Biological properties influenced by different tree species in deep Chambal ravine of Madhya Pradesh, India

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, dehydrogeneaseacticity and soil respiration were recorded under *Moringaoleifera*, respectively followed by *Albizialebbeck, Azadirachtaindica, Acacia nilotica,Dalbergiasissoo, Terminaliaarjuna, Millettia pinnata* and*Gmelinaarborea* while *Justiciaadhatoda* was recorded minimum, respectively*.* Tree stand growth significantly improved the soil biological properties. Thus, A. *Moringaoleifera* and *Albizialebbeck*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

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 Dhruvanarayana(1993) 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 $ha^{-1}year^{-1}$ (Singh *et al.,* 2014). 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 (Verma*et al.,* 2012). 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.

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 wasrandomizedblock design (RBD).

Microbial biomass carbon was determined by the modified fumigation-incubation method Jackinson and Ladd (1981).

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

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 (1994). Dehydrogenaseactivity insoilwascalculatedas =

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

Where, Concentration=AbsorbancevaluexYvalueofstandardcurve(78.58).

Soil respiration was estimated by closed jar method (Isermeyer 1952). Therateofsoilrespirationwascalculatedbythefollowingformula= $\frac{(\text{Vo}-\text{V})\times 1.1}{\text{Dwt}\times \text{T}}$

Where,T:Timeofincubationinhrs.,Vo:HClusedforblank,V: HClusedforsoilsample, Dwt:Drywt.of1gmoistsoil,

1.1:Conversionfactor(1ml0.05MNaOHequals1.1mgCO_2).

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, it is obvious that the maximum soil microbial biomass carbon was recorded under *Moringaoleifera* (65.08, 62.69, 62.24, 56.96, 52.26 and 42.38 µg/g), respectively followed by *Albizialebbeck,Azadirachtaindica,Acacianilotica,Dalbergiasissoo,Terminaliaarjuna,Millettia pinnata* and*Gmelinaarborea* while *Justiciaadhatoda* (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. 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**), CO_2 (r=0.310**) and DHA (r =0.557**) and significantlynegativerelationshipwithpH(r=-0.134*) andAPEA(r=-0.642**) contentintheGird zone. Since, organic matter and microbial activity are typically related to each other, thesignificant decrease in organic carbon probably intensifies the adverse effects of salinity onsoilmicrobialbiomass(Muhammad*et al.,*2006).AsthepHandECaresignificantlycorrelatedwithbiologicalproperties,thespecialeffectsofpHandECweremorepronounced. Thus, the study emphasizes that soil EC and pH should be considered asindicators of changes in biological soil health in soil salinized by saline irrigation water (Singh *etal.,*2018).The results obtained for soil microbial biomass carbon are verified from the findings of Sharma *et al.,* (2009) and Yadav *et al.,* (2011) 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.,* (2007) 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 tableand figure. 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 above table, it is obvious that the maximumdehydrogenaseactivitywas recorded under *Moringaoleifera* (90.23, 82.83, 82.47, 79.50, 70.68 and 69.27 microgram tpf/gm soil/day), respectively followed by *Albizialebbeck*(83.04, 80.59,81.80, 78.92, 70.48 and 67.97microgram tpf/gm soil/day)*,Azadirachtaindica*(80.65,80.54,80.03,78.43,68.55 and 66.72microgram tpf/gm soil/day)*,Acacianilotica*(79.67,79.82,77.98,77.83,67.89 *and*65.50microgram tpf/gm soil/day),*Dalbergiasissoo*(78.61, 77.64, 76.21, 73.77, 67.01, and 56.38microgram tpf/gm soil/day)*,Terminaliaarjuna*(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 and50.41 microgram tpf/gm soil/day) and *Gmelinaarborea*(67.06, 60.94, 62.18, 52.00, 51.82 and 46.04 microgram tpf/gm soil/day) while *Justiciaadhatoda* (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 (2005) 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.,* (2011) and Lalita (2004) 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 resultswerefoundbyBatra(2004). An Alkaline phosphatase enzyme activity was inversely related, and this relationship remainssignificantwithOC(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 alsoreportedbyKumar*etal*.(2013).

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, 90-120and 120-150 cm. According to the data presented in the above table, it is obvious that the maximum soil respiration was recorded under *Moringaoleifera* (31.94, 26.71, 21.74, 12.69, 10.98 and 7.24 CO_2 mg/g of soil/hrs.), respectively. Followed by *Albizialebbeck,Azadirachtaindica,Acacianilotica,Dalbergiasissoo,Terminaliaarjuna,Millettia pinnata* and*Gmelinaarborea* while *Justiciaadhatoda* (23.19, 14.99, 13.84, 6.44, 6.14 and 5.21 CO_2 mg/g of soil/hrs.) was recorded minimum, respectively.A similar result was found by Greenwood (1961) and Fornelio*et al*., (2017).

