



Biological Properties Influenced by Different Tree Species in Deep Chambal Ravine of Madhya Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment site planted with different multipurpose trees and their impact on soil biological properties were measured and analyzed. Based on overall growth on biological properties showed that preferred ranking tree species in the following order viz., maximum soil microbial biomass carbon, dehydrogenase activity and soil respiration were recorded under *Moringa oleifera*,

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respectively followed by *Albizia lebbeck*, *Azadirachta indica*, *Acacia nilotica*, *Dalbergia sissoo*, *Terminalia arjuna*, *Millettia pinnata* and *Gmelina arborea* while *Justicia adhatoda* was recorded minimum, respectively. Tree stand growth significantly improved the soil biological properties. Thus, *A. Moringa oleifera* and *Albizia lebbeck* species are most suitable multipurpose hardy tree species for rehabilitation of medium and deep ravines of Chambal ravines in India.

Keywords: Ravine lands; multipurpose trees; biological properties; microbial biomass and soil respiration.

1. INTRODUCTION

The land degradation due to water induced erosion is a major global problem and in India it affects more than 28% of total geographical area of the country [1 and ICAR (2010)]. Among various forms of land degradation, rainwater erosion affects 1.37 million ha area under ravine (GOI, 2003 and ICAR, 2010) and this occurs along several river systems in the alluvial zones of India. In Indian context, the word ravine refers to a network of gullies which are generally spread along any river system. The gully is an erosion channel developed by ephemeral streams with steep banks and a nearly vertically deep gully head enough to create hindrance to the normal tillage operations. The rate of gully erosion depends on the run-off producing characteristics of the watershed which are governed by the size and shape of drainage area, soil characteristics, the alignment, size, shape and gradient of the gully channel. The gully are widening and ravines are extending at the rate of 8 to 9 m per annum with average soil loss of more than 17 tons ha⁻¹ year⁻¹ [2]. It causes potential threat to nearby cultivated land, but led to other processes destructive to national economy, viz. floods in river basins, siltation in water reservoirs/tanks and the consequent loss in their storage capacity, choking of estuaries and harbors, damage to railway lines, roads and other public utility properties. These have encroached upon the inhabited villages; many of them had to be shifted to new sites to avoid loss of lives [3]. The objective of this study was to determine the success of reforestation with multipurpose trees for higher biomass production above & below ground carbon stock and improvement in soil biological properties.

2. MATERIALS AND METHODS

The present study was conducted at university experimental site at the village Aisah of Morena district of Madhya Pradesh. The geographical location of study area is 26° 40'40.84 N latitude and 78° 06'29.21E longitude with an altitude

ranges 150 to 240 m above mean sea level. In both these studies, heavy emphasis was laid on plantation from the very beginning several species of native forest trees and fruit trees were raised during 2012 at 3x3 m spacing evaluated on different sloppy and leveled patches of ravine land. The experiments were started in 2020-21 to 2021-22.

Soil sample three hundred twenty-four (162 first year and 162 second year) surface and subsurface soil (0-15, 15-30, 30-60, 60-90, 90-120, and 120-150 cm depths) samples collected from different nine trees (6 samples of each tree and one type tree with three replications) of the site. The experimental design was randomized block design (RBD).

Microbial biomass carbon was determined by the modified fumigation-incubation method [4].

$$\text{MBC } (\mu\text{g g}^{-1} \text{ of soil}) = \frac{\text{ECF} - \text{ECNF}}{\text{KEC}}$$

Where, KEC= 0.25± 0.05 and it represents the efficiency of extraction of microbial biomass carbon and ECF and ECNF are extractable C in the fumigated and non-fumigated solutions, respectively.

Dehydrogenase activity, as a determinant of total microbial activity in the soil under the tree species, was measured by following the procedure described by Tabatabai [5]. Dehydrogenase activity in soil was calculated as

$$= \frac{\text{Concentration} \times \text{Dilution}}{\text{Incubation time} \times \text{Soil weight}}$$

Where, Concentration = Absorbance value x Y value of standard curve (78.58).

Soil respiration was estimated by closed jar method [6]. The rate of soil respiration was calculated by the following formula = $\frac{(\text{Vo}-\text{V}) \times 1.1}{\text{Dwt} \times \text{T}}$

Where, T: Time of incubation in hrs., Vo: HCl used for blank, V: HCl used for soil sample, Dwt:

Dry wt. of 1g moist soil, 1.1:Conversion factor (1ml 0.05M NaO Hequals1.1mg CO₂).

