PHYSICOCHEMICAL PROPERTIES OF SOIL UNDER TWO DIFFERENT DEPTHS IN A TROPICAL FOREST OF INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE, ABEOKUTA, IBADAN , NIGERIA.

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ABSTRACT

The variations in the physicochemical properties of soil at two different depths in a tropical secondary forest of International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria was investigated. Soil samples were collected at three random points each from twenty-four sampling plots at predetermined depths of 0-15cm and 15-30cm with soil auger. Soil particle size was determined the using pipet method, Soil pH was determined in a water suspension at 2:5 soil/water ratio. Exchangeable Ca, Mg, K, Al, and available P were extracted by the Mehlich-3 procedure. Cations were determined by atomic absorption spectrophotometry and P by the Malachite green colometric procedure. Organic C was determined by chromic acid and digestion and spectrophotometry, Total N was determined using the Kjeldahl method for digestion and ammonium electrode determination. Analysis of variance was conducted using the General Linear Model (GLM) procedure of SAS. Statistical comparisons of the all the plots were performed by analysis of variance. The data for the various soil depths were grossly analyzed. The variation in the values of sand, clay and silt content among the soil depth is minimal. Sand (89.448^a), clay (5.925^a) and silt (9.525^a) contents are significantly different ($P>0.05$) in (0-15 cm) soil depth than in (15-30 cm). Irrespective of depth, sand content was significantly high in plot 84 (91.90^a), clay in plot 14 (9.900^a) and silt in plot 49 (12.600^a) at ($P>0.05$) (Table 2). The effect of depth was significant in 0-15 cm depth (table 1) in Ca (4.007^a), K (0.827^a), Mg (5.065^a), Na (1.102^a) and CEC (10.945^a). On the effect of depth, OM and OC content were significant in 0-15 cm depth (6.591^a and 3.854^a) respectively at ($P>0.05$). High soil fertility status in plots 6 and 69 that are Chromolaena odorata fallows could be due to the fact that, it is herbaceous, covers well the soil surface and does not immobilize plant nutrients. It is concluded that forest regeneration support improved soil nutrient status.

INTRODUCTION

Pedologists have identified five fundamental soil formation processes that influence soil properties**:** parent material, topography, climate, time and organisms (Soil Survey Staff, 2006). The parent material from which soils develop is a key factor that in many cases determines the kinds and contents of secondary minerals of soils, therefore determines its texture and chemical properties (IUSS Working Group WRB, 2006). However, living organisms such as vegetation also have an important role in a number of processes involved in soil formation including organic matter accumulation, profile mixing and biogeochemical nutrient cycling. Through litterfall and the process of vegetation decomposition, plants add humus and nutrients to the soil which influences soil structure and fertility (NRCS, 2007). Soil biological, chemical and physical properties are modified by plants by means of root exudation, uptake of nutrients, contaminants and root growth (Marcet *et al*., 2006). In fact, under equilibrium conditions, vegetation and soil are closely linked with each other that different vegetation type exhibit different physical properties (Wilson and Sellers, 1985). Studies have also showed that vegetation, production of organic matter**,** quality of forest floor and availability of nutrient elements, are strongly combined with the local precipitations, the physical properties of the soil as well as the history of land use (Wezel *et al*., 2000; Epstein *et al*., 1998; Burke *et al*., 1997)

The maintenance of natural systems or soil fertility in tropical forest ecosystems is achieved by high and rapid circulation of nutrients through the fall and decomposition of litter which is a function of the season. The decomposed litter is also the basis of many food chains in tropical forests and is a principal source of energy for the biota of the forest floor and soil, where the trophic chain of detritus predominates (Ola-Adams and Egunjobi, 1992; Oliveira and Lacerola, 1993; Regina et al., 1999). Decomposition is a key process in the control of nutrient cycling and formation of soil organic matter (Berge B. and McClaugherty, 2002). Extensive work has been done on the conversion of natural forests into agroforests and cultivated land systems (Lal, 2001; Walker and Desanker, 2004), as well as with soil organic matter dynamics in African tropical forests (Moyo, 1998; Rishirumuhirwa and Roose, 1998; Walker and Desanker, 2004) This study, however, examines the variations in the physicochemical properties of soil at two different depths in a tropical secondary forest of International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria

MATERIALS AND METHODS

Study Area

The study area is located on the one thousand hectares land in the International Institute of Tropical Agriculture (I.I.T.A) campus at Idi-Ose, North of Ibadan, Nigeria. It is located on longitude 7^0 30^1N and latitude 3^0 55^1E and 243m above sea level. The rolling topography is dominated by slopes that are 3-10% (, Moormann *et al.,* 1975). The area is under-lain by metamorphic rocks of pre-cambrian basement complex, consisting largely of banded gneiss alternating with strata of quartzites and quartz schists. The soils are predominately Ferric Luvisols (Moormann *et al.*, 1975).

