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Effect of multipurpose tree species on soil Physico-chemical properties and available nutrients in subtropical region of Himachal Pradesh

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Abstract
The study was intended to explore the status of soil physico-chemical properties under MPTs. The study revealed higher nutrient contents at surface layer D_1 (0– 15 cm) which decrease with the increase of soil depth. The soil under the MPTs showed pronounced changes. The pH were recorded maximum under *Melia composita* and lowest under *Ulmus villosa*. The EC were recorded maximum under *Albizia lebbeck* and minimum under *Melia composita* and *Toona ciliata*. The organic carbon varied significantly under MPTs and maximum Organic–C was observed under *Ulmus villosa* at both depths and minimum under *Albizia chinensis*. As regard to the available nutrients, i.e. available N, P and K were observed maximum under *Albizia lebbeck*, where as these were recorded minimum under *Ulmus villosa*.

Keywords: MPT's, organic carbon, soil physico-chemical and available nutrients

Introduction
The physiography of Himachal Pradesh is highly terrain and acute slopy which leads to high amount of soil erosion and area without tree cover on hilly slope is vulnerable to erosion and reduced fertility. Plantation of Multipurpose tree species in such areas can be one of the viable land-use management practices which can check land degradation. Major attributes of MPTs may sustain following criteria such as rapid juvenile growth, efficient dry matter production in terms of water and nutrient inputs, crown characteristics to maximise interception of solar radiation and ease of regeneration by coppicing (Fege, 1981) [4]. Multipurpose Trees provides timber and other non-timber forest products such as fruits, seeds, bulbs, bark, fibres, roots, leaves, small wooden logs, firewood, etc. Multipurpose tree species (MPTs) have always been an integral part of agriculture of the state. Trees like *Grewia optiva, Melia composita, Acacia mollissima*, *Toona ciliata*, etc. are commonly found in the farm areas of small and marginal farmers.

The Multi Purpose Tree species (MPT's) are able to maintain or improve soil health. The process by which trees improve soil fertility is photosynthesis, fixation of carbon and its transfer to the soil via litter and root decay. Nitrogen fixation by leguminous trees, improve nutrient retrieval by tree roots and erosion control by a combination of ground cover and barrier effects, efficient uptake of nutrient from soil. Soils found under trees have a favourable structure and water holding capacity through organic matter stabilization and root action and exudation of growth promoting substances.

Trees reduce soil erosion as well as improve the location by supplementing of nutrients and organic matter by decaying of plant parts like leaf litter (Nair, 1992). Due to the tree shade there is an enhancement of growth and mineral nutrition for the grass species. Shading enhances the accessibility of nutrients in the soil, and also improves the biological action of the soil.

The organic matter received through mineralisation is converted into soil organic carbon (SOC). The soil organic carbon that is stored for a long term in the form of humic substances (Kononova, 1996) [9]. Tree species influences the soil properties including the quality and quantity of soil organic carbon by the complex of the climate, soil type and management (Lal, 2005) [10]. Tree exert a major effect on soil by influencing microclimate, soil properties, primarily by the amount and composition of litter deposited and by nutrient uptake and accumulation. Multipurpose tree species producing high quality litter may enhance soil nutrient availability and crop yield through mineralisation of soil organic matter and green manure (Kimaro, 2008) [8].

In the present study *Albizia chinensis*, *Albizia lebbeck*, *Acacia mollissima*, *Dalbergia sissoo*, *Ulmus villosa*, *Toona ciliata* and *Melia composita* were selected to find out their impact on physico-chemical properties of soil and other parameters.

Materials and Methods

The present investigation was conducted at the Experimental farm of the Department of Silviculture and Agroforestry, Dr Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan-173230, Himachal Pradesh during 2017-2018. The site is located at an elevation of 1000-1300 m above mean sea level in the mid- Himalayan zone. It lies between 30°50´30'' to 30°52´0'' N latitude and 77°11´30'' E latitude (Survey of Indian Topo sheet Number 53F/1). Among Multipurpose Tree Species, *Albizia lebbeck*, *Acacia mollissima*, *Ulmus villosa* and *Melia composita* are man-made plantation whereas; *Albizia chinensis*, *Dalbergia sissoo* and *Toona ciliata* are growing naturally.The study sites were selected from different locations in main campus of this university. The methodologies applied are as under

MPTs (Multipurpose tree species)

1. T_1 = *Albizia chinensis*, T_2=*Albizia lebbeck*, T_3 = *Acacia mollissima*, T_4=D*albergia sissoo*, T_5 = *Ulmus villosa*, T_6 =*Toona ciliata*, T_7 = *Melia composita*
2. Soil samples were taken at two depths; Soil depth: D_1 (0-15 cm), D_2 (15-30 cm) analyzing the soil physico-chemical properties and nutrients availability. Number of treatments =14 (7×2), Number of replications = 3, Experimental design = RBD, Sample plot size = 33 m×33m (0.1 ha).

