International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; SP-8(6): 265-268
www.biochemjournal.com
Received: 06-03-2024
Accepted: 16-04-2024

Kinjal Chaudhary
Ph.D. Scholar, Department of Soil Science & Agricultural Chemistry, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India

JR Jat
Associate Professor, Department of Soil Science & Agricultural Chemistry, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India

Tejasvi Joshi
Ph.D. Scholar, Department of Agronomy, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India

Ankit H Chauhan
Ph.D. Scholar, Department of Soil Science & Agricultural Chemistry, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India

Corresponding Author:
Kinjal Chaudhary
Ph.D. Scholar, Department of Soil Science & Agricultural Chemistry, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India

Growth, biomass production and CO_2 sequestration of some important multipurpose trees under rainfed conditions

Kinjal Chaudhary, JR Jat, Tejasvi Joshi and Ankit H Chauhan

DOI: https://doi.org/10.33545/26174693.2024.v8.i6Sd.1289

Abstract
An experiment was conducted at Agroforestry Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat during 2019-20 on six years old Agroforestry tree plantation which consisting of five multipurpose tree species (MPTs) *viz*., *Tectona grandis*, *Eucalyptus camaldulensis*, *Gmelina arborea*, *Casuriana equisetifolia*, *Melia azadiracht* was designed in completely randomized block design with four replications. Significantly higher plant height (16.19 m), collar diameter (19.34 cm), DBH (15.48 cm), tree canopy N-S (5.27 m) and E-W (5.84 m), above ground green and dry biomass i.e. 1514.75 kg/tree and 1073.18 kg/tree and below ground green and dry biomass i.e. 302.94 kg/tree and 219.64 kg/tree, respectively was recorded in *Eucalyptus camaldulensis*. The highest carbon content (41.32%) and CO_2 sequestration (1609.91 kg/tree and 1006.20 t/ha) was recorded under *Casuarina equisetifolia* and *Eucalyptus camaldulensis* tree species, respectively. The mean maximum SOC (0.251 Mg/m^3) was noted under *Casuriana equisetifolia* tree species which was 105.72 percent higher over control.

Keywords: CO_2 Sequestrations, Multipurpose tree species (MPTs), Soil organic carbon stock (SOC)

Introduction

Agroforestry plays a great role in maintaining the natural resource base and increases the productivity in the rainfed area of arid and semiarid region. It is a collective name for land use system practices where woody perennials are deliberately grown on the same land unit of agricultural crops. Agroforestry system can be biologically more productive than either pure crop or pure trees systems provided that trees and crops are partially complemented in use of growth resources. Interaction of woody perennials with annual crops in to farming systems leads to greater prosperity at the farm level. Site selection is another criteria that should be considered during the tree selection. Many trees can be successfully grown in poor soils with intensive management. Planting of trees on farm lands will not only improve the economic and social status of farmers, but also help to improve the ecological condition of the area and soil fertility.

Trees provide food, fuel wood, fodder and timber, reduction in incidence of total crop failure and sustained productivity. Trees also provide the some more efficient recycling of nutrients by deep rooted trees on the site, reduction of surface run-off, nutrient leaching and soil erosion through impeding effect of tree roots and stems on these processes improve the microclimate, such as lowering of soil surface temperature and reduction in evaporation losses through a combination of mulching and shading, increment in soil nutrients through addition and decomposition of litter fall and improvement of soil structure through the constant addition of organic matter from decomposed litter.

As the tree biomass experience growth, the carbon held by the plant also increases carbon stock. As the forest biomass experiences growth, the carbon held captive in the forest stock increases. Over time, branches, leaves and other materials fall to the forest floor and may store carbon until they decompose. Carbon is also released as CO_2 when trees are harvested, although considerable carbon is stored in wood put in to long-term use such as in houses, furniture and books. Hence tree constitutes a major 'C' sink owing to the photosynthesis and storage of CO_2 in live and dead organic matter.

There is strong variation in the carbon sequestration potential among different plantation species variation in environmental conditions etc. can affect carbon sequestration (Banerjee and Prakasam, 2013) [2].