The site falls within the humid tropical lowland region with two distinct seasons: the longer wet season and shorter dry season. Wet season last for eight months and it extends from March to October while dry season last for four months from November to February. The rainfall pattern has bimodal peak with an annual total ranges between 1,300-1,500mm most of which falls between May and September. The average daily temperature ranges between 21^0C-23^0C while the maximum is between 28^0C and 34^0C. Mean relative humidity is in the range of 64-84% (Hall and Okali, 1979, Osunsina, 2004).

Soil Sampling, Physical and Chemical Analysis

Soil samples were collected at two different depths 0-15 cm and 15-30 cm randomly from the twenty four plots in a secondary rainforest with soil auger. The collected samples were then air dried, crushed and sieved through a 0.5 mesh size sieve and analyzed for pH, Total N, Organic C, available and exchangeable Ca, Mg, K, Al. Soil particle size was determined the pipet method (Gee & Bauder 1986), Soil pH was determined in a water suspension at2:5 soil/water ratio. Exchangeable Ca, Mg, K, Al, and available P was extracted by the Mehlich-3 procedure (Mehlich, 1984), Cations were determined by atomic absorption spectrophotometry and P by the Malachite green colometric procedure (Motomizu *et al.*, 1983). Organic C was determined by chromic acid and digestion and spectrophotometry (Hearnes, 1984). Total N was determined using the Kjeldahl method for digestionand ammoniumelectrode determination (Bremner and Tbatabai, 1972, Bremner,1982)

Statistical Analysis

Analysis of variance was conducted using the General Linear Model (GLM) procedure of SAS. Statistical comparisons of the all the plots were performed by analysis of variance. The data for the various soil depths were grossly analyzed.

RESULT

Physical Characteristics of Top Soil from the Study Area

The physical characteristic determined from the top soil is particle size distribution. Sand content was generally high in all the plots and the soil under the forest stand is classified as loamy sand. The variation in the values of sand, clay and silt content among the soil depth is minimal. Sand (89.448^a), clay (5.925^a) and silt (9.525^a) contents are significantly different ($P>0.05$) in (0-15 cm) soil depth than in (15-30 cm) (table 1). Irrespective of depth, sand content was significantly high in plot 84 (91.90^a), clay in plot 14 (9.900^a) and silt in plot 49 (12.600^a) at ($P>0.05$) (Table 2).

Calcium content was generally high in the 0-15 cm depth in all the plots; similar trend was evident in sodium, magnesium, potassium and CEC. The effect of depth was significant in 0-15 cm depth (table 1) in Ca (4.007[a]), K (0.827[a]), Mg (5.065[a]), Na (1.102[a]) and CEC (10.945[a]). However, irrespective of depths (Table 2), Ca was significantly high in plot 37 (7.020[a]), K in plot 28 (1.410[a]), Mg in plot 76 (8.205[a]), Na in plot 60 (1.702[a]) and CEC in plot 37 (16.380[a]) at (P>0.05). Manganese (Mn) was generally higher in 0-15 cm depth and 15-30 cm soil depth in all the plots except in plots 69, 48, 37, 68, 95 and 14. There appear to be more Copper (Cu) content in 15-30 cm depth. Mn (2.343[a]) and Cu (0.742[a]) were significantly higher in 0 -15cm depth (P>0.05) than 15-30 cm (Table 14). In addition, irrespective of depth (table 15), Mn was significantly high in plot 89 (16.920[a]) and Cu in plot 60 (3.867[a]) at (P>0.05). Soils under these plots are acidic especially at 0-15 cm depth (table13). This is evident in the significant level at (P>0.05) in 0-15 cm (6.9312[a]) table (1). The interactive effect of plots and soil depth showed that pH was significantly high in plot37 (7.635[a]), plot 57 (7.230[b]) and plot48 (7.203[b]) (table 2) Organic Matter (OM) was generally high in 0-15 cm depth than 15-30 cm. this reflects the higher values recorded in plots 90,49, 37, 41, 6, 17 except in few plots. Similar trend was observed for Organic carbon (OM) with values ranged from 0.2 to 14.96% (figure 9). On the effect of depth, OM and OC content were significant in 0-15 cm depth (6.591[a] and 3.854[a]) respectively at (P>0.05). Table (1). The interactive effect of plot, irrespective of depth, showed a significant difference in plot 14 (9.807[a]), plot 97 (6.285[b]) for OC, similar trend was observed for OM (Table 2). Total nitrogen (TN) content was significantly higher in 0-15 cm depth (2.7047[a]) than in 15-30 cm (figure 10). On the interactive effect, irrespective of depth, TN % was significantly higher in plot 56 (3.187[a]). The range of values is 0.61 to 3.99 ppm. The distribution of available phosphorus across the plots is generally higher in the 0-15 cm depth. Soil sampling depth exercise a significant effect in the 0-15 cm depth (1.495[a]) and irrespective of depth, Phosphorus was significantly high in plot 14 (2.930[a]) (table 1 and 2) respectively.