3. RESULTS AND DISCUSSION

Soil microbial biomass carbon (µg/g) pooled mean analysis of two years of experiments positive and significant effect of the treatments on soil organic carbon at different depths 0-15, 5-30, 30-60, 60-90, 90-120, and 120-150 cm. According to the data presented in the Table 1, it is obvious that the maximum soil microbial biomass carbon was recorded under *Moringa oleifera* (65.08, 62.69, 62.24, 56.96, 52.26 and 42.38 µg/g), respectively followed by *Albizia lebbbeck*, *Azadirachta indica*, *Acacia nilotica*, *Dalbergia sissoo*, *Terminalia arjuna*, *Millettia pinnata* and *Gmelina arborea* while *Justicia adhatoda* (53.26, 51.15, 50.99, 42.32, 35.12 and 32.21 µg/g) was recorded minimum. Soil microbial biomass carbon which signifies very labile carbon fraction of active carbon pool which is easily available for plant uptake through mineralization was higher under different tree species as compared to control [7]. The soil microbial biomass carbon was reported to be higher under tree species due to the relatively higher microbial population, the addition of a large quantity of organic matter to the soil. A similar case was with MBP which had direct and significant relation with OC ($r = 0.657^{**}$), available N ($r = 0.455^{**}$), CO₂ ($r = 0.310^{**}$) and DHA ($r = 0.557^{**}$) and significantly negative relationship with pH ($r = -0.134^{\dagger}$) and APEA ($r = -0.642^{**}$) content in the Gird zone. Since, organic matter and microbial activity are typically related to each other, the significant decrease in organic carbon probably intensifies the adverse effects of salinity on soil microbial biomass [8]. As the pH and EC are significantly correlated with biological properties, the special effects of pH and EC were more pronounced. Thus, the study emphasizes that soil EC and pH should be considered as indicators of changes in biological soil health in soil salinized by saline irrigation water [9]. The results obtained for soil microbial biomass carbon are verified from the findings of Sharma et al. [10] and Yadav et al. [11] who reported higher soil MBC under agro forestry and lower under control. The main reason is the addition of organic inputs in the form of litter fall, recycling of fine root biomass and pruning debris contributed considerably towards organic carbon thus positively affecting microbial population and activity. However, Munoz et al. [12] reported that

microbial biomass carbon was considerably less up to a depth of 10 cm in all agro forestry land use systems compared to treeless.

Dehydrogenises activity (microgram tpf/gm soil/day) the presence of tree species also significantly improves the soil enzymatic activity as represented in Table 1 and Fig. 1. Dehydrogenase is a good indicator of biological activity taking place in the soil. Dehydrogenase is an important enzyme in the Krebs cycle and electron transport system, hence used for studying biological activity. The pooled analysis depicts positive and significant effects of the treatments on dehydrogenase activity at different depths 0-15, 5-30, 30-60, 60-90, 90-120 and 120-150 cm. According to the data presented in the Table 1, it is obvious that the maximum dehydrogenase activity was recorded under *Moringa oleifera* (90.23, 82.83, 82.47, 79.50, 70.68 and 69.27 microgram tpf/gm soil/day), respectively followed by *Albizia lebbbeck* (83.04, 80.59, 81.80, 78.92, 70.48 and 67.97 microgram tpf/gm soil/day), *Azadirachta indica* (80.65, 80.54, 80.03, 78.43, 68.55 and 66.72 microgram tpf/gm soil/day), *Acacia nilotica* (79.67, 79.82, 77.98, 77.83, 67.89 and 65.50 microgram tpf/gm soil/day), *Dalbergia sissoo* (78.61, 77.64, 76.21, 73.77, 67.01, and 56.38 microgram tpf/gm soil/day), *Terminalia arjuna* (75.88, 74.24, 65.68, 61.98, 57.67 and 53.54 microgram tpf/gm soil/day), *Millettia pinnata* (73.58, 74.04, 63.53, 54.94, 55.80, 55.80 and 50.41 microgram tpf/gm soil/day) and *Gmelina arborea* (67.06, 60.94, 62.18, 52.00, 51.82 and 46.04 microgram tpf/gm soil/day) while *Justicia adhatoda* (55.34, 53.19, 52.89, 49.50, 47.76 and 45.56 microgram tpf/gm soil/day) was recorded minimum, respectively. Prasad and Mertia [13] reported considerably high dehydrogenase activity in tree rhizosphere as compared to non-rhizosphere soil owing to a greater supply of carbon and nutrients from dead root cells and rhizo-depositions. Yadav et al. [11] and Lalita [14] observed that the presence of an agri-silvi-horticultural system exerts a positive impact on the soil by facilitating the build-up of organic carbon thus improving the microbial population and enzymatic activity. Similar results were found by Batra [15]. An Alkaline phosphatase enzyme activity was inversely related, and this relationship remains significant with OC ($r = -0.657^{**}$), AN ($r = -0.440^{**}$), MBC ($r = -0.796^{**}$), MBN ($r = -0.772^{**}$), MBP ($r = -0.642^{**}$) and DHA ($r = -0.545^{**}$) and such relations have been also reported by Kumar et al. [16].