Results and Discussion

The data pertaining to effect of MPTs on soil pH has been recorded and presented in Table 1. The contents of the data presented in Table 1 revealed that all the MPTs had a significant effect on Soil pH (Table 1). Higher pH value (7.68) was recorded under T_4 (*Dalbergia sissoo*) followed by T_7 (*Melia composita*) (7.91) and lower pH value was recorded in T_5 (*Ulmus villosa*) (6.55). Among the two soil depths D_2 (15 – 30 cm) registered higher pH value (7.42) and D_1 (7.10) respectively. The cumulative effect of treatment and soil depth (T × D) had register significant effect on soil pH. It was statistically significant maximum under T_7D_2 (7.91), whereas minimum found in T_5D_1 (6.55). Raina and Kumar (2000). In general soil reaction was neutral which is ideal for the availability of most of the available nutrients from the soil, as well as from those applied through fertilizers.

The data pertaining to influence of MPTs on soil electrical conductivity (EC) has been recorded and presented in Table 1. The contents of the data presented in Table 1 shows that treatment, soil depth and interaction between soil depth and treatments, significantly influenced the EC (Table 1). Higher EC value was found under (*Albizia lebbeck*) T_2 (0.34 dS/m) where as minimum under (*Toona ciliata*) T_6 (0.22 dS/m) which was statistically at par with (*Melia composita*) T_7 (0.22 dS/m). The value of EC was found significant among two soil depths. EC in soil under different treatments varies from 0.22 – 0.34 dS/m, suggesting the low amount of soluble salts. Therefore the soil under study were in safe limits of EC i.e. < 0.8 dS/m. and evidence significant variation under species (Table 1). The results indicate that EC under tree canopies increased considerably as compared to the area devoid of vegetation. Raina and kumar (2000) and Verma (2003) have also reported average EC value in the range of 0.370 - 3.80 dS/m in the soils of forest of Rajgarh and Solan Division.

The critical examination of the data presented in Table 1 inferred significant variations in the bulk density (BD) values for different agroforestry tree species. The bulk density values however, increased with soil depth. The increase in clay content and soil compaction with the increasing soil depth was accompanied by a decrease in organic carbon content and this may be responsible for the increasing bulk density values in the surface soils. The maximum value significantly higher in area devoid of vegetation in comparison to different MPTs. The results indicated that woody perennials in the forest decreased the bulk density of soils. The data indicated that the bulk density of surface soils (0-15 cm) was the lowest (1.05 g cm^{-3}), which increased gradually with an increase in soil depth and attained its maximum value of 1.18 g cm^{-3} at 15 - 30 cm. The results are supported by Sharma and Qahar (1989). Who reported that the lower values of bulk density are indicative of top soil rich in Organic matter. Similar results on forest soils have, also been reported by Kaushal (1992) [7] and Malik (1992).

The results of the present investigation (Table 1) showed variation under treatments value ranging from 2.54-2.11%. It was improved markedly under *Ulmus villosa*, followed by *Acacia mollissima*, *Melia composita*, *Albizia lebbeck*, *Toona ciliata*, *Dalbergia sissoo* and *Albizia chinensis*. Organic carbon was found high under all tree species. This is because, the area covered by broad deciduous tree species all around, thus heavy litter fall and its subsequent decomposition may have contributed to high organic carbon. The results reveals that the (Table 1) organic carbon decrease with increase in depth which may be due to the addition of more litter fall on the surface soils. As regard the efficiency of individual species in improving the Organic carbon it can be related to the amount of litter production and rate of decomposition. The higher accumulation under *Ulmus villosa* may be attributed to more production of litter and lower rate of organic matter decomposition. Conversely the lowest Organic -C accumulation under *Albizia chinensis* may be ascribed to low litter production and faster rate of decomposition. The increase in organic-C under tree is well in consonance with the findings of other researchers (Hazra and Tripathi, 1986; Hussain *et al*., 1987 [6]; Sharma and Gupta, 1989).

