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Soil Properties as Influenced by Various Land Use Systems under Hill Ecosystem of North East India

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ABSTRACT

An investigation was undertaken to evaluate the soil properties of different land use systems viz. Jhum field (1st year), Jhum field (2nd year), Large cardamom based agro forestry system (4 year old), Orange based farming system (15 year), Jhum fallow (4 year) and Forest (>20 year) in Longleng district of Nagaland. Highest available P was recorded 21.91 kg/ha under Jhum 1st year, whereas lowest available K was found (219.81kg/ha) under Large cardamom agro-forestry system (4 year). Forest soil recorded 7.70%, 14.15%, 26.16%, higher pH, SOC, available N, respectively as compared to Jhum fallow 2nd year. Result revealed that maximum value of pH (5.31), SOC (2.58 %) and available N (413.95 kg/ha) were recorded under forestland (more than 20 years) followed by Orange based farming system as compared to other land use system.

Keywords

Shifting cultivation, Land use system, Soil properties, Soil depth, Hill ecosystem

INTRODUCTION

Shifting cultivation (SC) is one of the main forms of crop husbandry in North Eastern Region (NER) of India and it is locally known as *Jhumming* where the cultivators are known as *Jhumias*. In this system, a piece of forest land is slashed, burnt and cropped without tilling the soil, and the cropped land is subsequently fallowed to attain pre-slashed forest status through natural succession. Due to reduction of *Jhum* cycle from 20-30 years to 2–3 years, land degradation in the form of soil erosion and fertility depletion is taking place at an alarming scale (Layek *et al.*, 2014).Population pressure, limited land resources owing to difficult and inaccessible hilly terrain features, socio-economic impediments, land tenure systems, rapid decline in soil health and predominance and also several other anthropogenic degradation over aggradations processes are responsible for this shrink in fallow periods.While an estimated 12% of tribal population in India still practices shifting cultivation, the number of families involved in shifting cultivation in North east India is estimated to be 4.5 lakhs. As a result, SC system has become one of the most unsustainable farming systems, resulting in a large scale of soil degradation and ecological imbalance. It is believed that adoption of improved/alternate land use practices like agro forestry or lengthening the *Jhum* cycles by abandoning *Jhumming* for longer duration can help substantially in restoring the soil health *vis-à-vis* productive capacity of land. Improper land use has led to environment degradation in hilly region. The success in soil management to maintain soil quality depends upon an understanding of how soils respond to agricultural practices over time. Land use and soil management practices influence the soil nutrients and related soil processes, such as erosion, oxidation, mineralization and leaching, etc. (Liu *et al.*, 2010). The physico-chemical characteristics of soils are very much affected by the land use patterns. Land use in tropical areas cause significant modifications in soil properties in which agriculture have a major contribution (Pal *et al.*, 2013) and especially cultivation of deforested land, may rapidly diminish soil quality (Ayoubi *et al.*, 2011).

Agriculture is the mainstay of livelihood for the people of Nagaland and shifting cultivation (*Jhum*) is the predominant farming system in the state. In another recent estimate, it is reported that land under shifting cultivation in Nagaland covering an area of 7,000 sq km out of the total state geographical area of 16,579 sq km (Rathore *et al.* 2010). A total of 73% of the people in Nagaland are dependent on agriculture (Nakro, 2009).Rice is predominant crop cultivated in almost all districts of Nagaland which is followed by colocasia, cassava, beans and pulses. The state still witnessed least development regarding production practices, land and other resource use pattern, technological progress and their adoption rate, etc. These systems were developed for the proper evaluation of integrated land used systems so as to evolve an alternative system for sustainable food production in areas with shifting cultivation. Nagaland state is occupying the forest area of 862930 ha and Long leng District is having 24.27% forest area. Orange and Large cardamom based agro forestry system land use are also becoming popular nowadays to replace *Jhum* farming to sustain livelihood in Longleng District of Nagaland. The soil physical properties play an important role in determining its suitability for crop production. Productivity of the soil is the function of management practices which are determined by its dynamic physical and chemical characteristics. Therefore, there

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is special need for the analysis of soil nutrients in relation to land use. Such a local analysis is necessary to estimate nutrient storage in plantation and cultivated ecosystems. Therefore, the present study was initiated to investigate the soil properties of different land use systems of the hill ecosystem of Nagaland.

