Assessment of Soil Microbial Status Under Different Land Use System at Various Depth at Eastern Uttar Pradesh

Abstract

The present study was undertaken toassessment of soil microbial status under different land use system at various depth of main campus of University at Acharya Narendra, Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) during 2018-2019.

The land use systems selected for study were rice-wheat cropping system (RWCS), legume based cropping system (LBCS), and vegetable based cropping system(VBCS). Plantation land (mango, aonla and bael orchard), forest land (shisham, teak and eucalyptus) and barren land (NSP-6 farm). Soil samples were taken with GPS system from four depths viz. 0-15, 15-30, 30-45 and 45-60cm in order to analyze microbial population(bacteria, fungi and actinomycetes). The bacterial population (cfu $\times 10^5$ g^{-1}) under all the four land use viz. crop land, plantation land, forest land and barren land was decreased with increasing soil depth, which ranged from 2.76 to 4.95 cfu $\times 10^5$ g^{-1} soil. The average bacterial population values were higher in forest land followed by plantation land, crop land and barren land. The fungi population (cfu $\times 10^3$ g^{-1}) under all the four land use viz. crop land, plantation land, forest land and barren land was, also, decreased with increasing soil depth at all land use system and ranged from 0.85 to 1.77cfu $\times 10^3$ g^{-1} soil. The average fungi population values were higher in forest land followed by crop land, plantation land and barren land. The actinomycetes population (cfu $\times 10^4$ g^{-1}) under all the four land use viz. crop land, plantation land, forest land and barren land was decreased with increasing soil depth at all land use system. The population varied from 0.57 to 1.02 cfu $\times 10^4$ g^{-1} soil. The average actinomycetes population values were higher in forest land followed by plantation land, crop land and barren land.

Keyword: Soil Depth, Land Use System, Soil Microbial Population, Colony Forming Unit (CFU) , GPS System, Cropping System etc.

Introduction

The soil functions as a reservoir of nutrients and water, so provides supports to the plants. Unless being a physical medium, it may be also act as a living system. It is the natural resource

for food production, fodder production, fuel and fiber……. etc. for human being and others. Soil influences directly and indirectly to the agricultural productivity, quality of water, climate of world by act as a medium for plant growth and development and as regulator of flow of water and nutrient cycling.

In ecosystem level activities including the breakdown of organic matter and nutrient cycling, diverse microbial communities are supported by soil. Millions species of bacteria, actinomycetes, fungus, and algae can be found in only few cubic cm of soil. Physical and chemical characteristics of the soil, such as pH, moisture, the amount of organic matter present, and the availability of nutrients, can have an impact on the diversity, abundance, and activity of the microbial population (Rongzhong *et al*., 2009).

In continuous land use systems, maintaining and enhancing soil health is crucial to sustaining agricultural output, which helps the farming community by ensuring a steady income and protecting the land from deterioration (Pandey *et al*., 2023).

Land use is characterized by the arrangements, activities and inputs, that people undertake in a certain land cover type to produce change or maintain it (Abad *et al.*, 2014).

A wide variety of living things thrive in soil. From invertebrates like worms and insects to mammals like rabbits, rats, and badgers, it provides refuge to a wide variety of species. Additionally, microbes live there. These living things interact with one another and the soil to produce ever-changing conditions. This enables adjustments to soil production and fertility (Bhattarai *et al*., 2015).

Soil depth plays the most significant role in establishing microbial communities, other edaphic factors, such as organic matter in the soil, soil bulk density, and how much time that soils were saturated with water. Also, it plays a significant role in explaining the variation in the composition of soil microbial communities (Hao *et al*., 2021).

Microbiological populations are essential to the ecology, plant and animal health, food safety, and crop productivity (Hartman *et al*., 2018).The cycling that occurs in organic mixtures is controlled by soil microflora, which are also essential components of other biological processes. (Oladeji and Odelade, 2016).

Soil is a home to a rich microbial ecology that includes microscopic bacteria and fungi, microfauna (nematodes and protozoans), mesofauna, and macrofauna. Soil micro biomes are

thefundamental component of agricultural ecosystems, hosting a variety of biogeochemical activities such as nutrient cycling and organic matter decomposition (Hao *et al*., 2021).

