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Growth, Biomass Production and CO_2 Sequestration of Some Important Multipurpose Trees under Rainfed Condition

K.N. Patel*, R.R. Shakhela and J.R. Jat

Department of Agricultural Chemistry and Soil Science, C. P. College of Agriculture,
Sardarkrushinagar Dantiwada Agricultural University,
Sardarkrushinagar - 385 506, Gujarat, India
**Corresponding author*

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A B S T R A C T

An experiment was conducted at Agroforestry Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat, India, The experiment was designed in randomized block design with four replications on 30 years old agroforestry tree plantation which consisted of four multipurpose tree species (MPTs) *viz., Azadirachta indica*, *Prosopis cineraria*, *Prosopis juliflora* and *Acacia tortolis*. Significantly the highest plant height (9.29 m), CD (29.16 cm) and DBH (31.36 cm) was recorded under *Azadirachta indica, Prosopis juliflora, Acacia tortolis*, respectively, whereas significantly the highest tree canopy N-S (7.18 m) and E-W (7.32 m) was also noted under *Acacia tortolis*. Above ground green and dry biomass and below ground green and dry biomass of different tree species did not differed significantly. The highest C content (41.55 per cent) and CO_2 sequestration (1847.11 kg/tree and 2052.35 t/ha) was recorded under *Prosopis juliflora* tree species. The descending order of carbon content in different tree species was *Prosopis juliflora* > *Azadirachta indica* > *Prosopis cineraria* > *Acacia tortolis.* Maximum SOC (0.544 Mg/m^3) was noted under *Acacia tortolis* which was 242.14 per cent higher over control.

Introduction

Agroforestry plays a great role in maintaining the natural resources and increases the productivity in the rainfed area of arid and semiarid region. Trees provide food, fuel wood, fodder, fertilizer 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 improvement of microclimate, such as lowering of soil surface temperature and reduction of evaporation of soil moisture 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.

Carbon sequestration issues in tree are being enormous momentum in recent time. A vital role of trees is recycling of air in the lower atmosphere. Forests store and release carbon dioxide through natural processes. As a tree grows, it takes in CO_2 from the atmosphere and releases O_2 in the process of photosynthesis. The carbon that is taken from the air is incorporated into sugars (such as glucose), that become the building blocks for production of wood. About one-half the weight of dry wood is carbon and that carbon is stored or sequestered as long as the wood is in existence. When trees die, decay or burn they release carbon stored in the soils and biomass (organic matter such as stems, stumps and slash) as CO_2 into the atmosphere. Carbon is also released as CO_2 when trees are harvested, although considerable carbon is stored in wood put into 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 can affect carbon sequestration.

Trees improve land cover in agricultural fields in addition to providing 'C' inputs to the soil. The most significant increase in 'C' stock occurs in fine textured soils, where 'C' is better protected through soil aggregation. Trees in degraded lands offer a great opportunity to sequester more carbon and seek carbon credits. There is constant addition of organic matter to the soil through decaying dead roots, which lead to improvement in the 'C' status of the soil. The overall fertility build-up in tree system may be attributed by the nature and diversity of species and due to heavy litter fall and their subsequent decomposing in the soil profile. Planting of multipurpose tree species in the field serves a dual purpose *i.e.*, promotion of biodiversity and carbon sequestration.

Materials and Methods

The field experiment was carried out at Agroforestry Research Station, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat. The experiment consisted on 30 years old agroforestry tree plantations of multipurpose tree species (MPTs) *viz., Azadirachta indica*, *Prosopis cineraria*, *Prosopis juliflora* and *Acacia tortolis* was designed in randomized block design with four replications. The experiment consisting of 96 trees in a plot with a plot size of 48 m × 18 m under 3m × 3m tree spacing.

