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Studies on Soil Microbial Population Status in Different Land Uses in Udhagai Range, Nilgiri South Forest Division

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Abstract

The impact of above ground vegetation and soil characteristics on below ground microbial population was tested by analyzing the soil under five different land uses (Shola forest, Eucalyptus plantation, Wattle plantation, Grass land and Barren land) of Udhagai range, which comes under Nilgiri south forest division, Nilgiri District, Tamil Nadu State. This study was carried out to provide fundamental information on soil biological properties and also to compare the differences between natural forest, mono-rehabilitated forest and natural regenerated forest. The soil samples were collected from different land uses at the depths of 0 – 15 cm (surface) and 15 – 30 cm (sub surface). The results showed that the highest population of bacteria (75.70×10^6 cfu gram per soil), fungi (26.80×10^4 cfu gram per soil) and actinomycetes (10.10×10^5 cfu gram per soil) were recorded in shola forest compared to other land uses and the least population of microorganisms, bacteria, fungi and actinomycetes were observed in barren land 16.40×10^6 cfu gram per soil, 6.90×10^4 cfu g^{-1}, 1.50×10^5 cfu gram per soil, respectively. A maximum number of CFUs of bacteria, fungi and actinomycetes were found in shola forest. Among the five different landuse patterns, the shola forest harbours rich bacterial, fungal and actinomycetes populations due to the availability of optimum pH, high moisture, organic content and aboveground biomass with moderate aboveground plant diversity.

Keywords: Different land use, microbial diversity, bacteria, fungi and actinomycetes.

Introduction

Microorganisms form a vibrant living community in the soil contributing to a number of nutrient transformations. They are involved in organic matter decomposition, N_2fixation, solubilization and immobilization of several major and minor nutrients. Microbes also play an important role in soil structure maintenance, soil borne disease control and plant growth promotion through secretion of hormones. Soil properties played an important role in determining the distribution of the various microbial groups (Alexander, 1971). The Nilgiris' natural montane grasslands and shrub lands interspersed with sholas has been much disturbed by extensive tea plantations, extensive commercial planting along with harvesting of non native eucalyptus and wattle plantations (*Acacia dealbata*, *Acacia mearnsii)* and cattle grazing. Further in Nilgiris (Udhagai south range), the area under forest vegetation is gradually diminishing because of increasing human activities. Clearing forest, for cultivation often results in a rapid decline in soil fertility due to decline in the microbial population of the soil. The numbers of and distribution of microorganisms present in forest soils are often influenced by soil environment, particularly soil pH, the amount and quantity of humidified and non himidified soil organic matter, levels of available phosphorus and nutrient cations. Clearing and cultivation of tropical forest is usually accompanied by a decline in both amount of organic matter in the underlying growth (Okonkwo, 2010). This study deals with bacterial, fungal and actinomycetes populations in relation to the different land uses in udhagai range present in the Nilgiri south forest division in Tamil Nadu.

Materials and Methods

Soils and Site Description The study was conducted at Udhagai range, Nilgiri south forest division, during August 2015 to July 2016. Geographically, the study site lies at 11° 22′47″ N latitude and 76°40□1″ E longitude and at an altitude ranging from 2000 to 2350 meters above sea level (MSL). The study area has been put under different land uses like Shola forest, Eucalyptus plantation, Wattle plantation, Grass land and Barren land. The climate is characterized by warm, temperate to sub-tropical rainy season with good tropical sunshine. The temperature during the study period ranged from 20-

38 °C. The total rainfall received during the study period (for the year 2015-2016) was 473 mm and the number of rainy days was 67 days. The soils of the study area are lateritic in origin and are derived from Charnockites or what is known as Nilgiri Gneiss. The soils are generally deficient in plant nutrients and are acidic with their pH value ranging from 3.8 - 5.5. Different land use soil samples of Udhagai range were collected.