Table 1: Effect of Soil depth on Soil Properties

Soil properties	**0-15 cm**	**15-30 cm**
Soil pH	6.931[a]	6.775[b]
OC/%	3.854[a]	3.189[b]
OM/%	6.591[a]	5.931[b]
P/ppm	1.495[a]	1.398[b]
Al/meg	0.958[b]	1.208[a]
T.N/%	2.705[a]	1.694[b]
Na	1.102[a]	0.900[b]
K	0.827[a]	0.597[b]
Ca	4.007[a]	3.049[b]
Mg	5.065[a]	4.136[b]
ECEC	10.945[a]	8.682[b]
Mn	2.343[a]	2.272[b]
Cu	0.742[a]	0.566[b]
Sand	89.449[a]	84.475[b]
Clay	5.925[a]	2.400[b]
Silt	9.525[a]	7.962[b]

Means with the same letter on the same column are not significantly different (p>0.05

Table 2: Effect of plots on Soil properties

Plots	pH/ mg/kg	OC/%	OM/%	P/ppm	Al/cmol/kg	TN/%	Na/ cmol/kg	Ca/ cmol/kg
plo14	6.353^{j}	9.807^{a}	17.355^{a}	2.930^{a}	1.25^{b}	2.230^{i}	0.870^{bc}	4.250^{e}
plot17	7.075^{bcd}	1.980^{l}	3.472^{r}	1.040^{l}	1.00^{c}	1.678^{n}	0.870^{bc}	3.000^{i}
plot26	6.707^{efgh}	2.890^{i}	5.035^{n}	1.440^{f}	1.50^{a}	2.435^{f}	1.315^{ab}	2.750^{i}
plot28	6.820^{defgh}	3.290^{h}	5.725^{l}	1.445^{f}	1.00^{c}	2.770^{c}	1.300^{ab}	5.500^{b}
plot30	6.655^{fghi}	1.195^{n}	5.210^{m}	1.335^{g}	0.50^{e}	2.383^{g}	1.085^{bc}	3.917^{f}
plot37	7.635^{a}	4.485^{de}	7.815^{e}	1.140^{kj}	0.50^{e}	2.017^{l}	1.305^{ab}	7.020^{a}
Plot41	6.690^{fghi}	2.265^{j}	3.995^{o}	1.530^{e}	1.00^{c}	2.375^{g}	0.870^{bc}	2.750^{i}
Plot48	7.203^{b}	0.200^{o}	0.350^{u}	1.050^{l}	1.50^{a}	1.640^{o}	1.085^{bc}	3.250^{h}
Plot49	6.623^{ghi}	3.695^{g}	3.442^{r}	1.965^{b}	0.75^{d}	2.520^{e}	1.027^{bc}	4.500^{d}
Plot56	6.542^{ij}	3.857^{g}	6.765^{j}	1.995^{b}	1.25^{b}	3.187^{a}	0.870^{bc}	2.750^{i}
Plot57	7.230^{b}	2.195^{kj}	3.820^{p}	1.140^{kj}	1.50^{a}	2.360^{g}	1.085^{bc}	3.500^{g}
Plot6	6.818^{defgh}	2.890^{i}	5.005^{n}	1.120^{k}	1.50^{a}	2.272^{h}	0.870^{bc}	2.667^{j}
Plot60	6.967^{bcde}	4.59^{d}	8.160^{d}	0.955^{m}	0.75^{d}	2.148^{j}	1.702^{a}	3.392^{g}
Plot61	6.567^{ij}	1.995^{kl}	7.283^{h}	1.310^{g}	1.50^{a}	0.952^{q}	1.085^{bc}	2.750^{i}
Plot68	7.070b^{cd}	4.385^{def}	7.640^{f}	1.270^{ghi}	1.50^{a}	2.668^{d}	0.870^{bc}	3.250^{h}
Plot69	6.968^{bcde}	4.290^{d}	7.460^{g}	1.295^{gh}	1.25^{b}	2.257^{h}	0.870^{bc}	2.250^{j}
Plot70	6.690^{fghi}	1.585^{m}	2.780^{s}	1.205^{ij}	1.50^{a}	2.020^{l}	0.65^{c}	3.000^{i}
Plot76	6.855^{defg}	4.390^{def}	7.640^{f}	1.750^{d}	0.25^{f}	1.900^{n}	0.870^{bc}	3.500^{g}
Plot8	6.495^{ij}	2.095^{jkl}	3.645^{q}	1.860^{c}	1.50^{a}	2.932^{b}	0.870^{bc}	3.000^{i}
Plot89	6.580^{ghij}	6.085^{c}	10.590^{c}	1.550^{e}	0.50^{e}	2.002^{l}	0.870^{bc}	3.750^{f}
Plot90	6.851^{defg}	4.490^{de}	6.595^{k}	1.225^{hi}	1.00^{c}	2.280^{h}	0.870^{bc}	2.855^{i}
Plot95	7.003^{bcd}	4.190^{f}	7.122^{i}	1.402^{f}	1.00^{c}	2.120^{k}	1.300^{ab}	3.750^{f}
Plot97	6.900^{cdef}	6.285^{b}	10.935^{b}	1.440^{f}	1.00^{c}	1.615^{p}	0.65^{c}	2.750^{i}
Plot84	7.160^{bc}	1.400^{m}	2.430^{t}	1.320^{g}	1.00^{c}	2.028^{l}	0.870^{bc}	5.000^{c}

Means with the same letter on the same column are not significantly different (p>0.05)

Table 2: Effect of plots on Soil properties (Continue)

