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SEASONAL DYNAMICS OF MICROBIAL POPULATION IN DIFFERENT LAND USE IN RI-BHOI DISTRICT OF MEGHALAYA, INDIA

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Abstract

Seasonal variations in microbial population and relationship of microbes with some soil parameters were studied in Ri-Bhoi district of Meghalaya. Soil samples were drawn from surface and subsurface region of three land uses (Agricultural crop land, horticultural crop land and Forest land) in pre-monsoon, monsoon and post-monsoon seasons. Populations of bacteria, fungi, decreased significantly with depth. Seasonal variation was significant in case of both bacteria, fungi and both attained population peak in monsoon season. In case of soil physico-chemical parameters, organic C, available N, P, K showed significant depth-variation. The soil colour varied widely in hue (7.5YR-10YR), value (3-5) and chroma (3-8). The soil texture varied from sandy to clayey. The soils varied widely in organic carbon (0.39-1.20 percent), bulk density (0.97-1.67 gm/cc), pH (4.5-5.4), CEC (5.97 to 13.04 cmol (p^+) kg^{-1} soils), base saturation (18.1-50.9 percent) and available N (501.8-715.0 kg ha^{-1}), P_2O_5 (9.8-32.1 kg ha^{-1}), K_2O (241.9-392.3 kg ha^{-1}). The soils were classified as OxyaquicDystrudepts (B1, B2), and TypicDystrudepts (B3).

The microbial biomass carbon (MBC) was observed to be the highest under forest vegetation and was the lowest in agricultural cropland. The bacterial and fungal population ranged from 44-236 cfu x 10^6 per gram and 2.90-25.55 cfu x 10^2 per gram soil, respectively. In the present study, wide variations were observed in microbial populations which were related to seasonal variation and varied land uses.

Key words : Microbial population, monsoon season, agricultural cropland, seasonal variation.

Introduction

Soil microbial communities are widely recognized as anintegrative component of soil quality because of soil quality because of their crucial involvement in much ecosystem process (Warcup and Waksman, 1950). Microbial activity is probably the most important factor in controlling the nutrient cycling in soil. Microbes takes part in the disintegration and decomposition process leading to release of nutrients trapped in plant and animal debris, rocks and minerals, and synthesize and release hormones essential for plant growth. Microbes are highly versatile, they carry out all known biological reactions 80-90% of the reaction in soil are the reactions medated by microbes (Coleman and Crossley, 1996; Nanniperi, 1994). They are essential components of the biotic community in natural forests, and are largely responsible for ecosystem functioning because they participate in most nutrient transformations (Hackl *et al*., 2004). Several studies reported that the composition of soil microbial community can be altered by plant species, plant diversity, vegetation or forest type (McCulley and Burke, 2004; Waldrop, 2000; Porazinska, 2003; Balser, 2005;Bartelt-Ryser, 2005) soil type, seasonal variability in water temperature and availability of organic substances.

The importance of soil microbes in soil functioning is well recognized. Soil microbial biomass does not only play a key role in the cycling and transforming process of nutrients but also serves as the most important warehouse and source of nutrient elements suggesting the effective status of soil nutrients and the change of biological activity after the soil is affected by the external world. Soil physico-chemical characteristics influence the composition of the soil microbial community their activity and the level of microbial biomass (Schnurer *et al*., 1985;

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Dick, 1994). It is thus important to determine optimum diversities of soil microbial populations of different land use systems for their sustainable management. In order to maximize the beneficial effects of microbial activity, there is a need for greater understanding of factors influencing microbial communities and their activities. The relationship between soil microbial communities particularly bacteria and fungi and their activities, plant quality and ecosystem sustainability are still poorly understood in land uses of Meghalaya, India. The present study was undertaken to obtain a better understanding of the interactions between fungi and bacteria and different vegetation and land uses, various environmental factors in the soil profile and the seasonal variation of microbial population in Ri-Bhoi District of Meghalaya.

Materials and Methods

Study area

Ri-Bhoi districts of Meghalaya was selected for the present study. Ri-Bhoi district lies between 25°15' and 26°15' N latitudes and 91°45' and 92°15' E longitudes. It is bounded on the north by Kamrup district and on the East by Jaintia Hills and Karbi Anglong district of Assam and on the West by West Khasi Hills district. Ri-Bhoi district covers an area of 2448 km².The sampling sites differ in aspect of vegetation, elevation, rainfall and temperature. The Ri-Bhoi district of Meghalaya consists mainly of Archeangnessic complex, Shillong Group of rocks-quartzites, granites and alluvium. In Ri-Bhoi district the average annual rainfall is 2,695 mm. The soil moisture regime of the study area is *udic*. The temperature of these sites ranges from 10°C in December to 30°C in the month of July and August. Normally January and August months records minimum (12.3°C) and maximum (35.2°C) temperatures respectively. The temperature regime of the study area is *thermic*. The State as a whole is rich in species of flora and varies from open scrub (Grassland) to pine forest in the central plateau region. The rest is covered by mostly deciduous to evergreen forests and transitional tropical moist deciduous pine forests.