The biometric observations of the tree species were recorded during February, 2016 from four plants of each tree species and with a total of 16 plants of each tree species were measured randomly. Height of trees was recorded with the help of Ravi's altimeter and collar girth (CG) and girth at breast height (GBH) was with the help of measuring tape. The CG was converted to collar diameter using formula $CD = CG/\pi$ and GBH was converted to diameter at breast height by $DBH = GBH/\pi$. Similarly, the plant canopy from North to South (N-S) and East to West (E-W) was measured using measuring tape. Biomass in the tree was estimated as per the formula suggested by Ahmed *et al.*, 2009 ($W = 0.25\ D^2\ H$) 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 meter. The root system weight about 20 per cent, as much as the above ground weight of the tree. Therefore the total green weight of the tree = W × 120 per cent.

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

To study the carbon content in trees sample were collected from the different parts of the trees such as branches, leaves and barks. The carbon content in all collected plant samples were estimated by dry ashing method (Prasad *et al.*, 2010). The known quantity of oven dried sample (4.0 g) was placed in silica crucible and burnt it in an electronic furnace (GEI model-850) at 550°C for four hours. The ash content, inorganic elements in the form of oxide 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 $C_6H_{12}O_6$]

The weight of carbon dioxide sequestration in the tree was determined as

$$\text{Carbon content (kg/ha)} = \frac{\text{Carbon content (\%)} \times \text{total DM (kg/ha)}}{100}$$

Soil organic carbon stock (SOC) was calculated as per the formula suggested by Batjes, 1996.

Qi = CiDiEi (1 - Gi)

Where,
Q = Soil Organic Carbon Stock (Mg/m3),
Ei = Soil depth (m),
Ci = Carbon content in soil (g C/g),
Di = Bulk Density (Mg/m3) and
Gi = Coarse fragments.

Results and Discussion

Growth parameters of MPTs

Data on growth parameters are presented in table 1 revealed that among different tree species a significant variation existed in plant height at the end of 30 years of age. Significantly the highest plant height was noted under *Azadirachta indica* (9.29 m) while the lowest plant height (7.31 m) was observed in *Prosopis cineraria* whereas the highest CD (29.16 cm) was noticed in *Prosopis juliflora* (T_3) and followed by *Acacia tortolis* (26.75 cm), *Prosopis cineraria* (25.55 cm) and *Azadirachta indica* (20.08 cm). The results are in agreement with those of Nandeshwar *et al.,* (2006) and Gill and Gupta (2005). Among the tree species significantly the highest DBH was noticed in *Acacia tortolis* (31.36 cm) but the lowest DBH (17.63 cm) was recorded in *Azadirachta indica*. The results are in agreement with those of Giri Rao *et al.,* (2000) and Devevaranavadgi *et al.,* (2000). The canopy spread in N-S and E-W directions was significantly higher in *Acacia tortolis* and followed by *Prosopis juliflora*, *Azadirachta indica* and *Prosopis cineraria*. Results are in close conformity with the findings of Nandeshwar *et al.,* (2006) and Devevaranavadgi *et al.,* (2000).

Biomass production

A perusal of data presented in table 2 revealed that maximum above ground green (1822.91 kg/tree) and dry biomass (1321.61 kg/tree), below ground green (364.58 kg/tree) and dry biomass (264.32 kg/tree) was recorded under *Prosopis juliflora* and followed by *A.tortolis*, *P. cineraria* and *A. indica.*Similar results were reported by Miria and Khan (2012).

Effect of different MPTs on CO_2 sequestration

The data pertaining to carbon content (%) in tree indicated in table 3 exhibited significantly higher values in *Prosopis juliflora* (41.55 per cent), whereas the *Acacia tortolis* (38.40 per cent) have the lowest value as compare to other tree species.

Total composite carbon content in tree was not influenced significantly due to different tree species. However the maximum total carbon content was recorded under *Prosopis juliflora* (663.87 kg/tree) and followed by *Acacia tortolis* (500.25 kg/tree), *Prosopis cineraria* (408.54 kg/tree) and *(Azadirachta indica* (366.45 kg/tree).Similar results were also reported by Dey (2005).