Plots	K/cmol/kg	Mg/cmol/kg	ECEC	Mn/mg/kg	Cu/mg/kg	Sand/%	Clay/%	Sil/%
plo14	0.522e	2.565^{n}	8.195^{n}	1.085^{b}	0.240^{n}	80.200^{i}	9.9^{a}	9.90^{cd}
plot17	0.770c	4.105^{j}	8.740^{k}	0.555^{b}	0.333^{l}	87.400^{ed}	3.6^{f}	9.00^{de}
plot26	0.770c	4.620^{h}	9.440^{j}	1.4350^{b}	0.563^{h}	90.100^{b}	2.7^{g}	7.20^{gf}
plot28	1.410a	7.253^{b}	15.390^{b}	1.115^{b}	0.871^{b}	87.000^{def}	4.5^{e}	9.00^{de}
plot30	0.638d	2.305^{o}	8.035^{p}	3.825^{b}	0.093^{p}	89.200^{bc}	4.5^{e}	6.30^{g}
plot37	0.900b	7.180^{c}	16.380^{a}	0.935^{b}	0.804^{e}	83.800^{g}	5.4^{d}	10.80^{bc}
Plot41	0.640d	5.125^{g}	9.393^{j}	0.985^{b}	0.562^{h}	86.500^{ef}	6.3^{c}	7.20^{gf}
Plot48	0.510e	3.845^{k}	8.700^{k}	1.155^{b}	0.454^{i}	89.200^{bc}	2.7^{g}	8.10^{ef}
Plot49	0.640d	3.850^{k}	10.075^{i}	3.760^{b}	0.831^{d}	82.900^{gh}	4.5^{e}	12.60^{a}
Plot56	0.900b	6.155^{e}	10.673^{h}	0.635^{b}	0.416^{j}	88.300^{cd}	1.8^{h}	8.25^{ef}
Plot57	0.770c	5.90^{f}	11.250^{g}	0.6950^{b}	0.221^{n}	89.200^{bc}	0.9^{i}	9.90^{cd}
Plot6	0.640d	4.360^{i}	8.120^{o}	4.378^{b}	0.667^{g}	89.767^{bc}	1.8^{h}	8.10^{ef}
Plot60	0.638d	3.665^{l}	8.565^{l}	3.260^{b}	3.867^{a}	89.200^{bc}	2.7^{g}	8.10^{ef}
Plot61	0.770c	2.050^{p}	6.655^{s}	0.890^{b}	0.858^{c}	85.567^{f}	4.5^{e}	8.10^{ef}
Plot68	0.640d	7.180^{c}	11.940^{f}	0.925^{b}	0.468^{i}	83.800^{g}	5.4^{d}	10.80^{bc}
Plot69	0.640d	2.31^{o}	6.070^{t}	0.820^{b}	0.280^{m}	88.30^{cd}	5.4^{d}	6.30^{g}
Plot70	0.557e	3.335^{m}	7.625^{r}	1.1667^{b}	1.336^{b}	86.50^{ef}	4.5^{e}	9.0^{de}
Plot76	0.770c	8.205^{a}	13.345^{c}	0.875^{b}	0.811^{e}	88.45^{cd}	2.7^{g}	9.0^{de}
Plot8	0.640d	3.33^{m}	7.845^{q}	1.180^{b}	0.722^{f}	82.00^{h}	9.0^{b}	9.0^{de}
Plot89	0.770c	6.92^{d}	12.310^{e}	16.920^{a}	0.374^{k}	83.80^{g}	4.5^{e}	11.70^{b}
Plot90	0.640d	3.295^{m}	7.665^{r}	3.750^{b}	0.709^{f}	86.50^{ef}	6.3^{c}	7.20^{gf}
Plot95	0.640d	7.180^{c}	12.875^{d}	1.240^{b}	0.154^{o}	89.20^{bc}	1.8^{h}	9.00^{de}
Plot97	0.64d	3.85^{k}	7.885^{q}	0.675^{b}	0.095^{p}	88.30^{cd}	2.7^{g}	9.00^{de}
Plot84	0.64d	1.835^{q}	8.345^{m}	3.130^{b}	0.000^{q}	91.900^{a}	1.8^{h}	6.30^{g}