The assessment of the long-term health of agricultural soils or the identification of unhealthy soils may be influenced by the soil microbial characteristics with regard to changes in soil depth. A better understanding of the impact of land use system on biological properties of soil is essential for evaluation of soil quality and thereby enhancing cropping system sustainability (Aparicio and Costa, 2007**)**. Therefore, the present study was aimed to assess the soil microbial status under different land use system at various depthsat Acharya Narendra Deva, University of Agriculture and Technology, Kumarganj, Ayodhya as eastern part of Uttar Pradesh, which might also be able to add value to the documentation of the microbial status of the study area and provide future line of work.

Materials and Methods:

Sampling sites:

Geographically, experimental site or sampling site is located at $26^0$47' N latitude and $81^0$12' E longitude and altitude of about 113 meters above from mean sea level in Indo-gangetic regions of Uttar Pradesh. Four land use system were identified for study at main campus of Acharya Narendra Deva, University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.), which are crop land, plantation land, forest land and barren land. Cropland system is characterized by addition of chemical fertilizer and farm yard manure (FYM). Soil samples were collected under rice-wheat cropping system (RWCS), legume based cropping system (LBCS), and vegetable based cropping system (VBCS). Plantation land system is characterized by addition of FYM and regular addition of organic matter in the form of falling leaves of mango, aonla and bael orchard, whereas forest land use system is characterized by regular addition of organic matter in the form of falling leaves including those of tree species (shisham, eucalyptus and teak) at forestry farm. On the other hand, Barren land is characterized by some grasses and no tree stands at NSP-6 farm.The details of land use system is given below:

Chart 1 : Details of land used system

No.	Land use system	Location
	Crop cultivated land	Agronomy Farm, ANDUAT
1	Rice-Wheat Cropping System	GPB Farm, ANDUAT
2	Legume based cropping system	Vegetable Farm, ANDUAT
3	Vegetable based cropping system	

	Plantation land	
4	Mango orchard	Horticulture Farm, ANDUAT
5	Aonla orchard	Horticulture Farm, ANDUAT
6	Bael orchard	Horticulture Farm, ANDUAT
	Forest Land	
7	Shisham	Forestry Farm, ANDUAT
8	Eucalyptus	Forestry Farm, ANDUAT
9	Teak	Forestry Farm, ANDUAT
10	**Barren land**	NSP-6 farm, ANDUAT

Soil sampling and analysis

Three spots were selected from selected sites randomly under each land use system. Soil samples were taken with the help of auger from 0-15 , 15-30 , 30-45 and 45-60 cm depths, respectively in each land use system. In all 120 samples, 36 from crop land use, 36 from plantation land use, 36 from forest land use and 12 from barren land use system, respectively were taken with GPS system. The details of GPS location of sampling aregiven below:

Chart 2 : GPS location of sampling place

Land use system	**Sample number**	**GPS location**	
A. Crop land		**Latitude**	**Longitude**
RWCS	1	$26^0$32’35”N	$81^0$49’31”E
	2	$26^0$32’30”N	$81^0$49’31”E
	3	$26^0$32’31”N	$81^0$49’32”E
LBCS	1	$26^0$32’5”N	$81^0$50’3”E
	2	$26^0$32’5”N	$81^0$50’4”E
	3	$26^0$32’6”N	$81^0$50’30”E
VBCS	1	$26^0$32’54”N	$81^0$50’29”E
	2	$26^0$32’53”N	$81^0$50’29’E
	3	$26^0$32’53”N	$81^0$50’30”E
B. Plantation land		**Latitude**	**Longitude**
Mango	1	$26^0$32’57”N	$81^0$50'32”E
	2	$26^0$32’57”N	$81^0$50’31”E
	3	$26^0$32’58”N	$81^0$50’32”E
Aonla	1	$26^0$32’53”N	$81^0$50’38”E