Sample collection

Three soil profiles, from Ri-Bhoi district B1, B2 and B3 were collected from areas under agricultural crop, tea, and forest, the detailed description of these profiles are presented in table 1. Horizon-wise soil samples were collected from each profile to study the variation of microbial population depth wise. On the other hand samples were collected from each site for three seasons pre monsoon (March to May), Monsoon (June to September) and post monsoon (October to February). Samples were taken from two depths of each profile to study its seasonal variation.

Analytical procedures

Samples were dried in inoculation chamber, powdered and sieved through 2mm sterilized sieve. Microbial count was done immediately in case of unexpected delay samples were preserved in sterilized container under refrigeration for the shortest possible time.

Isolation, identification and estimation of microbial populations (fungi and bacteria) from the soil

One gram soil sample was placed in a test tube containing 9 ml of sterile distilled water and the suspension was mixed properly with the help of a vortex mixture. From this suspension, further dilutions were made aseptically. For isolation of bacteria, soil 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7} and 10^{-8} dilutions were finally selected. From this dilution, 0.1 ml of the soil suspension was transferred to sterilized micro pipette and plating of serial dilutions was done onto Nutrient Agar plates. For fungi, plating of serial dilutions was done onto Czapek-Doxagar plates, in similar manner. In case of fungi 0.1 ml of the soil suspension was transferred from 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5} and 10^{-6} dilutions. Then the plates were incubated at 30°C ± 2°C and the population was counted using colony counter. Colony forming units (CFU's) of fungi and bacteria were calculated on dry weight basis using following formulae

$$\text{CFU of fungi } g^{-1}\text{dry weight} = \frac{\text{Number of colonies}}{\text{Dry weight of soil (g)}}$$

$$\text{CFU of bacteria } g^{-1}\text{dry weigh} = \frac{\text{Number of colonies} \times \text{dilution factor} \times \text{inoculum}}{\text{Dry weight of soil (g)}}$$

Soil pH was determined with pH meter in 1:25 soil:water suspension, organic C by titrimetric method (Walkley and Black, 1934). The particle size analysis was carried out by pipette method after removing organic matter (Piper, 1966). Bulk density of the soil was determined by clod method (Black, 1965), available N content by alkaline permanganate method (Subbiah and Asija, 1956), whereas available P was extracted by Bray I reagent (Bray and Kurtz, 1945) and determined by blue color method. Available K was extracted by neutral normal ammonium acetate and estimated with the help of flame photometer as described by Jackson (1973). For mechanical analysis international pipette method was followed. Data obtained for different aspects were subjected to standard statistical treatment.