Means with the same letter on the same row are not significantly different (p>0.05)

DISCUSSION AND CONCLUSION

The particle size distribution varied among soil depths. Sand decreased with soil depth while clay increased with soil depth in all the plots. Silt did not follow a regular pattern. This explains the significant different ($P > 0.05$) between the two depth. Similar trends in the particle size distribution have been reported by Muoghalu and Awokunle (1994) in the Nigerian rainforest region and Chima (2007) in Omo biosphere reserve, Nigeria. Although there are significant differences among the plots, the variation in sand content across plot is not much. The sand content of plot 84 is significantly different with respect to soil depth, the sand content of the 0 -15cm depth (89.449 m) varied significantly from that of the 15 – 30 cm depth. The clay content of plot 14 varied significantly from other plots. Although the texture is an intrinsic soil property, vegetation modification could have contributed to the variations in particle size distribution (Chima, 2007).

Calcium (Ca) and magnesium (Mg) decreased significantly with soil depth in all the plots in the study area with 0-15 cm depth varying significantly from 15-30 cm depth. The relative richness of the top 0-15 cm layer could be attributed to the regular restitution of nitrogen, phosphorus and basic cations at the soil surface via decomposition [Agoume and Birang (2009); Dabin (1984)]. Sodium content decreased with depth and significantly varied in 0-15 cm depth (1.1022^{a}) and significant in plot 60 (1.702^{a}). The accumulation of these cations is likely to increase pH (Muoghalu and Awokunle, 1994; Chima, 2007; Agoume and Birang 2009). Potassium content was generally high in the entire plot ranging from 0.26 to 1.54 mol/kg) and showed a significant difference in 0-15 cm depth (0.827^{a}) and plot 28 (1.410^{a}). This can be attributed to the leaching of the cations down the soil depth by rainfall (Wong *et al.,*, 2005). It was observed that soil content of most of the exchangeable bases reduced down the profile.