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

Sr. No.	Particular of treatment	Tree Height (m)	CD* (cm)	DBH** (cm)	Tree Canopy (m)	
					N-S	E-W
T_1	*A. indica*	9.29	20.08	17.63	5.06	4.80
T_2	*P. cineraria*	7.31	25.55	23.76	4.62	4.57
T_3	*P. juliflora*	8.02	29.16	19.55	6.94	6.78
T_4	*A. tortolis*	7.63	26.75	31.36	7.18	7.32
T_5	Control	-	-	-	-	-
	S.Em. (±)	0.30	1.65	1.14	0.48	0.45
	C.D. at 5 %	0.97	5.29	3.66	1.53	1.43
	C.V. (%)	7.53	13.04	9.92	16.04	15.19

*Collar diameter, ** DBH Diameter at breast height

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

Sr. No.	Particular of treatment	AGGB (kg/tree)	AGDB (kg/tree)	BGGB (kg/tree)	BGDB (kg/tree)	Total dry biomass (t/ha)
T_1	*A. indica*	1072.73	777.73	214.55	155.55	1036.97
T_2	*P. cineraria*	1208.02	875.82	241.60	175.16	1167.75
T_3	*P. juliflora*	1822.91	1321.61	364.58	264.32	1762.15
T_4	*A.tortolis*	1500.92	1088.16	300.18	217.63	1450.88
T_5	*Control*	-	-	-	-	-
	S.Em. (±)	188.33	136.54	37.67	27.31	182.06
	C.D. at 5 %	NS	NS	NS	NS	NS
	C.V. (%)	26.88	26.88	26.88	26.88	26.88

AGGB = Above ground green biomass, AGDB = Above ground dry biomass, BGGB = Below ground green biomass and BGDB = Below ground dry biomass

Table.3 Carbon content and CO_2 sequestration in different tree species (30 years age)

Sr. No.	Particular of treatment	Carbon content (%)	Total carbon content (kg/tree)	CO_2 sequestration in tree (kg/tree)
T_1	*A. indica*	39.24	366.45	1343.53
T_2	*P. cineraria*	38.91	408.54	1497.82
T_3	*P. juliflora*	41.55	663.87	1847.11
T_4	*A. tortolis*	38.40	500.25	1834.05
T_5	Control	-	-	-
	S.Em. (±)	0.20	68.46	223.22
	C.D. at 5 %	0.64	NS	NS
	C.V. (%)	1.02	28.25	27.38

Table.4 Soil organic carbon stock (Mg/m^3) under different MPTs after thirty years of plantation at different soil depth

Sr. No.	Particular of treatment	Soil organic carbon stock (Mg/m^3)			Mean
		0-30 cm	30-60 cm	60-90 cm	
T_1	*A. indica*	0.397	0.331	0.448	0.392 (146.54%)
T_2	*P. cineraria*	0.300	0.341	0.625	0.422 (165.41%)
T_3	*P. juliflora*	0.263	0.556	0.503	0.441 (177.36%)
T_4	*A.tortolis*	0.392	0.574	0.669	0.544 (242.14%)
T_5	Control	0.094	0.133	0.250	0.159
	S.Em. (±)	0.02	0.02	0.03	-
	C.D. at 5 %	0.05	0.07	0.10	-
	C.V. (%)	11.72	11.71	12.69	-

Figures in parentheses indicate the per cent values increase over control

The CO_2 sequestration of different MPTs did not exhibit significant difference under different trees species (Table 3). However the maximum value (1847.11 kg/tree) was noted under *Prosopis juliflora* species and minimum (1343.53 kg/tree) was recorded under *Azadirachta indica* tree species. Tree species to be the most efficient capturing CO_2 from the atmosphere because tree is the source of producing oxygen and stores carbon dioxide in the growing biomass through the process of photosynthesis and also increasing the soil organic carbon content. The increasing trend of CO_2 sequestration in selected tree species are as follows: *Prosopis juliflora* > *Acacia tortolis* > *Prosopis cineraria* > *Acacia indica*. Similar results were also reported by Banerjee and Prakasam (2013).