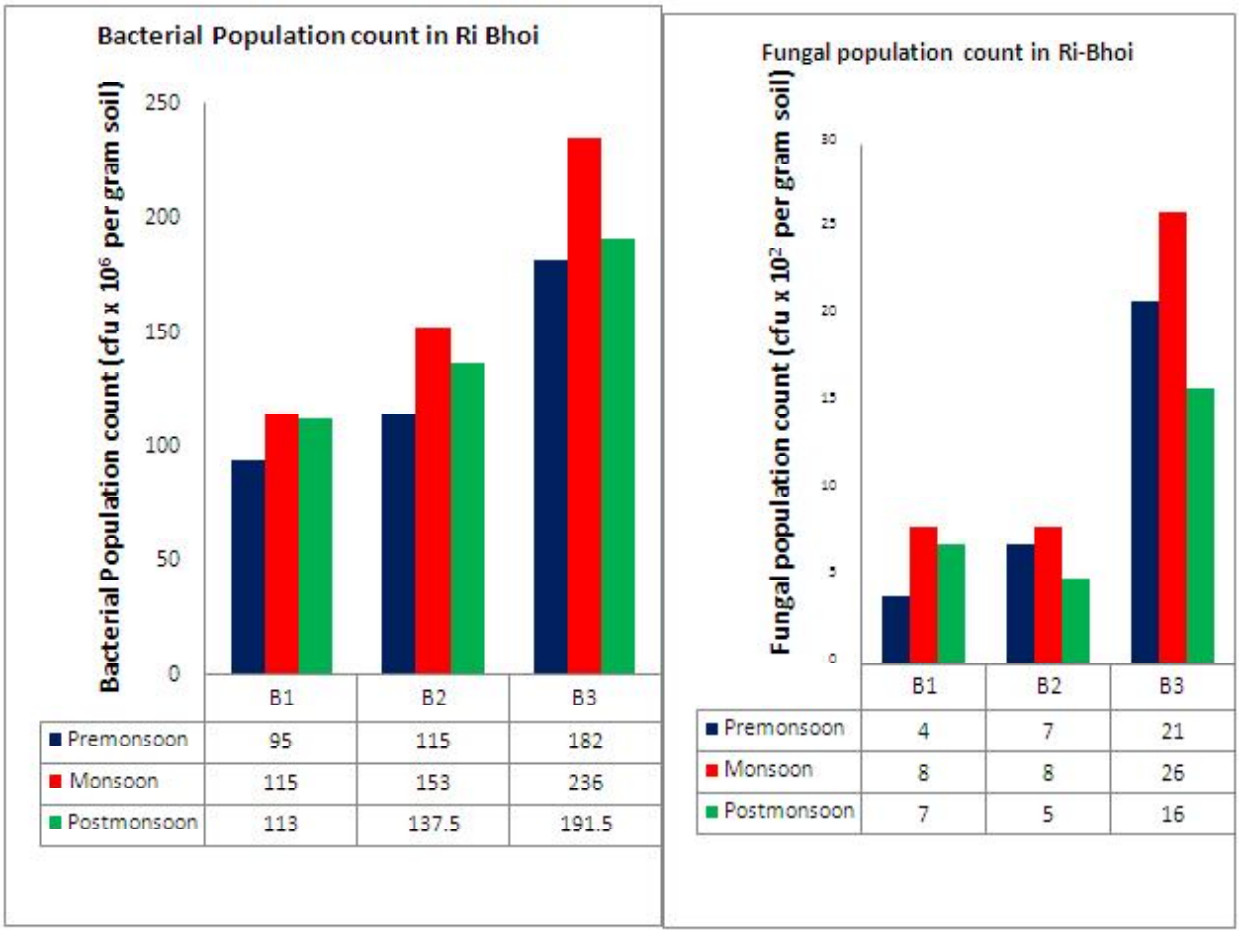

Fig. 1 : Season-wise microbial population (bacteria and fungi) in the surface horizons of Ri-Bhoi Hills districts.

Results and Discussion

Physico-chemical parameters

Soil varied from sandy to clayey and the structure varied from crumb to sub-angular blocky. Weak structure was observed in the surface and subsurface horizons. The bulk density was low in the surface horizon and it increased with soil depth. Lower bulk density in the surface horizon may be due to higher organic carbon content in the surface. The bulk density of the soils was found to be inversely related with soil organic carbon as evident from the negative significant correlation between bulk density and organic carbon (r= -0.689**) (table 2).

The pH (1:2.5 soil: water ratio) of the soils was found to be in acidic range (Table 2) varying widely from 4.5 to 5.4. Higher pH was observed in B3 (pH 5.0-5.4) under forest land which may be due to less weathering and/or water saturation in some parts of the year. The significant negative correlations of soil pH with clay (r= - 0.572**) (table 4) suggest that clay is the main contributor to soil acidity. Higher concentration of nutrient elements like N, P, K and organic C were found in surface soils which generally decreases with increase in soil depth due to decomposition of weeds and pruned materials and also regular application of FYM and fertilizers. The available nitrogen content was higher in the surface horizons and it decreased with soil depth except in some horizons where its distribution was irregular. Irregular distribution of available N in soils (B2) (table 1) may be attributed to leaching of N to lower horizons during cultivation horticultural crops, respectively. Significant positive correlation of available N with soil organic carbon (r= 0.573**) indicates that soil organic carbon is a good indicator of available N in the soil; on the other hand, negative correlation with pH (r= - 0.546**) indicates that soil acidity retards loss of available N in soil resulting in more accumulation in soil. The available P_2O_5 content of the soils was higher in the surface horizon and it decreased soil depth (table 1). In general, available P_2O_5 rated medium to high in the studied soils. Significant positive correlations of available P_2O_5 with soil organic carbon (r= 0.724**) and negative correlation with pH (r= -0.220) (table 4) suggest contribution of soil organic carbon and soil acidity to available form of P_2O_5. The available K_2O

Table 1 : Site characteristics of the study area.