This is apparent because the cations are concentrated in the organic matter rich surface soil that is mixed with little (heterogeneous in nature) at different stages of decomposition which continuously release the cations. This is similar to the finding of Oyedele *et al.,*, 2008; effective cation exchange capacity (ECEC) decreased consistently with soil depth in all the plots with 0-15 cm depth being significantly different from 15-30 cm depth. The decrease in ECEC with depth is attributed to a decrease in organic matter content. The low ECEC content in the 15-30 cm depth reminded that the adsorption capacity of this soil was humus dependent. However the result of the ECEC of this study is higher when compared with studies of Chima (2007) in Omo biosphere, Nigeria and Agoume and Birang (2009); Menzies and Gillman (1997). In humid zone of southern Cameroon, similar associations of soil organic matter and ECEC have been reported by Muoghalu and Awokunle, 1994; Mesfin 1980; Chima, 2007.

Manganese and copper were higher in the 0-15 cm depth significantly (2.343[a]) and (2.272[b]) respectively than in 15-30 cm depth. Overall, manganese were significantly higher in plot 89 (16.9200[a]) and copper in plot 60 (3.868[a]). This decrease with soil depth is attributed to the strong association of copper with soil organic matter.

Soil pH decreased with soil depth nearly in all the plots but significantly different in 0-15 cm depth (6.9312[a]) and highest in plot 37 (7.635[a]). This higher value is expected as most soil in the tropics have their ranging from acidic to slightly neutral (Alloway and Aryes, 1997). Similar trend has been observed in the study by Oyedele *et al.,*, (2008). This may also be attributed to the buffering effect of soil organic matter against pH change in addition to the release of basic cations during organic matter decomposition. Soil pH is an important parameter that directly influence sorption/desorption, precipitation/dissolution, complex formation and oxidation reduction reactions. As observed by Mclean and Bledsoe (1992) the maximum retention of cationic metals occurs at pH >7 while anionic occurs at pH <7.

The percentage organic matter in all the plots was highest in the 0-15 cm depth. The significance difference is probably due to the accumulation and decay of leaf litter and root within the tree canopies. The decrease of organic matter with depth may be due to the decrease in the abundance of the fine roots with depth; at greater depth, larger diameter roots predominate. The organic matter content of the sub soil plays an important role in adsorption reaction in the soil thereby preventing pollutants from reaching ground water sources (Alloway and Aryes, 1997; Puls *et al.*, 1991, Mclean and Bledose 1992, Oyedele *et al.*,, 2008).

The mean total nitrogen was highest in plot 56 (3.187[a]) and the least was found in plot 61 (0.952[a]). The distribution with depth is similar to that of organic matter. This is expected since about 90% of soil nitrogen is in organic combination. High total nitrogen value observed in this study could be attributed to the species composition of the IITA forest and the rate of decomposition Hobbie, (1996) and Vanlauwe *et al.*, (1997) reported that species with high nitrogen content decompose more rapidly.

Generally available phosphorus decreased gradually with depth though there were significant differences among the plots, the variations was minimal. The highest and lowest available phosphorus among the plots were recorded under plot 14 (2.930[a]) and plot 60 (0.955[a]) respectively.

Higher phosphorus content in the soil is an indication of the increased decomposition of organic matter occurring under regenerating canopy. Similar result has been found in the studies of Ola-Adams (1999), Chima 2007, Ishabiyi, 2010.

Aluminum saturation increases with soil depth, this explains the significant difference in 15-30 cm depth (1.20833[a]) than 0-15 cm depth (0.0583[b]). Sanchez et al., (1982) defined two important thresholds values: soils with 10-60% Aluminum saturation present acidity problems while soil with more than 60% aluminum saturation exhibit aluminum toxicity. Thus acidity problem will occur in top soil and aluminum toxicity problems in the sub soil. The limited amount of exchangeable aluminum in the top-soil could be due to complexation with organic matter because it is in that layer where the latter is concentrated. This is similar to the findings of Agoume and Birang (2009).

High soil fertility status in plots 6 and 69 that are *Chromolaena odorata* fallows could be due to the fact that, it is herbaceous, covers well the soil surface and does not immobilize plant nutrients for a long period in the standing biomass leading to shortening of the nutrient cycling.

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