Carbon sequestration refers to the provision of long-term storage of carbon in the terrestrial biosphere, underground or the oceans so that the build up of carbon dioxide (the principal greenhouse gas) concentration in the atmosphere can be reduce. In another word, it can be defined as the removal of carbon (C) from the atmosphere by storing it in the biosphere. About two-thirds of terrestrial carbon is sequestered in the standing forests, forest under storey plants, leaf and forest debris, and in forest soils (Sedjo *et al.*, 1998) [12]. The removal of greenhouse gases from the atmosphere into sinks i.e. soil is one way of addressing climate change.

Materials and Methods

Site description: The field experiment was carried out at Agroforestry Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat. Geographically, Sardarkrushinagar is situated 28 km West of Palanpur at 72˚ - 19' East longitude and 24˚ - 19' North latitude at an altitude of 154.52 metre above the sea level.

Climate and weather conditions: The climate of the North Gujarat is typically semi-arid type. In general, monsoon is warm and moderately humid, winter is fairly cold and dry, while summer is quite hot and dry. The monsoon commences by middle of June and retreats by the middle of September with an average rainfall of 623.44 mm in 24 rainy days. The regular winter season starts by the middle of October and it continues till the end of February. The December and January are the coldest months of winter season and the summer season commences with the beginning of March and ends by the middle of June in which April and May are the hottest months of the season. The area receives erratic and less precipitation with high evapotranspiration due to high solar radiation and wind speed.

Experimental details: An experiment was conducted at Agroforestry Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India, during 2019-20 on six years old Agroforestry tree plantation which consisted of five multipurpose tree species (MPTs) *viz.*, *Tectona grandis*, *Eucalyptus camaldulensis*, *Gmelina arborea*, *Casuriana equstifolia*, *Melia azadiracht was* designed in completely randomized block design with four replications. The experiment consisting of 96 trees per species with a plot size of 24 m × 16 m under 4 m × 4 m tree spacing.

Collection of plant sample

To study the carbon content, tree samples were collected from the different parts of the trees such as branches, leaves and barks and prepared a composite sample by mixing all plant parts. The collected samples were dried under shade and in hot air oven at 60 ± 5 ºC for 24 hours. The dried samples were crushed and grinded in grinding mill and the plant sample was used for carbon estimation.

Growth parameters of tree: The biometric observations of four plants of each tree species in each replication were recorded randomly in the month of January, 2020 regarding growth and development of the tree species. Height of trees was recorded with the help of Ravi's multi meter and collar girth (CG) and girth at breast height (GBH) with the help of measuring tape. The CG was converted to collar diameter (CD) using formula CD = CG/π and GBH was converted to (diameter at breast height) DBH = GBH/π. Similarly, the plant canopy from North to South (N-S) and East to West (E-W) was measured using measuring tape.

Estimation of biomass in the tree (Ahmed *et al.*, 2009)

Determine the total (green) weight of the tree using the following formula

$$W = 0.25\ D^2\ H$$

Where,

W = Above ground weight of the tree in kg,

D = Diameter of the trunk in cm (CD) and

H = Height of the tree in mete

Determine the dry weight of the tree

The tree has average 72.5 percent dry matter and 27.5 percent moisture. Therefore, the total dry matter weight of the tree =W × 72.5 percent.

Root system weight

The root system weight about 20 percent, as much as the above ground weight of the tree. Therefore root system weight of the tree = W × 20 percent.

Determination of CO_2 sequestration (%)

Determination of carbon content in (%) plant samples

The carbon content in all collected plant samples were estimated by dry ashing method (Prasad *et al.*, 2010) [8]. The known quantity of oven dried sample (4.0 g) was placed in silica crucible and burnt in an electronic furnace at 550 °C for four hours. The ash content, inorganic elements in oxide form, left after burning was weighted and carbon content was calculated by using following equation.