2. Impact of MPT's on soil Nutrient availability

A perusal of data presented in (Table 2) shows that the tree species, soil depth and their interaction exercised significant influence on available nitrogen. The data presented in (Table 2) shows that available N under treatment varied markedly among the different species ranging 238.43 – 375.47 kg/ha. It was followed the trend T_2(375.47 kg/ha), T_3(362.58 kg/ha), T_1(359.88 kg/ha), T_4(358.53 kg/ha), T_5(334.13 kg/ha), T_7(242.33 kg/ha) and T_6 (238.43 kg/ha), respectively in descending order. Available nitrogen, as expected was found significantly more in the soil under N fixing tree species. The average effect of depth on available N found significant under the tree. Among two soil depths, depth D_1 (0-15) was recorded higher with available nitrogen (331.47 kg/ha) and it was recorded minimum in D_2 (317.50 kg/ha). Table 2 showed the significant variation under tree species from 238.43 kg/ha to 375.47 kg/ha under *Albizia lebbeck*. As expected the nitrogen fixing trees did prove relatively more efficient in increasing available N content compared to non- fixing trees. Similar results indicating an improvement in macronutrient status including N under tree covers have been also been reported by Laskar and Datta (1992). The similar findings have been reported by Sharma (1989) and Bhola and Mishra (1998) [2]. The available N content in the soil showed a general diminishing trend as the depth of the soil increased. Patel and Singh (2000) made similar observations with *Albizia lebbeck* and *Cordia dichotoma*.

It is evident from the data presented in (Table 2) that soil available P differed significantly under MPTs and demonstrated a discernible improvement under tree canopies. The available P improved remarkedly under tree canopies in comparison to area devoid of vegetation which reinforces the earlier findings Aggarwal *et al*. (1993) [1] reported that there was an increase of 43% in available P under the *Prosopis cineraria* over the soils in adjacent open fields. Similar improvements in available P under tree canopies have also been observed by others like Palled *et al*. (1987); Sharma and Gupta (1989) and Bhola (1995) [3]. As in the case of nitrogen, the top soil also showed higher Phosphorus content under all tree species. It is suggestive of the fact that mineralization of organic matter on the soil surface contributed to Phosphorus richness in the top soil. Kimaro *et al*. (2008) [8] reported that agroforestry tree species producing high quality litter may enhance past-fallow soil nutrient availability and crop yields through mineralization of soil organic matter and green manure due to the high soil N and P levels resulting from net release by high quality foliage. However, it is observed that the tree species vary with respect to their ability to supplement soil phosphorus. It is possible that the Phosphorus efficiency vary with plants, as it depends on various factors like soil characteristics.

The data presented in (Table 2) reflects that all the treatments, soil depths and interactions had a significant effect on available potassium (kg/ha). Higher available potassium (351.97 kg/ha) was recorded in T_2 treatment, whereas it was recorded minimum in T_5 treatment. On the other hand depth (D_1) registered higher value for available potassium as compared to depth (D_2). The soil available K showed significant variation under different tree species as well as different depth of soil (Table 2). Dhyani *et al*. (1990) concluded that soil under *Bauhinia purpurea*, *Grewia optiva*, *Eucalyptus tereticornis*, *Leucaena leucocephala* contained more available K_2O in comparison to area which was without trees. Laskar and Datta (1992) observed an improvement of available nutrient status of soil under 3 years of tree cover of *Dalbergia sissoo*, *Leucaen*a *leucocephala*, *Acacia auriculiformis* and *Albizia lebbeck*. As regards the effect of individual tree species on soil chemical characteristics it may be attributed to differences in litter production and its rate of decomposition differential nutrient release capacity and recycling potential of the species. Parsad *et al*. (1985) also reported that the changes in soil chemical properties under different vegetation may be attributed to differential biocycling of nutrients by different species.

Table 1: Effect of multipurpose tree species on soil physico-chemical properties.

