~~ best suitable for Melia plantation for Eastern Dry Zone of Karnataka. The germplasms MD-135, MD-174 and MD-129 were found to accumulate lesser CO_2 than the local germplasms viz., HKT-1 and KGL-1, hence, these germplasms are not suitable for the current location.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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