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

S.No.	Treatment	SMBC(µg/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	*Moringa oleifera*	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	*Terminalia arjuna*	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	*Azadirachta indica*	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	*Gmelina arborea*	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	*Millettia pinnata*	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	*Albizia lebbeck*	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	*Acacia nilotica*	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	*Dalbergia sissoo*	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	*Justicia adhatoda*	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. ±		**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**

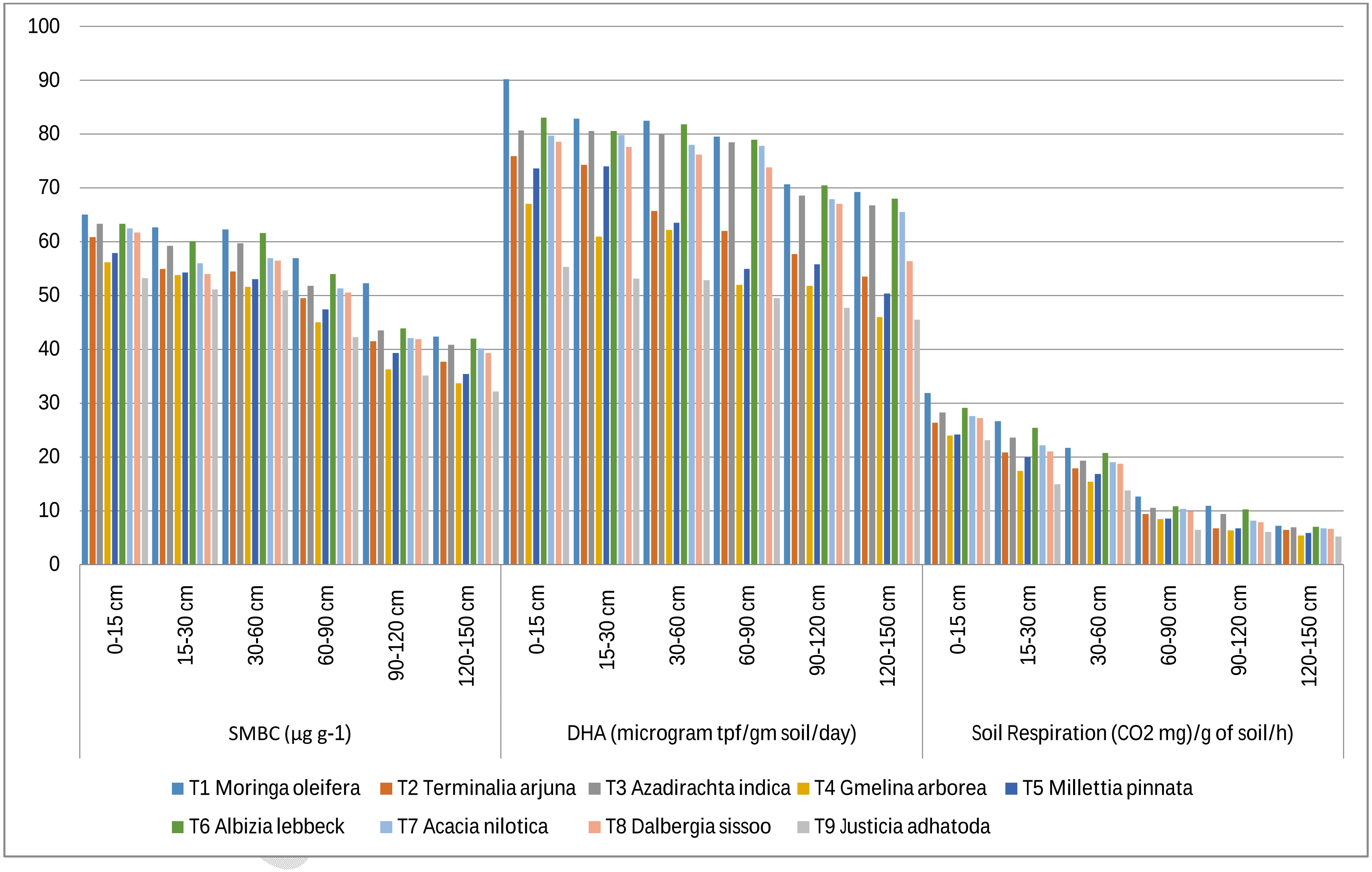

Figure 1.Effect of tree species on SMBC, DHA and soil respiration at different soil depths (cm)

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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