S. no.	Location	Latitude & Longitude	Lithology	Physiography	Land use	Slope
Ri-Bhoi District						
B1	Umbih	25° 44.467' N92°01.605' E	Alluvium	Intermontane Valley	Agricultural land	0-1
B2	Umeit	25° 42.712' N91° 57.366' E	Alluvium	Intermontane Valley	Horticultural land-vegetable cultivation	0-1
B3	Umiam (Barapani)	25° 40.312' N91° 54.273 E	Gneiss	Hills	Forest	3-5

Table 2 : Organic carbon, bulk density, pH, EC and available nitrogen, potash and phosphorus of the soils of Ri-Bhoi district.

Depth (cm)	O.C.(%)	Bulk densityg/cc	pH (1:2.5 H_2O)	E.C. (1:2.5 H_2O) (dSm^{-1})	Available (kg ha^{-1})		
					N	P_2O_5	K_2O
B1: Mynsain (Agril crop)							
0-20	0.96	1.08	5.0	0.06	589.6	27.2	310.7
20-35	0.77	1.11	5.2	0.06	564.5	22.4	307.1
35-60	0.53	1.10	4.5	0.08	577.0	13.5	305.0
60-75	0.48	1.22	4.7	0.08	564.5	10.9	282.5
75-150	0.39	1.41	5.1	0.07	526.8	10.6	308.2
B:2 Umeit (Horticulture farm)							
0-15	1.03	1.11	5.1	0.06	715.0	32.1	392.3
15-35	0.91	1.27	5.2	0.05	689.9	20.8	317.9
35-85	0.62	1.38	5.1	0.05	539.4	15.9	241.9
85-120	0.42	1.55	5.3	0.06	501.8	12.0	284.9
120-180	0.40	1.67	5.2	0.06	514.3	10.4	318.5
B3 : Barapani / Umiam (Forest)							
0-20	1.20	0.97	5.2	0.07	715.0	16.3	397.2
20-45	0.81	0.97	5.2	0.07	627.2	15.9	326.2
45-85	0.77	1.15	5.4	0.05	664.8	10.3	298.1
85-115	0.62	1.33	5.4	0.06	589.6	9.8	390.0
115-130	0.50	1.47	5.0	0.07	564.6	10.1	271.6

content of the soil was high. Higher amount of available N, P_2O_5 and K_2O in the surface horizons might be due to phytocycling of these nutrient elements.

Soil Microbial Parameters

Depth dynamics

Soil microbial population in each of the profiles varied significantly with depth. It is observed that the population of both bacteria and fungi is higher in the surface and lower in the sub surface soil. The bacterial population ranged from 93cfu × 10^6 per gram to 236cfu × 10^6 per gram in the surface soil and 44cfu × 10^6 per gram to 172cfu × 10^6 per gram in the sub surface soil (table 4). Similarly in fungi the pupulation ranged from 4 cfu x 10^2 per gram to 25.55cfu x 10^2 per gram in the surface horizon and 2.90 cfu x 10^2 per gram to 9.95cfu x 10^2 per gram in the sub surface layers. A perusal of the data on microbial population (tables 4, 5) showed that the bacterial population was lowest (93 cfux 10^6 per gram) in B2 under horticulture crops. Bacterial count was highest in soils of B3 (Forest) (236 cfu x 10^6).In general, the bacterial population was higher than the fungal population. A higher microbial population in surface layer can be related to better soil conditions and biomass in terms of nutrients as compared with the subsurface soil. Microbial population generally decreases downwards the soil profile, which is a trend also been reported in forest soil profiles (Richter and Markewitz, 1995) indicating less microbial activities at lower soil depths. Selvam (2010) also reported that it could possibly be due to decreasing of aeration and substrate supply with increasing soil depth. Similar observations were made by Alexander (1961), Behera *et al*. (1991), Bhabulkar *et al*. (2000), Khokhar *et al*. (2001) and Gogoi *et al*. (2003).

Table 3 : Correlation coefficients (r) among soil properties.

	Sand	Silt	Clay	OC	BD	pH	EC	Fe_2O_3	Al_2O_3
Sand	1.000								
Silt	-0.853	1.000							
Clay	-0.841	0.436	1.000						
OC	-0.161	0.123	0.150	1.000					
BD	-0.240	0.133	0.277	-0.689	1.000				
pH	0.554	-0.370	-0.572	-0.086	-0.176	1.000			
EC	0.209	-0.125	-0.230	-0.110	-0.066	-0.336	1.000		
N	-0.425	0.225	0.500	0.573	-0.132	-0.557	0.155		
P_2O_5	-0.513	0.536	0.330	0.766	-0.421	-0.219	-0.075		
K_2O	-0.167	0.203	0.076	0.580	-0.383	-0.060	0.005		
Ca^{++}	-0.200	0.202	0.133	0.496	-0.207	-0.226	0.075		
Mg^{++}	-0.193	0.150	0.175	0.086	-0.181	-0.567	0.056		
K^+	-0.252	0.008	0.425	0.191	0.139	-0.614	-0.111		
Na^+	-0.021	0.059	-0.027	0.475	-0.260	0.005	0.037		
CEC	-0.252	0.008	0.425	0.191	0.139	-0.614	-0.111		
Fe_2O_3	0.134	0.124	-0.360	-0.497	0.143	0.237	-0.107	1.000	
Al_2O_3	-0.035	-0.118	0.184	-0.063	0.240	-0.047	0.105	-0.136	1.000
PBS	-0.043	0.287	-0.224	0.246	-0.426	0.160	0.139	0.166	-0.360