Table 1. Effect of tree species on SMBC, DHA and soil respiration at different soil depths (cm)

S. No.	Treatment	SMBC ($\mu\text{g/g}$)						DHA (microgram tpf/gm soil/day)						Soil respiration (CO_2 mg/g of soil/hrs.)					
		0-15	15-30	30-60	60-90	90-120	120-150	0-15	15-30	30-60	60-90	90-120	120-150	0-15	15-30	30-60	60-90	90-120	120-150
T ₁	<i>Moringa oleifera</i>	65.08	62.69	62.24	56.96	52.26	42.38	90.23	82.83	82.47	79.50	70.68	69.27	31.94	26.71	21.74	12.69	10.98	7.24
T ₂	<i>Terminalia arjuna</i>	60.82	54.96	54.52	49.49	41.51	37.73	75.88	74.24	65.68	61.98	57.67	53.54	26.41	20.89	17.94	9.44	6.79	6.52
T ₃	<i>Azadirachta indica</i>	63.30	59.27	59.76	51.78	43.56	40.90	80.65	80.54	80.03	78.43	68.55	66.72	28.25	23.65	19.37	10.53	9.45	6.92
T ₄	<i>Gmelina arborea</i>	56.20	53.81	51.59	45.05	36.32	33.69	67.06	60.94	62.18	52.00	51.82	46.04	24.04	17.44	15.42	8.49	6.41	5.46
T ₅	<i>Millettia pinnata</i>	57.93	54.31	53.03	47.39	39.33	35.39	73.58	74.04	63.53	54.94	55.80	50.41	24.23	20.04	16.83	8.60	6.73	5.87
T ₆	<i>Albizia lebbbeck</i>	63.31	60.14	61.66	53.96	43.87	42.01	83.04	80.59	81.80	78.92	70.48	67.97	29.10	25.41	20.80	10.87	10.27	7.06
T ₇	<i>Acacia nilotica</i>	62.47	56.00	56.91	51.29	42.10	40.18	79.67	79.82	77.98	77.83	67.89	65.50	27.62	22.16	19.00	10.36	8.16	6.77
T ₈	<i>Dalbergia sissoo</i>	61.70	53.96	56.49	50.59	41.93	39.36	78.61	77.64	76.21	73.77	67.01	56.38	27.24	21.05	18.78	9.93	7.87	6.65
T ₉	<i>Justicia adhatoda</i>	53.26	51.15	50.99	42.32	35.12	32.21	55.34	53.19	52.89	49.50	47.76	45.56	23.19	14.99	13.84	6.44	6.14	5.21
S.Em. \pm		0.95	1.17	0.97	0.76	0.71	0.56	0.88	1.01	1.00	0.53	0.51	0.94	0.57	0.62	0.27	0.20	0.19	0.19
C.D.		2.73	3.36	2.80	2.18	2.05	1.62	2.55	2.92	2.88	1.52	1.46	2.71	1.64	1.80	0.77	0.57	0.56	0.54