	2	$26^0$32’53”N	$81^0$50’38”E
	3	$26^0$32’54”N	$81^0$50’37”E
Bael	1	$26^0$32’56”N	$81^0$50’33”E
	2	$26^0$32’55”N	$81^0$50’31”E
	3	$26^0$32’56”N	$81^0$50’32”E
C. Forest land		**Latitude**	**Longitude**
Shisham	1	$26^0$33’23”N	$81^0$50’48”E
	2	$26^0$33’23”N	$81^0$50’49”E
	3	$26^0$33’22”N	$81^0$50’48”E
Eucalyptus	1	$26^0$33’21”N	$81^0$50’48”E
	2	$26^0$33’23”N	$81^0$50’49”E
	3	$26^0$33’22”N	$81^0$50’48”E
Teak	1	$26^0$33’57”N	$81^0$50’40”E
	2	$26^0$33’57”N	$81^0$51’40”E
	3	$26^0$34’12”N	$81^0$51’57”E
D. Barren land		**Latitude**	**Longitude**
NSP-6 farm	1	$26^0$32’22”N	$81^0$50’39”E
	2	$26^0$32’21”N	$81^0$50’38”E
	3	$26^0$32’21”N	$81^0$50’39”E

Results and Discussion

Effect of different land used systems on soil microbial status of soil at various soil depths:

Microbial Population

Bacterial Count

Bacterial population was estimated by Aneja (2003) method using serial dilution technique used Thornton’s nutrient agar medium.

Fungal Count

Fungal population was estimated by Aneja (2003) method using serial dilution technique used martin rose Bengal agar medium.

Actinomycetes Count

Actinomycetes population was estimated by Aneja (2003) method using serial dilution technique used Ken-Knight's medium.

Total microbial count (bacteria, fungi and actinomycetes count in soil)

The microbial count (bacteria, actinomycetes and fungi) was carried out by serial dilution and plating techniques suggested by Rao (1999). Media were prepared for desired micro flora. One gram of sieved (2 mm) soil was added to 9 ml sterile water blank and shaked for 15-20 minutes. Serial dilutions of 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6} and 10^{-7} were prepared and 0.1 ml of aliquots of various dilutions were poured in autoclaved Patri-plate. The autoclaved and cooled (45^0C) medium was poured into sterile plates. The plates were rotated for uniform distribution of bacterial cells and fungal spores in the aliquot under the media and allowed to solidify. After the media solidified the plates were inverted and incubated at 28± 2^{o}C for 3-4 days. The appearances of colonies on the surface of medium in the plates were observed. The Population count of bacteria, fungi and actinomycetes were noted using dilution plate technique by employing nutrient agar (NA), martin rose Bengal agar medium and ken knight's agar medium respectively. The microbial counts were expressed as colony forming unit per gram of soil (CFU g^{-1} soil).The composition of different media for soil microbial count is given in Table (1).

Table 1. Composition of different media for the soil microbialcount.

Composition of nutrient agar medium	
Ingredient	**Quantity**
Peptone	5g
Beef extract	3g
Agar	15g
pH	6.8-7.2
Distilled water	1000ml
NaCl	8g
Composition of Martin's rose Bengal medium	
Ingredient	**Quantity**
Glucose	10g
Peptone	5g
KH_2PO_4	1g
$MgSO_4.7H_2O$	0.05g
Streptomycin	30mg
Agar	15
Rose Bengal	0.035g
Distilled water	1000ml

Composition of Ken-knight's agar medium	
Ingredient	**Quantity**
Dextrose	1g
$NaNO_3$	0.10g
KH_2PO_4	0.10g
$MgSO_4.7H_2O$	0.10g
KCl	0.10g
Agar	15g
Distilled water	1000ml

Effect of different land use systems on bacterial population, (g^{-1} soil) at various soil depths.

Bacteria population (cfu×10^5 g^{-1}):

The bacterial population (cfu×10^5 g^{-1}) of soil is given in Table (2) and illustrated by Fig. (1). The bacterial population of soil relatively differed under different land use with their depths and ranged from 2.76 to 4.95 cfu×10^5 g^{-1} soil.