	N	P_2O_5	K_2O	Ca^{++}	Mg^{++}	K^+	Na^+	CEC
N	1.000							
P_2O_5	0.485	1.000						
K_2O	0.523	0.483	1.000					
Ca^{++}	0.521	0.453	0.188	1.000				
Mg^{++}	0.228	0.102	0.059	0.168	1.000			
K^+	0.490	0.058	0.170	0.210	0.424	1.000		
Na^+	0.362	0.318	0.792	0.083	0.051	0.233	1.000	
CEC	0.490	0.058	0.170	0.209	0.424	1.000	0.233	1.000
Fe_2O_3	-0.521	-0.201	-0.432	-0.191	0.091	-0.291	-0.490	-0.291
Al_2O_3	0.321	-0.188	0.004	0.003	-0.235	0.156	-0.129	0.156
PBS	-0.009	0.395	0.202	0.339	0.256	-0.622	0.055	-0.622

Table 4 : Microbial population (Bacteria) in soils of Ri-Bhoi district.

Depth (cm)		Bacteria (cfu × 10^6 per gram)		
		Pre-monsoon	Monsoon	Post-monsoon
Ri-Bhoi district				
B1: Mynsain (Agril crop)				
Ap	0-20	99.00	155.50	113.00
Bw1	20-35	89.00	116.50	88.00
B2 :Umeit (Horticulture farm)				
Ap	0-15	93.00	153.00	137.50
AB	15-35	44.50	122.00	87.50
B3 :Barapani /Umiam (Forest)				
A	0-20	182.00	236.00	151.50
Bw1	20-45	79.50	172.50	89.50

Table 5 : Microbial population (Fungi) in soils of Ri-Bhoi district.

Depth (cm)		Fungi (cfu × 10^6 per gram)		
		Pre-monsoon	Monsoon	Post-monsoon
Ri-Bhoi district				
B1: Mynsain (Agril crop)				
Ap	0-20	4.00	7.65	6.45
Bw1	20-35	3.35	2.90	3.35
B2 :Umeit (Horticulture farm)				
Ap	0-15	6.75	7.90	4.65
AB	15-35	5.45	4.90	2.50
B3 :Barapani / Umiam (Forest)				
A	0-20	21.10	25.55	15.50
Bw1	20-45	8.40	6.60	9.95

Seasonal dynamics

Bacterial and fungi population showed a significant seasonal variation. Their population increase from pre monsoon season and attained a peak in monsoon and decreased there afterwards towards post monsoon. In comparison to fungi, bacteria showed a sudden outburst in the monsoon season probably because fungi are the inferior competitor. Population peak attained during monsoon season is related to the greater availability of nutrients and other favourable conditions such as moisture and diurnal soil temperature fluctuations at mesophilic range. Similar observations were also made by Das *et al*. (1991), Singh *et al*. (1999) and Kokhar *et al*. (2001). A slightly higher and constant fungal population in other seasons might be because fungi can grow by utilizing resistant substances left by other micro organisms after decompositions of simple substances (Nishio and Kusano, 1980). Soil microbial population was less during periods when temperature and moisture conditions are low, while it peaked during rainy season when the litter decomposition rate is at its peak in the forest floor. The seasonal variation in the fungal spectrum of soil might be due to seasonal variation in soil moisture, temperature, pH and organic matter of soil.

Conclusion

Results from the present study demonstrate that management certain types of vegetation and land use exert a profound influence on microbial population. Different plant species affect soil microbial processes, which are dependent upon their litter quality and quantity and also upon below-ground biomass supporting microbial activities. The climatic conditions in the different season of the year changes the soil dynamics and thus resulting to a variation in Microbial population in different land uses. Our data suggest that forest soil may be healthier when compared to other land use soils. Results also indicate that microbial population was influenced by physic-chemical characteristics of the soil at the study sites.

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