Treatments(T)	pH		Mean	Electrical Conductivity (dS/m)		Mean	Bulk Density (g cm^{-3})		Mean	Organic carbon (%)		Mean
	Depth(cm)			Depth(cm)			Depth(cm)			Depth(cm)		
	D_1	D_2		D_1	D_2		D_1	D_2		D_1	D_2	
T_1(*Albizia chinensis*)	7.17	7.79	7.48	0.31	0.29	0.30	1.06	1.13	1.10	2.15	2.06	2.11
T_2 (*Albizia lebbeck*)	7.11	7.21	7.16	0.36	0.32	0.34	1.08	1.18	1.13	2.61	2.46	2.53
T_3 (*Acacia mollissima*)	6.86	6.92	6.89	0.26	0.22	0.24	1.07	1.13	1.10	2.58	2.50	2.54
T_4 (*Dalbergia sissoo*)	7.55	7.81	7.68	0.31	0.27	0.29	1.08	1.17	1.13	2.20	2.08	2.14
T_5 (*Ulmus villosa*)	6.55	6.84	6.70	0.37	0.24	0.30	1.02	1.16	1.09	2.57	2.51	2.54
T_6 (*Toona ciliata*)	7.20	7.43	7.32	0.24	0.19	0.22	1.05	1.17	1.11	2.28	2.10	2.19
T_7 (*Melia composita*)	7.24	7.91	7.58	0.25	0.19	0.22	1.05	1.14	1.10	2.63	2.45	2.54
Mean	7.10	7.42		0.30	0.24		1.06	1.13		2.43	2.31	

CD T (Treatments) 0.05 0.01 0.02 0.01
D (Depths) 0.03 0.00 0.01 0.01
T×D 0.07 0.01 0.03 0.02

Table 2: Impact of MPT's on Available soil Nutrients

Treatments(T)	Nitrogen Kg/ha		Mean	Phosphorus Kg/ha		Mean	Potassium Kg/ha		Mean
	Depth(cm)			Depth(cm)			Depth(cm)		
	D_1	D_2		D_1	D_2		D_1	D_2	
T_1(*Albizia chinensis*)	367.33	352.43	359.88	37.73	34.40	36.06	347.60	335.45	341.53
T_2 (*Albizia lebbeck*)	384.97	365.97	375.47	59.38	34.73	47.06	360.57	343.36	351.97
T_3 (*Acacia mollissima*)	368.70	356.47	362.58	39.00	31.58	35.29	354.65	338.48	346.56
T_4 (*Dalbergia sissoo*)	361.33	355.73	358.53	35.17	29.14	32.16	328.50	316.57	322.53
T_5 (*Ulmus villosa*)	244.57	232.30	238.43	26.36	23.69	25.03	226.51	218.74	222.63
T_6 (*Toona ciliata*)	341.00	327.27	334.13	30.86	26.56	28.71	319.24	306.34	312.79
T_7 (*Melia composita*)	252.37	232.30	242.33	31.23	23.74	27.49	285.56	248.64	267.10
Mean	331.47	317.50		37.10	29.12		317.52	301.08	

T (Treatments) 1.68 1.20 1.58
D (Depths) 0.90 0.64 0.84
T×D 2.38 1.70 2.23

Conclusion

The study was intended to explore the status of soil chemical characteristics under MPTs. The study revealed higher nutrient contents at surface layer D_1 (0– 15 cm) which decrease with the increase of soil depth. The soil under the MPTs showed pronounced changes. The pH were recorded maximum under *Melia composita* and lowest under *Ulmus villosa*. The EC were recorded maximum under *Albizia lebbeck* and minimum under *Melia composita* and *Toona ciliata*. The organic carbon varied significantly under MPTs and maximum Organic–C was observed under *Ulmus villosa* at both depths and minimum under *Albizia chinensis*. As regard to the available nutrients, i.e. available N, P and K were observed maximum under *Albizia lebbeck*, where as these were recorded minimum under *Ulmus villosa*. A comparison of soil chemical characteristics under MPTs and control revealed an improvement in soil EC, Organic carbon and available nutrients. The *Albizia lebbeck* and *Acacia mollissima* are excelled amongst all studied tree species for improving available soil nutrients. The soil bulk density was higher under *Dalbergia sissoo* and *Albizia lebbeck* and lowest in *Ulmus villosa*. The bulk density depicted an increasing trend with the increase in soil depth.

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