At 0-15cm depth of soil, bacterial population was recorded highest under shisham forest land (4.95 cfu×10^5 g^{-1}) followed by teak forest land (4.81 cfu×10^5g^{-1}), while the lowest population was recorded under NSP-6 farm (3.21 cfu×10^5 g^{-1}). The larger pore space and organic material provided to the soil by leaf litter, which acts as a source of energy for the microbial population, may be the cause of the higher bacterial density in forest land. Similar results were also observed by Wani *et al*. (2018).

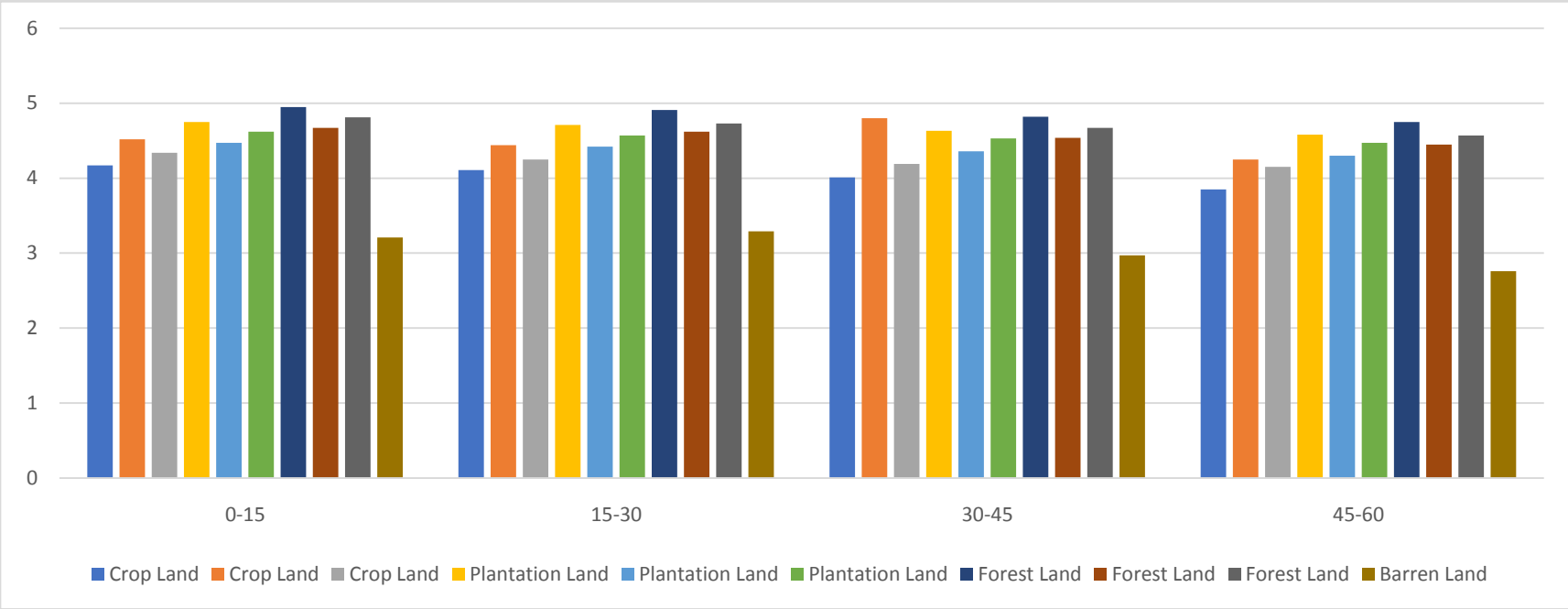
At 15-30cm soil depth, maximum bacterial population was recorded in shisham forest land (4.91 cfu×10^5 g^{-1}) followed by teak forest land (4.73cfu×10^5 g^{-1}) then mango orchard (4.71 cfu×10^5 g^{-1}). Meanwhile, the minimum population was recorded under NSP-6 farm (3.29 cfu×10^5 g^{-1}). At 30-45cm soil depth the highest bacterial population was recorded under shisham forest land (4.82 cfu×10^5 g^{-1}) followed by LBCS (4.8cfu×10^5 g^{-1}) then teak forest land (4.67 cfu×10^5 g^{-1}). Meanwhile, the lowest population was recorded in NSP-6 farm (2.97 cfu×10^5g^{-1}). At 45-60cm soil depth, the minimum bacteria population was observed in NSP-6 farm(2.76 cfu×10^5 g^{-1}). Whereas, the maximum microbial population was recorded under shisham forest land (4.75 cfu×10^5 g^{-1}) followed by mango orchard (4.58 cfu×10^5 g^{-1}) then teak forest land (4.57cfu×10^5 g^{-1}).Microorganisms activity in the soil is reflected by microbial respiration. Increased microbial activity is caused by the presence of more organic material in grasslands and forests with healthy vegetation cover. Due to plant roots, plant leavings, and an increase in