The soil samples were collected to determine the soil microbial population from each land uses at the depths of 0 – 15 cm (surface) and 15 – 30 cm (sub surface) the following standard sampling procedure. The soil samples were collected from representative fields' then and then stored in a refrigerator at 4ºC for microbial population analysis and counting. Isolation and enumeration of bacteria, fungi, actinomycetes from the soil was done by serial dilution and plating technique (Parkinson *et al.*, 1971). The bacteria were enumerated by plating one ml of 10^6 dilutions in the sterile petridishes using Nutrient Agar medium. Fungal population was enumerated by plating one ml of 10^4 dilutions in the sterile petridishes using Martin's Rose Bengal Agar medium. One ml of 10^5 dilutions was transferred to sterile petridishes and plated in Ken knight's Agar medium and incubated.

Results and Discussion

Bacterial population

The bacterial populations in the forest significantly enhanced decomposition process. Among the land uses the highest bacterial population of 93×10^6 cfu per gram soil was recorded in the shola forest at 0 – 15 cm depth (Table1). The study is on line with findings of Milind Bunyan *et al.*, (2012) where in his studies showed that the bacterial population of 93.22×10^6 cfu per gram soil of shola forest. The least bacterial population bacterial was observed in barren land 14.8×10^{-6} cfu per gram it was found in 15 – 30cm depth. Similar results were reported by Shepherd *et al.*, (2000); Sharma *et al.*, (2009), the results of their study were of 36.54-64.21 cfu $\times$ 10^6 g^{-1} dry soil of bacterial population.

Table 1. Status of microbial population in different land uses of Udhagai range

Sl.No	Land use	Bacteria ($\times10^6$)		Mean	Fungi ($\times10^4$)		Mean	Actinomycetes ($\times10^5$)		Mean
		0 – 15 cm	15 - 20 cm		0 - 15 cm	15 - 30 cm		0 – 15 cm	15 - 30 cm	
1	Sholas	93.0^a	58.4^a	75.70	35.2^a	18.4^a	26.80	12.2^a	8.0^a	10.10
2	Eucalyptus	23.6^c	17.0^c	20.30	11.8^b	8.2^b	10.00	4.6^{bc}	2.2^b	3.40
3	Wattle	26.2^c	21.6^c	23.90	12.4^b	9.4^b	10.90	4.8^{bc}	2.8^b	3.80
4	Grassland	46.8^b	39.8^b	43.30	30.6^a	17.2^a	23.90	7.6^b	3.2^b	5.40
5	Barren land	18.0^c	14.8^c	16.40	9.2^b	4.6^b	6.90	1.8^c	1.2^b	1.50
	Mean	41.52	30.32		19.84	11.56		6.20	3.48	
	SD	30.94	20.23		12.08	6.99		4.50	3.09	
	CV %	74.52	66.72		60.89	60.47		72.58	88.79	

Means with the same letter are not significantly different at $P \leq 0.05$ according to DMRT.

Table 2. Pearson's correlation matrix for various microbial populations in Udhagai range

	pH	*Org.C*	*Avl.N*	*Avl.P*	*Avl.K*	*Bacteria*	*Fungi*	*Actinomycetes*
pH	1							
Org.C	0.657**	1						
Avl.N	0.586**	0.918**	1					
Avl.P	0.463*	0.867**	0.935**	1				
Avl.K	0.593**	0.816**	0.930**	0.824**	1			
Bacteria	0.768**	0.983**	0.906**	0.833**	0.840**	1		
Fungi	0.726**	0.876**	0.968**	0.895**	0.918**	0.900**	1	
Actinomycetes	0.571**	0.961**	0.952**	0.900**	0.881**	0.947**	0.910**	1