MATERIALS AND METHODS

A study was undertaken to evaluate the soil properties of various land use systems in Longleng District of Nagaland. Longleng Districtis a strip of mountainous territory and situated in the northern Nagaland and lies between 26˚26' N latitude and 94˚52' E longitude with an altitude ranges from 260-1306 m above MSL. The experimental site lies in humid subtropical zone with an average rainfall from 2000-2500 mm. The mean temperature ranges from 7°C to 27°C during the year with high atmospheric humidity. The soil is generally high in soil organic carbon (1.7% – 2.7%), medium in available N (296-340 kg/ha), and medium in available P (10-14 kg/ha) and K (170-182 kg/ha). The different land use were T_1: *Jhum* field (1^{st}year), T_2: *Jhum* field (2^{nd}year), T_3: Large cardamom based system (LC), T_4: Orange based system (O), T_5: *Jhum* fallow (4 year) and T_6: Forest (>20 years). Soils were collected from three depth (0-20, 20-40 and 40-60 cm) of seven different villages of Longleng, Sakshi and Tamlu block under Longleng District on various land use system.

The collected soil samples were brought to the laboratory, air-dried, grinded and sieved through a 2 mm wire mesh and samples were analyzed for different properties (available N, P, K, S and SOC, pH of soil following by standard procedure methods. The mean data of all the observation was statistically analysed using the F-test through standard procedure. The test of significance of treatment wasd one on basis of the t-test. The differences between treatments means, which were higher than respective CD values were considered as significant difference (LSD) at the 5% level of probability (P=0.05).

RESULTS AND DISCUSSION

Soil Reaction (pH)

Soil pH is an important property, which helps in understanding processes and speciation of chemical element in soil. Among the various land use system, the highest value of soil pH was found (5.31) with Forest (> 20 year) followed by l arge cardamom based farming system (5.09) as compared to other land use system and the lowest value was found in *Jhum* 2^{nd} year (4.93) (Table 1). The pH of all the treatments shows at par with each other. Lower pH might be due to high rainfall which resulted in maximum leaching of bases and accumulation of more acid forming cations like Al, Fe and Mn leading to increased acidity (Saha *et al.,* 2012). The pH varied with variation in land use systems. Similar results found by Kumar *et al.* (2012). Soil pH decreased with increase in soil depth. Maximum value of pH (5.36) was found in Forest (>20 year) with soil depth of 0-20 cm as compared to other depth and land use system. The result revealed that pH decreased with increase in soil depth in all land use system (Fig. 1). Similar findings also reported by Nayak and Srivastava (1995).

Table 1: Soil properties as influenced by different land use system

Land Use System	pH	SOC (%)	Av. N (kg/ha)	Av. P (kg/ha)	Av. K (kg/ha)	Av. S
Jhum 1^{st} yr (T_1)	4.96	2.25	385.32	21.91	236.43	35.44
Jhum 2^{nd} yr (T_2)	4.93	2.26	328.10	21.21	232.19	20.02
Large Cardamom AF system (4 yr) (T_3)	5.09	1.93	361.89	18.96	219.81	38.25
Orange based farming system (15 yr) (T_4)	4.94	1.88	385.27	17.08	223.40	37.53
Jhum fallow (4 yr) (T_5)	4.96	2.43	314.44	17.33	275.39	32.39
Forest (> 20 yr) (T_6)	5.31	2.58	413.95	18.83	286.77	30.90
SEm (±)	0.17	0.04	6.89	2.25	3.38	7.29
CD (P=0.05)	NS	0.11	19.48	0.80	9.57	NS

Soil Organic Carbon (SOC)

Higher value of soil organic carbon (SOC) was significantly recorded (Table 1) 2.58 % and 2.43% in forest land (>20 years) and *Jhum* fallow (4^{th} year) respectively as compared to other land use system and minimum under orange based farming system (1.88 %). The value of SOC recorded under *Jhum* 1^{st} year (4.96 %), *Jhum* 2^{nd} year (4.93) were at par with each other and also SOC value of Large cardamom based farming (FS) system and Orange based FS were found at par with each other (Table1). Variation in organic carbon in soils under different land uses may be due to leaf litter and their rate of decomposition. The result revealed that the value of SOC content decreased with increasing in soil depth in all the land use system (Fig.1). Maximum SOC was recorded 2.67 % with surface layer (0-20 cm) followed by 20-40 cm (2.62 %) and 40-60 cm (2.45 %) with forest land (Fig. 1).