organic matter, grassland and forests have more active microorganisms (Yousefifard *et al*., 2007).

Table 2. Effect of different land use system onbacteria population (cfu×10^5 g^{-1}) at various soil depths

Soil depth	Crop land			Plantation land			Forest land			Barren land
	RWCS	LBCS	VBCS	Mango	Aonla	Bael	Shisham	Eucalyptus	Teak	NSP-6 farm
0-15	4.17	4.52	4.34	4.75	4.47	4.62	4.95	4.67	4.81	3.21
15-30	4.11	4.44	4.25	4.71	4.42	4.57	4.91	4.62	4.73	3.29
30-45	4.01	4.8	4.19	4.63	4.36	4.53	4.82	4.54	4.67	2.97
45-60	3.85	4.25	4.15	4.58	4.3	4.47	4.75	4.45	4.57	2.76
MD	4.06	4.48	4.22	4.67	4.39	4.55	4.86	4.58	4.7	3.09
SD	0.139	0.228	0.082	0.076	0.073	0.063	0.089	0.096	0.101	0.241
CV	0.01	0.05	0.006	0.005	0.005	0.004	0.008	0.009	0.01	0.05

Fig.1. Effect of different land use system on bacteria population (cfu×10^5 g^{-1}) at various soil depths



Effect of different land use systems on fungi population, (g^{-1} soil) at various soil depths.

Fungi Population ($cfu\times10^3\ g^{-1}$):

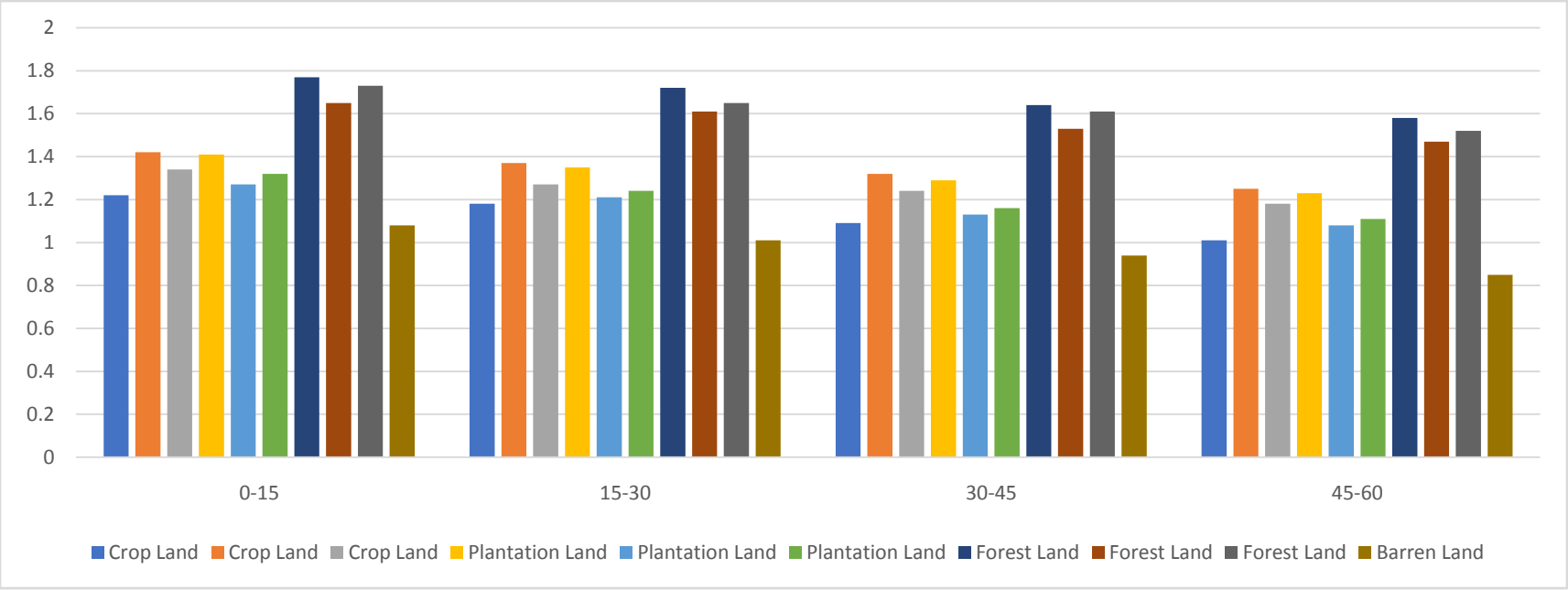
The effect of different land use at various depth of soil on fungi populationhas been given in Table (3) and illustrated by Fig. (2). The perusal of the table indicates that the fungi Population has been considerably affected by different land use at various soil depth and ranged from 0.85 to 1.77 $cfu\times10^3\ g^{-1}$.