** Significant at P = 0.01; * significant at P = 0.05 level

Shola soils recorded higher bacterial population compared to all other vegetation. The highest population of bacterial population could be ascribed to the difference in pH, organic carbon and available nutrient status as well as the difference in plant root exudation, which are known to influence the bacterial population in soil. This is in line with findings of Mishra, (2006) and Arun nagendran *et al.,* (2014) where in it has been reported that the population composition and the activity of microorganisms are largely regulated by soil physico-chemical properties. Various parameters like temperature, pH, carbon resources and changes in electrolyte concentration had influence the microbial diversity (Lee, 2001). Fierer and Jackson (2005) they have observed and reported that, the soil pH as a best predictor of bacterial richness (Table 2). Similarly, it has also been reported that changes in soil environment like soil moisture, pH and temperature attributed indirectly by plant characteristics which has affected the soil microbial diversity and composition (Angers *et al.,* 2000).

Fungal population

The population of the fungi was high in the soil sample collected from shola forest at 0 – 15 cm depth (35.2×10^4 cfu per gram soil). The lowest value for fungi count was recorded in 15 - 30 cm depth of barren land soil 4.6×10^4 cfu per gram soil (Table 1 and Fig.1). Similar type of findings was reported by Sankaran and Balasundaran, (2000). The density of fungal propagules in the shola forests ranged from 10.23 - 28.78 x 10^3 cfu per g of soil averaging to 16.39 x 10^3 for the whole sampling period.

The density of fungal propagules in the soil was significantly higher in shola forest compared to other vegetation. The occurrence of higher density of fungal propagules in shola forest soil may be attributed to the fact that shola forest provided favorable acidic environment. The density of fungal propagules/g of soil in shola forests and grasslands recorded during this study is comparable to that reported by Reddy (2012) from soils of Nilgiri forests of comparable altitude. It also agrees well with the data recorded by Sankaran (1981) and Zachariah (1981) from soils of Malabar. However, it is lower than that reported by Saksena (2005) and Upadhyay Rai (2009) and from other parts of India. This variation in density of fungal propagules in soil can be ascribed to the difference in micro- and macro-climatic and edaphic factors prevalent at each site, which are known to influence the fungal population. The lack of variation in soil fungal counts between individual sampling sites of shola and grasslands reflects the similarity in the climatic and edaphic factors referred above.

A decrease in the population of fungi was observed with increase in soil depth. This trend reflected under all locations. High organic matter in top soil might influence the fungal population. Similar findings were also reported by Brodie *et al.,* (2002) who have studied the microbial dynamics in a temperate upland grassland ecosystem and reported that, the microbial diversity was positively correlated with concentration of the soil organic matter. High diversity and abundance of microbial population in rice field with rich organic content substantiates the significance of available organic carbon which promotes the abundance of microbial diversity.

Actinomycetes population

The soils of shola forest registered higher mean values (10.10×10^5 cfu per gram soil) of actinomycetes population when compared to grassland, wattle plantation and Eucalyptus plantation. The lowest actinomycetes population was noticed in the barren land (1.50×10^5 cfu per gram soil). Soil microbial biomass can be limited by soil moisture under both dry and wet conditions. Many reports that have showed that the soil microbial biomass declined upon drying and increase upon rewetting (Wardle, 1998; West *et al.,* 2005 and Orchard and cook, 2006).

The density of actinomycetes recorded the highest in the soils of shola forest followed by grassland but the population level was found to be least among the microbes studied. This low population density may be due to the low temperature and acidic environment prevalent in the high altitudes of shola, grassland, Eucalyptus and wattle plantation. Similar observation was made by Redding *et al.,* (2002) on the existence of positive correlation between soil moisture, temperature and microbial population.

Summary and Conclusion

Studies on the population density of microorganisms viz., bacteria, fungi and actinomycetes revealed that there is significant difference in population in different land uses. The results showed that the highest population of bacteria, fungi and actinomycetes was recorded in shola forest and the least count of microorganisms was observed in barren land. Shola forest in the Udhagai forest range has maintained the maximum microbial population among all other land uses and followed by grasslands and wattle plantation.

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