Carbon content (%) = 100 - [Ash (%) + molecular weight of O_2 (53.3%) in $C_6H_{12}O_6$]

Determination of the weight of Carbon Dioxide (CO_2) sequestration in the tree

Carbon dioxide is composed of one molecule of carbon and two molecules of oxygen. The atomic weight of carbon is 12.001115 and the atomic weight of oxygen is 15.9994. Therefore, the weight of CO_2 is 1(C) + 2 (O) = 43.999915.The ratio of CO_2 to C is 43.999915/12.00115= 3.6663. Therefore, to determine the weight of carbon dioxide sequestration in the tree. Multiply the weight of carbon in the tree by 3.6663.

Carbon content (kg/ha)

$$\text{Carbon content (kg/ha)} = \frac{\text{Carbon content (\%) X Yield (kg/ha)}}{100}$$

Soil Organic Carbon Stock (SOC): Soil organic carbon stock (SOC) was calculated as per the formula suggested by Batjes, 1996 [3].

$Q_i = C_i D_i E_i (1 - G_i)$

Where,
Q_i = Soil Organic Carbon Stock (Mg/m^3),
E_i = Soil depth (m),
C_i = Carbon content in soil (g C/g),
D_i = Bulk Density (Mg/m^3) and
G_i = Coarse fragments.

Results and Discussion

Growth parameters of MPTs: A perusal of data presented in Table 1 revealed that among all the five tree species significantly the highest plant height (16.19 m), collar diameter (19.34 cm) and diameter at breast height (15.48 cm) was recorded under the *Eucalyptus camaldulensis* tree species over rest of the tree species and it was closely followed by *Casuriana equistifolia* in case of plant height and DBH but *Melia azadiracht* was closely followed in case of CD. Similarly significantly the highest tree canopy N-S (5.27 m) and E-W (5.84 m) was recorded under *Eucalyptus camaldulensis* tree species over *Tectona grandis* but remained at par with rest of the tree species. These results are in close conformity with the findings of Roy *et al.* (2005) [10], Singh *et al.* (2009) [15], Singh *et al.* (2011) [14], Sarkar *et al.* (2017) [11], Datta *et al.* (2007) [5] and Singh *et al.* (2011) [14].

Table 1: Growth parameter of various MPTs under rainfed condition after six years of planting (Average of four trees)

Sr. No.	Treatments	Tree Height (m)	CD (cm)	DBH (cm)	Tree Canopy (m)	
					N-S	E-W
T_1	Teak (*Tectona grandis*)	5.23	8.30	7.83	2.86	3.01
T_2	Nilgiri (*Eucalyptus camaldulensis*)	16.19	19.34	15.48	5.27	5.84
T_3	Sevan (*Gmelina arborea*)	7.03	15.39	12.96	4.19	4.00
T_4	Saru (*Casuriana equistifolia*)	15.67	15.42	14.92	4.25	4.25
T_5	Bakyam Neem (*Melia azadiracht*)	7.95	17.08	14.10	5.08	5.40
T_6	Open field (Control)	-	-	-	-	-
	S.Em. (±)	0.188	0.147	0.365	0.54	0.59
	C.D. at 5%	0.568	0.442	1.09	1.62	1.76

Biomass production: The data presented in Table 2 revealed that significantly the highest above ground green (1514.75 kg/tree, 946.71 t/ha) and dry biomass (1073.18 kg/tree and 686.36 t/ha) as well as below ground green (302.94 kg/tree, 189.34 t/ha) and dry biomass (219.64 kg/tree and 137.27 t/ha) and total dry biomass (823.641 t/ha) was recorded under *Eucalyptus camaldulensis* tree species over rest of the tree species and it was followed by *Casuriana equistifolia*, *Melia azadiracht*, *Gmelina arborea* and *Tectona grandis* i.e. 506.953, 315.485, 226.871, 49.18 t/ha, respectively. These results are in agreement with those of Chaturvedi *et al.* (2016) [4] and Miria and Khan (2012) [7].