At 0-15cm depth of soil, fungi population was recorded highest under shisham forest land (1.77 $cfu\times10^3\ g^{-1}$) followed by teak forest land (1.73$cfu\times10^3\ g^{-1}$) then eucalyptus forest land (1.65 $cfu\times10^3\ g^{-1}$) . Higher fungal count in the forest land soils may be due to low pH and higher organic matter content, accumulation possibly due to root biomass incorporation and huge amount of leaf litter. (Garg 1998). Similar finding was also observed by Qin (2006). Whereas ,the lowest population was under NSP-6 farm (1.08 $cfu\times10^3\ g^{-1}$). At 15-30cm soil depth, maximum fungi population was recorded in shisham forest land (1.72 $cfu\times10^3\ g^{-1}$) followed by teak forest land (1.65$cfu\times10^3\ g^{-1}$) then eucalyptus forest land (1.61 $cfu\times10^3\ g^{-1}$) . While, minimum recorded was under NSP-6 farm (1.01 $cfu\times10^3\ g^{-1}$). At 30-45cm soil depth, the highest fungi population was recorded under shisham forest land (1.64 $cfu\times10^3\ g^{-1}$) followed by teak forest land (1.61$cfu\times10^3\ g^{-1}$) then eucalyptus forest land (1.53 $cfu\times10^3\ g^{-1}$). Whereas, the lowest population was recorded in NSP-6 farm (0.94 $cfu\times10^3\ g^{-1}$). At 45-60cm soil depth, the minimum fungal population was observed in NSP-6 farm (0.85 $cfu\times10^3\ g^{-1}$) and the maximum was recorded under shisham forest land (1.58 $cfu\times10^3\ g^{-1}$) followed by teak forest land (1.52$cfu\times10^3\ g^{-1}$) then eucalyptus forest land (1.47 $cfu\times10^3\ g^{-1}$).

Table 3. Effect of different land use system on fungi population (cfu×10^3 g^{-1}) at various soil depths

Soil depth	Crop land			Plantation land			Forest land			Barren land
	RWCS	LBCS	VBCS	Mango	Aonla	Bael	Shisham	Eucalyptus	Teak	NSP-6 farm
0-15	1.22	1.42	1.34	1.41	1.27	1.32	1.77	1.65	1.73	1.08
15-30	1.18	1.37	1.27	1.35	1.21	1.24	1.72	1.61	1.65	1.01
30-45	1.09	1.32	1.24	1.29	1.13	1.16	1.64	1.53	1.61	0.94
45-60	1.01	1.25	1.18	1.23	1.08	1.11	1.58	1.47	1.52	0.85
MD	1.13	1.34	1.25	1.32	1.17	1.2	1.68	1.57	1.63	0.97
SD	0.093	0.072	0.066	0.077	0.084	0.092	0.084	0.081	0.087	0.098
CV	0.008	0.005	0.004	0.006	0.007	0.008	0.007	0.006	0.007	0.009