These results are similar to the findings of Kumar *et al.* (2012). In general, forest land uses showed higher levels of SOC. The increase in humus content on decomposition of added organic sources may be responsible for increasing the negative charge on the organic colloid of the soil, which in turn would contribute to increase in SOC of the soil.The soil organic carbon content of surface soil was significantly higher than lower soil layer (Dhumgond *et al.* 2017).

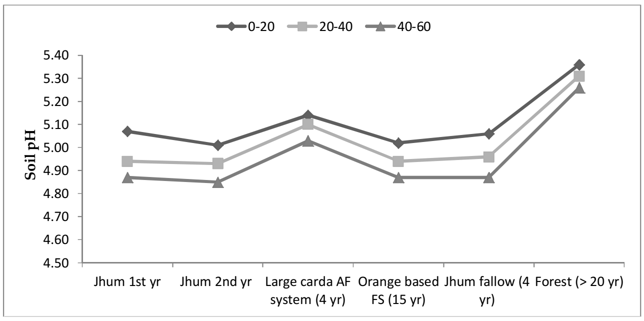


Fig. 1: pH as influenced by different land use system and depth

Available Nitrogen (N)

Available nitrogen (N) is defined as nitrogen in the root zone in a chemical form absorbed by plant roots. The major part (>90%) of soil nitrogen exists in complex combination in the organic matter fraction. It becomes available to plants after breakdown to simple forms followed by mineralisation. Nitrogen was found in the highest amount under natural forest as compared to the other land use studied (Pal *et al.*, 2013).Highest available N was recorded in Forest soil (413.95 kg/ha) followed by *Jhum* 1st year(385.32 kg/ha), Orange based farming system (385.27 kg/ha) as compared to other land use system (Table1) and the lowest value was found in *Jhum* fallow 4 year (314.44 kg/ha). Available N recorded with *Jhum* 1st year and Orange based FS (15 year) were showed at par to each other and also LC based AFS (15 year) and also *Jhum* fallow (4th year) were found at par to each other. In forest use system, recycling of nutrients due to falling leaves of tree species was the possible reason for high available N, P and K value.Similar result was in agreement with (Sharma *et al.* 2006). Among the soil depth, result revealed that increasing in soil depth decreased the available N. Maximum available N was found 390.80 kg/hain surface soil depth of 0-20 cm (Fig. 2) followed by 20-40 cm(362.10 kg/ha) and the lowest a depth of 40-60 cm (341.40 kg/ha).Percentage increased in available N was recorded 14.46 and 6.06 % higher in depth of 0-20 and 20-40 cm respectively as compared to 40-60 cm. Similar resultwas also in agreement with Dhumgond *et al.*,(2017).

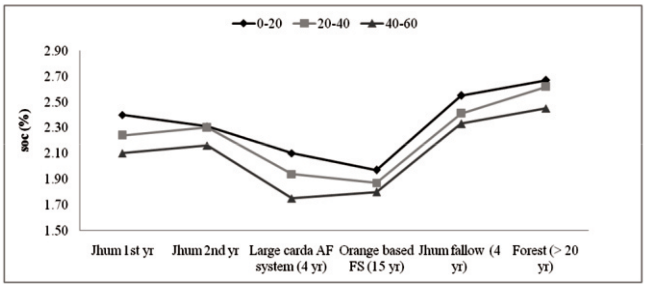
Available Phosphorus (P)

The data result on the effect of various land use systems on available phosphorus (P) in soil is presented in (Table 1). Result revealed that available P value ranges from 17.08 to 21.91 kg/ha in various land use system. Maximum available P was found 21.91 kg/ha under *Jhum* 1st year followed by 21.21 kg/ha under *Jhum* 2nd year and the minimum available P was found under Orange based farming system (17.08 kg/ha). On the basis of soil depth, result revealed that the highest value of available P (Fig. 2) was found in surface soil (20.86 kg/ha) followed by 40-60 cm (19.18 kg/ha)and lowest value of P was found in sub-surface layer (17.62 kg/ha). These results are conformity with Huck YwihCh'ng *et al.* (2014) and Mandal *et al*. (2011).