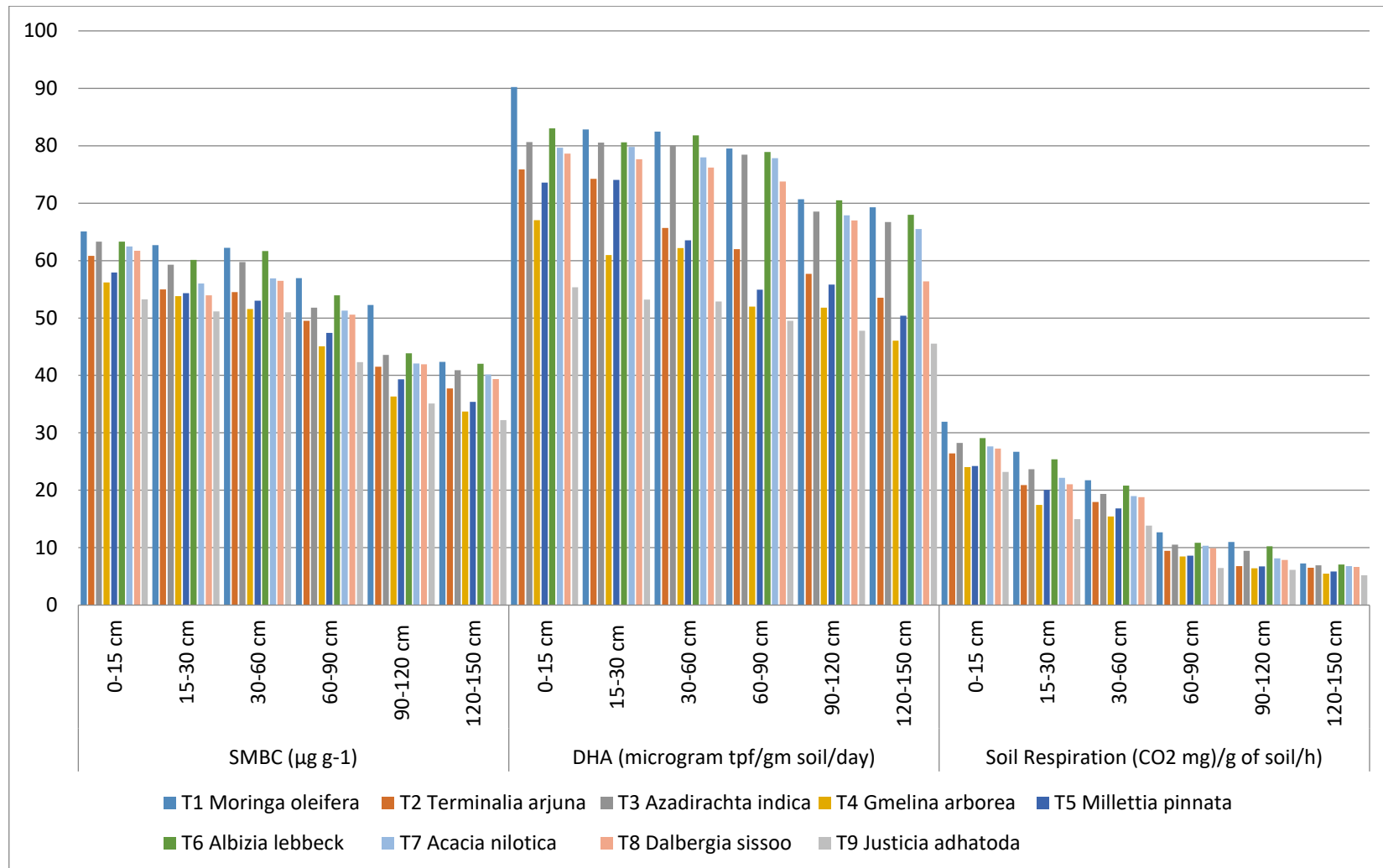


Fig. 1. Effect of tree species on SMBC, DHA and soil respiration at different soil depths (cm)

Soil respiration the pooled analysis depicts positive and significant effects of the treatments on soil respiration at different depths 0-15, 5-30, 30-60, 60-90, 90-120 and 120-150 cm. According to the data presented in the Table 1, it is obvious that the maximum soil respiration was recorded under *Moringa oleifera* (31.94, 26.71, 21.74, 12.69, 10.98 and 7.24 CO₂ mg/g of soil/hrs.), respectively. Followed by *Albizia lebbeck*, *Azadirachta indica*, *Acacia nilotica*, *Dalbergia sissoo*, *Terminalia arjuna*, *Millettia pinnata* and *Gmelina arborea* while *Justicia adhatoda* (23.19, 14.99, 13.84, 6.44, 6.14 and 5.21 CO₂ mg/g of soil/hrs.) was recorded minimum, respectively. A similar result was found by Greenwood [17] and Fornelio et al. [18].

4. CONCLUSION

The conclusion of our study results indicated that *Moringa oleifera* (Drumstick) has the most promising tree species, followed by *Albizia lebbeck*, *Azadirachta indica*, *Acacia nilotica*, *Dalbergia sissoo*, *Terminalia arjuna*, *Millettia pinnata*, and *Gmelina arborea*, while *Justicia adhatoda* recorded minimum biological activity. Simultaneously, development of the aboveground vegetation canopy due to suitable tree planting influences on the addition of letter residues, decomposition of leaf litter, and fine root turnover may cause improvements in soil biological properties in the long run. Thus, the ravine lands of India have a huge potential for biomass production, livelihood security, C-stocking, and improvement in soil environment with adopting tree species to achieve both economic and ecological aim of quick green cover, ecological restoration, and carbon balance in sustaining economic and environmental benefits.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

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

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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