Fig. 2. Effect of different land use system on fungi population (cfu×10^5 g^{-1}) at various soil depths



Effect of different land use system on actinomycetes population (cfu×10^3 g^{-1}) at various soil depths

Actinomycetes Population (cfu×10^4 g^{-1})

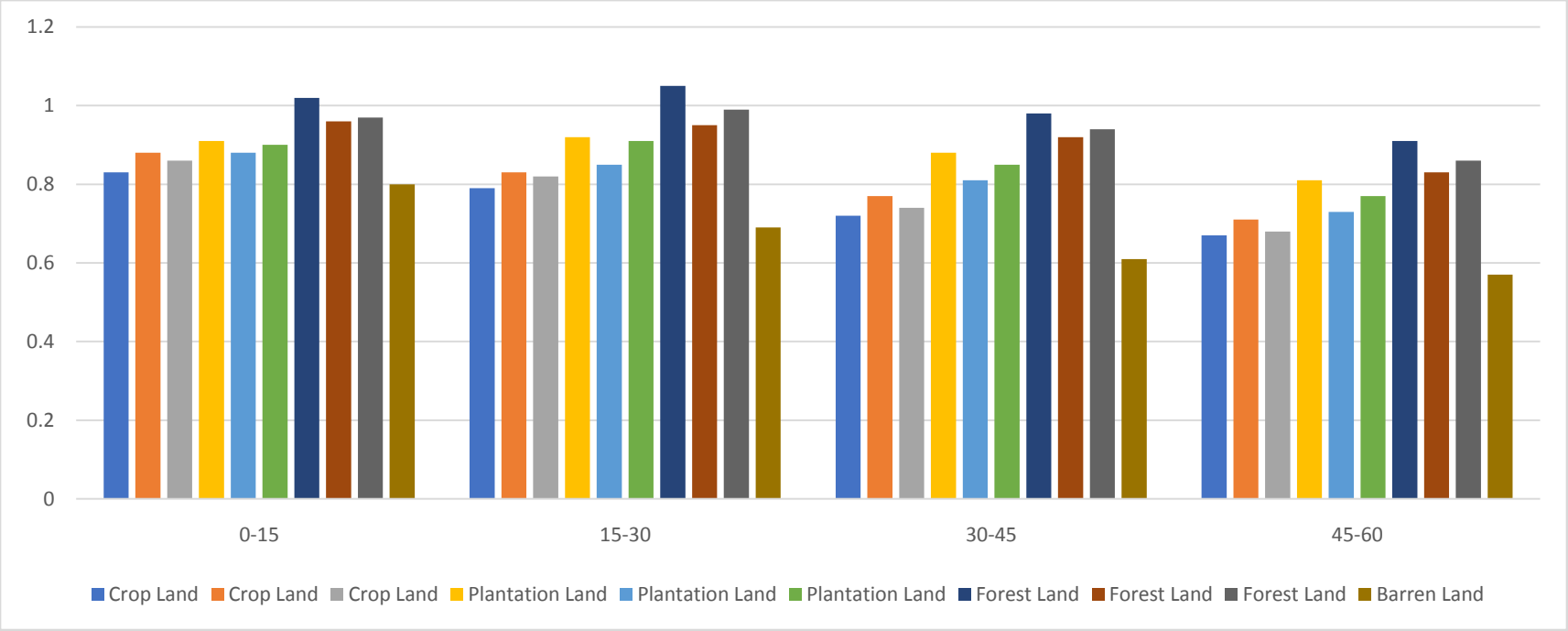
The data regarding the effect of different land use at various depths of soil on actinomycetes populationhas been given in Table (4) and Fig. (3). The perusal of the Table indicates that the actinomycetes population has been relatively affected by different land use at various soil depths. The population was varied from 0.57 to 1.05 cfu×10^4 g^{-1} soil.