Available Potassium (K)

The term available potassium (K) incorporates both exchangeable and water soluble forms of K present in soil. In the present study, forest soil showed the highest available K (286.77 kg/ha). It may be due to biomass residue after burning of forest trees. The K in soils of Forest soil may be because of the contribution from an undisturbed ecosystem where there is a natural balance and no removal of residues that removes K (Wubie 2013). The lowest available K value recorded in Large cardamom based AF system (219.81 kg/ha) (Table 1). Sharma *et al.* (2003) reported low to medium available K content. On the basis of the average values of K for different land use system, irrespective of the soil depth, the available K may be arranged in term of the superiority as: $T_6 > T_5 > T_1 > T_2 > T_4 > T_3$ (Table 1). Result revealed that available K decreased with increasing soil depth (Fig. 2). Highest value of available K was found 190.49 kg/ha with surface layer and followed by 20-40 cm (157.49 kg/ha) and minimum under 40-60 cm (133.50 kg/ha).These results are in conformity with Dhumgond *et al.* (2017).

Fig. 2: SOC (%) as influenced by different land use system and depth



Available Sulphur (S)

The data on the effect of various land use systems on available S in soil is presented in (Table 1). Sulphur generally occurs in soils mainly in organic or as sulphate. In surface soils most of it usually presents as organic sulphur but in calcareous soil sulphates may pre-dominate. Important categories of sulphate in soils include water-soluble sulphate, adsorbed sulphate and insoluble sulphate associated with calcium carbonate. Although soluble sulphate is readily available to plants, the amounts present in surface soils are often small and usually prove inadequate for plant growth.The maximum value of available S (38.25 kg/ha) was recorded in large cardamom based agro forestry system followed by Orange based farming system (15 yr) (37.53 kg/ha) and the minimum value was recorded in *Jhum* 2nd year (20.02 kg/ha). Here, all the data statistically showed non-significant with each other in all the land use systems. Maximum available sulphur was found (65.68 kg/ha) in depth 40-60 cm whereas, the lowest S content was found (58.23 kg/ha) in depth 0-20 cm

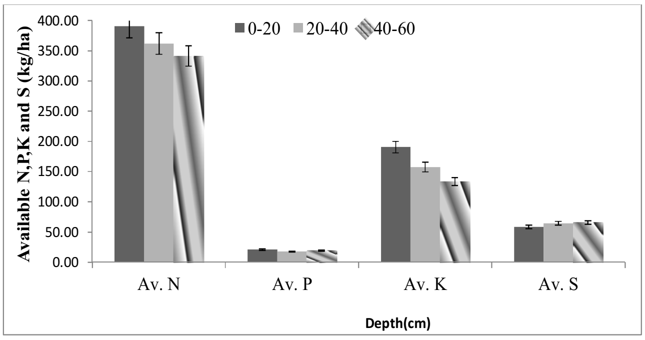


Fig. 3: Available N, P & K (kg/ha) as influenced by depth of soil

(Fig. 3). Percentage increase of available sulphur was recorded 12.87 and 2.30 % higher in depth of 40-60 and 20-40 cm respectively as compared to surface layer soil (0-20 cm). In general, the S content increases down the soil depth. Same findings was also reported by Singh *et al.* (2006).

Relationship between available soil nutrients under different land use system

The data revealed that the SOC and available N showed a high positive significant correlation with soil pH with (r = 0.454) and (r = 0.858). The data showed a negatively significant correlation between available S and available N (r = -0.704) content (Table 2).

CONCLUSIONS

From the present investigation it was observed that the soils of all the land use system were strongly acidic, high SOC, moderate N, low P and moderately high in potassium content. Based on the soil properties, forest land use system was superior as compared to other land use system. SOC status was much lower in orange and cardamom system but *jhum* farming system was found relatively better after forest land use system.

Table 2: Correlation coefficients (r) among different soil chemical properties

Soil properties	*pH*	*SOC*	*Avl. N*	*Avl. P*	*Avl. K*	*Avl. S*
pH	1					
SOC	0.454	1				
Avl. N	0.858	0.166	1			
Avl. P	-0.276	-0.016	0.041	1		
Avl. K	-0.008	-0.262	0.385	0.123	1	
Avl. S	-0.488	0.183	-0.704	-0.425	-0.257	1

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