Table 2: Biomass allocation in above and below ground green and dry biomass of MPTs after six years of plantation

Sr. No.	Treatments	AGGB (kg/tree)	AGDB (kg/tree)	BGGB (kg/tree)	BGDB (kg/tree)	Total dry biomass (t/ha)
T_1	Teak (*Tectona grandis*)	90.46	65.58	18.09	13.11	49.188
T_2	Nilgiri (*Eucalyptus camaldulensis*)	1514.75	1073.18	302.94	219.64	823.641
T_3	Sevan (*Gmelina arborea*)	417.23	302.49	83.44	60.50	226.871
T_4	Saru (*Casuriana equistifolia*)	932.32	675.93	186.46	135.19	506.953
T_5	Bakyam Neem (*Melia azadiracht*)	580.20	420.62	116.04	84.13	315.485
T_6	Open field (Control)	-	-	-	-	-
	S.Em.(±)	20.62	12.89	4.12	2.99	11.21
	C.D. at 5%	62.17	38.86	12.43	9.11	33.81

CO_2 sequestration

The data regarding the carbon content in the composite sample (stem + bark + branch + root) of different tree species presented in Table 3 indicated that significantly the highest carbon content (41.32 percent) was found in *Casuriana eqistifolia* over *Eucalyptus camaldulensis* (33.27 percent) but remained at par with rest of the tree species. Similar results were also reported by Sharma *et al.* (2016) [13].

Significantly the highest total carbon content (439.112 kg/tree and 274.445 t/ha) and CO_2 sequestration (1609.91 kg/tree and 1006.20 t/ha) was recorded under *Eucalyptus camaldulensis* over rest of the tree species at six years age of trees and it was followed by *Casuriana equistifolia*, *Melia azadiracht*, *Gmelina arborea* and the lowest value was obtained by *Tectona grandis.* Similar results were also reported by Kumar *et al.* (2019) [6] and Sharma *et al.* (2016) [13].

Table 3: Carbon content and CO_2 sequestration in different tree species (6 years old trees)

Sr. No.	Treatments	Carbon content (%)	Total carbon content (kg/tree)	Total carbon content (t/ha)	CO_2 sequestration (kg/tree)	CO_2 sequestration (t/ha)
T_1	Teak (*Tectona grandis*)	40.82	32.151	20.094	117.88	73.67
T_2	Nilgiri (*Eucalyptus camaldulensis*)	33.27	439.11	274.44	1609.91	1006.20
T_3	Sevan (*Gmelina arborea*)	40.27	146.10	91.31	535.66	334.79
T_4	Saru (*Casuriana equistifolia*)	41.32	335.15	209.47	1228.76	767.97
T_5	Bakyam Neem (*Melia azadiracht*)	40.10	202.425	126.51	747.65	467.28
T_6	Open field (Control)	-	-	-	-	-
	S.Em.(±)	0.416	9.839	6.149	35.90	22.44
	C.D. at 5%	1.253	29.66	18.53	108.22	67.64

Soil organic carbon stock

Data given in Table 4 pertaining to soil organic carbon stock under different MPTs at different soil depth indicated that significantly the highest soil organic carbon stock (0.278 Mg/m^3), (0.241 Mg/m^3) and (0.235 Mg/m^3) was noted under *Casuriana equisetifolia* at 0-30 cm, 30-60 cm and 60-90 cm depth, respectively. The magnitude of SOC below different tree species was *Casuriana equisetifolia* >*Melia azadiracht* >*Tectona grandis* >*Gmelina arborea* >*Eucalyptus camaldulensis.*

Mean maximum SOC (0.251 Mg/m^3) was noted under *Casuriana equisetifolia* (T_4) tree species which was 105.73 percent higher over control.