At 0-15cm depth of soil, actinomycetes population was recorded highest under shisham forest land (1.02 cfu×10^4 g^{-1}) followed by teak forest land (0.97 cfu×10^4 g^{-1}) then eucalyptus forest land (0.96 cfu×10^4 g^{-1}).The presence of trees in the forestland may have reduced the impact of heavy rainfall and other climatic variables thus, favoring abundant growth of fungi in the forest land (Asadu *et al.*, 2015). Whereas, lowest under NSP-6 farm (0.8 cfu×10^4 g^{-1}) the less microbial count in cultivated land is due to low organic matter and use of fertilizers and more tillage practices. The results corroborate with the finding of Okonkwo(2010). At 15-30cm soil depth, maximum actinomycetes population was recorded in shisham forest land (1.05 cfu×10^4 g^{-1}) followed by teak forest land (0.99 cfu×10^4 g^{-1}) then eucalyptus forest land (0.95 cfu×10^4 g^{-1}). The more activity of microorganisms in grassland and forests is, also, due to presence of more plant roots (Wani *et al*., 2018). While, the minimum populationwas recorded under NSP-6 farm (0.69 cfu×10^4 g^{-1}). At 30-45cm soil depth, the highest actinomycetes population was recorded under shisham forest land (0.98 cfu×10^4 g^{-1}) followed by teak forest land (0.94 cfu×10^4 g^{-1}) then eucalyptus forest land (0.92 cfu×10^4 g^{-1}). The lowest population was recorded in NSP-6 farm (0.61cfu×10^4 g^{-1}). At 45-60cm soil depth, the minimum actinomycetes population was observed in NSP-6 farm (0.57 cfu×10^4 g^{-1}) and the maximum was recorded under shisham forest land (0.91 cfu×10^4 g^{-1}) followed by teak forest land (0.86 cfu×10^4 g^{-1}) then eucalyptus forest land (0.83 cfu×10^4 g^{-1}). Actinomycetes population was significantly affected by different land use system and conditions (Kumar *et al.*, 2017)

Table 4. Effect of different land use system on Actinomycetes population (cfu×10^4 g^{-1}) at various soil depths

Soil depth	Crop land			Plantation land			Forest land			Barren land
	RWCS	LBCS	VBCS	Mango	Aonla	Bael	Shisham	Eucalyptus	Teak	NSP-6 farm
0-15	0.83	0.88	0.86	0.91	0.88	0.9	1.02	0.96	0.97	0.8
15-30	0.79	0.83	0.82	0.92	0.85	0.91	1.05	0.95	0.99	0.69
30-45	0.72	0.77	0.74	0.88	0.81	0.85	0.98	0.92	0.94	0.61
45-60	0.67	0.71	0.68	0.81	0.73	0.77	0.91	0.83	0.86	0.57
MD	0.75	0.8	0.78	0.89	0.83	0.87	0.99	0.93	0.95	0.65
SD	0.071	0.073	0.081	0.049	0.065	0.063	0.061	0.059	0.057	0.101
CV	0.005	0.005	0.006	0.002	0.004	0.004	0.003	0.003	0.003	0.01

Fig. 3. Effect of different land use system on Actinomycetes population (cfu×10^5 g^{-1}) at various soil depths



Conclusion

It is possible to draw the conclusion that the soil depth and various land used systems had an impact on the soil micro biome. It can, also, be concluded that while crop land use (RWCS, LBCS, and VBCS) requires the addition of organic matter, FYM, and some chemical fertilizers to maintain soil productivity, fertility, and health, plantation land (mango, aonla, and bael), forest land (shisham, Eucalyptus, and teak), and are good for sustainable fertility and soil health. For better productivity, fertility, and soil health, bare land (NSP-6 farm) needs to be reclaimed with gypsum in accordance with the GR values for gypsum requirements. Following reclaiming, paddy crops with salt-tolerant varieties should be grown with green manure, addition of FYM, and chemical fertilizers as necessary.

This study will help for further used for planners and for better use and management of the soils of the main campus of university.

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