Soil Organic Carbon Stock (SOC)

A perusal of data presented in table 4 revealed that significantly the highest SOC stock at 0-30 cm soil depth (0.397 Mg/m^3) was recorded under *Azadirachta indica* and at 30-60 cm and 60-90 cm soil depth (0.574 and 0.669 Mg/m^3, respectively) was recorded under Acacia tortolis tree species. Among the all treatments the lowest SOC stock (0.094, 0.133 and 0.250 Mg/m^3, respectively) at 0-30, 30-60 and 60-90 cm soil depth was recorded under open field. The increasing trend of SOC under tree species was as *Acacia tortolis* > *Prosopis. juliflora* > *Prosopis cineraria* > *Acacia indica*. *Acacia tortolis* tree species stored 242.14 per cent higher organic carbon and SOC stock in soils over control (open field condition). Tree plays an important role in soil C sequestration. Tree helps in sequestering carbon in their biomass in the soil and in wood products. Since a large total land area is suitable for tree plantation, there is potential for large scale carbon sequestration (Subba Rao and Saha, 2014). The similar results were also reported by Banerjee and Prakasam (2013)

Among the tree growth parameters of 30 years of stand age, significant variation in plant height, CD, DBH and plant canopy has been observed in the tree studied.

Among the selected MPTs *Acacia tortolis* tree species stored 242.14 per cent higher organic carbon and SOC stock in soils over control. Maximum CO_2 sequestration through tree was noted under *Prosopis juliflora*. Block based agroforestry system (Tree in block) has the potential to sequester carbon from the atmosphere, net reduction in CO_2 emission, improve soil quality and conserve natural recourses.

References

Ahmed, H., Yola, S. and Keles. 2009. Changes in carbon and oxygen production in forest timber of Balci forest management unit in Turky. *African Journal Biotechnology*. 8(19): 4872-4883.

Ahmedin, A. M., Bam, S., Siraj, K. T. and Raju, A. J. S. 2013. Assessment of biomass and carbon sequestration potentials of standing *Pongamia pinnata* in Andhra University, Visakhapatnam, India. *Bioscience Discovery*. 4(2): 143-148.

Banerjee, S. K., and Prakasam, U. 2013. Biomass carbon pool and soil organic carbon sequestration in *Tectona grandis* plantations. *Indian Forester*. 139(9): 797-802.

Buvaneswaran, C., Velumani, R. and Jayaraj, R. S. C. 2012. Carbon Seqestration potential of *Tectona grandis L.* under agroforestry systems in Tamil Nadu. *Agroforestry for Mitigating Global Warming and Genetic Resource Conservation*. pp: 212-218.

Devevaranavadgi, S. B., Guggari, A. K., Kalaghatagi, S. B., Wali, S. Y. and Patil, M. B. 2000. Performance of different tree species and their effect on physical and chemical properties of soil in northern dry zone of Karnataka. *Crop Research*. 20(3): 525-533.

Dey, S. K., 2005. A preliminary estimation of carbon stock sequestrated through rubber (*Hevea brasiliensis*) plantation in North Eastern Region of India. *Indian Forester*. 131(11): 1429-1436.

Gill, A. S., and Gupta, S. K. 2005. Biomass production of trees under semi- arid rainfed agroforestry system. *Indian forester*. 131(4): 591- 594.

GiriRao, L. G., Joseph, B. and Sreemannarayana, B. 2000. Growth and biomass production of some important multipurpose tree species on rainfed sandy loam soils. *Indian Forester*. 126(7): 772- 781.

Jackson, M. L., 1962. Soil Chemical Analysis Prentice Hall, Englowood Cliffs, N.J.

Miria, A., and Khan, A. B. 2012. Biomass estimation and carbon storage in selected multipurpose trees and common wild grasses. *Indian Forester*. 138(9): 853-856.

Nandeshwar, D. L., Vijayaraghavan, A. and Meshram, M. 2006. Performance of different multipurpose tree species in degraded land of Satpura region of Madhya Pradesh. *Indian Forester*. 132(2): 205-210.

Prasad, R., Saroj, N. K., Newaj, R., Venkatesh, A., Dhyani, S. K. and Dhanai, C. S. 2010. Atmospheric carbon capturing potential of some agroforestry trees for mitigation of warming effect and climate change. *Indian Journal of Agroforestry*. 12(2): 37-41.

Subba Rao, A., and Saha, R. 2014. Agroforestry for soil quality maintainance, climate change mitigation and ecosystem services. *Indian Farming*. 63(11): 26-29.

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