Table 4: Effect of different MPTs on Soil organic carbon stock (6 years old tree species)

Sr. No.	Treatments	Soil organic carbon stock (Mg/m^3)			Mean
		0-30 cm	30-60 cm	60-90 cm	
T_1	Teak (*Tectona grandis*)	0.194	0.183	0.181	0.186 (52.45)
T_2	Nilgiri (*Eucalyptus camaldulensis)*	0.156	0.161	0.152	0.156 (27.86)
T_3	Sevan (*Gmelina arborea*)	0.164	0.165	0.163	0.164 (34.42)
T_4	Saru (*Casuriana equistifolia*)	0.278	0.241	0.235	0.251 (105.73)
T_5	Bakyam Neem (*Melia azadiracht*)	0.212	0.211	0.207	0.210 (72.13)
T_6	Open field (Control)	0.133	0.123	0.111	0.122
	S.Em.±	0.004	0.004	0.003	-
	C.D. at 5%	0.011	0.012	0.009	-

Conclusion

The growth parameters of six years old multipurpose tree species varied significantly among them *Eucalyptus camaldulensis* obtained the highest plant height, collar diameter, diameter at breast height, plant canopy and carbon sequestration and closely followed by *Casuarina equisetifolia* and *Melia azadiracht.* Significantly higher carbon content (41.32 percent) in tree and SOC stock in soil was noted under *Casuarina equisetifolia*.

References

1. Ahmed H, Yola S, Keles S. Changes in carbon and oxygen production in forest timber of Balci forest management unit in Turkey. Afr. J Biotechnol. 2009;8(19):4872-4883.
2. Banerjee SK, Prakasam U. Biomass carbon pool and soil organic carbon sequestration in Tectona grandis plantations. Indian For. 2013;139(9):797-802.
3. Batjes NH. Total carbon and nitrogen in the soils of the world. Eur J Soil Sci. 1996;47(2):151-163.
4. Chaturvedi OP, Handa AK, Kaushal R, Uthappa AR, Sarvade S, Panwar P. Biomass production and carbon sequestration through agroforestry. Range Manag Agrofor. 2016;37(2):116-127.
5. Datta M, Singh NP. Growth characteristics of multipurpose tree species, crop productivity and soil properties in agroforestry systems under sub-tropical humid climate in India. J For Res. 2007;18(4):261-270.
6. Kumar P, Mishra AK, Kumar M, Chaudhary SK, Singh R, Singh K, *et al*. Biomass production and carbon sequestration of Eucalyptus tereticornis plantation in reclaimed sodic soils of north-west India. Indian J Agric Sci. 2019;89(7):1091-1095.
7. Miria A, Khan AB. Biomass estimation and carbon storage in selected multipurpose trees and common wild grasses. Indian For. 2012;138(9):853-856.
8. Prasad R, Saroj NK, Newaj R, Venkatesh A, Dhyani SK, Dhanai CS. Atmospheric carbon capturing potential of some agroforestry trees for mitigation of warming effect and climate change. Indian J Agrofor. 2010;12(2):37-41.
9. Prasath CN, Balasubramanian A, Radhakrishnan S, Prasanthrajan M. Growth and carbon stock assessment in three year-old fast growing trees grown under wasteland condition at Sivagangai district of Southern Tamil Nadu. Int J For Crop Improv. 2016;7(1):29-34.
10. Roy KC, Zaman MS, Salam MA, Bari MS, Hossain MF. Performance of multipurpose trees and field crops under different management practices in agroforestry system. Nat Sci Found. 2005;34(1):15-19.
11. Sarkar P, Das B, Bhatt BP. Melia azadiracht L. a promising agroforestry species for improving livelihood to farmers of eastern plateau and hill region of India. Int Q J Life Sci. 2017;12(2):1095-1100.
12. Sedjo RA, Sohngen B, Jagger P. Carbon Sinks in the Post-Kyoto World. RFF Climate Issue Brief No. 13. [Internet]; c1998.
13. Sharma V, Patel P, Kumar D. Estimation of standing state biomass and carbon sequestration potential of multipurpose tree species at Mohand range, Dehradun Forest division, Uttarakhand. Indian For. 2016;142(11):1087-1092.
14. Singh IS, Awasthi OP, Singh RS, More TA, Meena SR. Changes in soil properties under tree species. Indian J Agric Sci. 2011;82(2):146-151.
15. Singh YP, Singh G, Sharma DK. Biomass and bio-energy production of ten multipurpose tree species planted in sodic soils of Indo-Gangetic plains. J For Res. 2009;21(1):19-24.