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Impact of land use types and soil depths on selected soil properties in Igboora, Nigeria

N. O. Olla[1]*, P.A. Babajide[2], W. B. Bello[1], S. O. Ogunjinmi[3], A. S. Alabi[4], O. M. Busari[5], A. C. Olowofela[1], and T. N. Hamzat[1]

[1]*Department of Soil Science Technology, Oyo State College of Agriculture and Technology, Igboora, Nigeria.*
[2]*Department of Crop Production and Soil Science, Ladoke Akintola University of Technology, P.M.B, 4000, Ogbomoso, Nigeria.*
[3]*Department of Crop Production Technology, Oyo State College of Agriculture and Technology, Igboora, Nigeria.*
[4]*Department of Forestry Technology, Oyo State College of Agriculture and Technology, Igboora, Nigeria.*
[5]*Department of Horticultural Technology, Oyo State College of Agriculture and Technology, Igboora, Nigeria.*

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Corresponding Author's E-mail Address:
gbengaolla@yahoo.co.uk **+2348030659348**

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ABSTRACT

This study was carried out to evaluate the impacts of land-use types at different sampling depths on some selected soil properties within the Oyo State College of Agriculture and Technology, Igboora, Nigeria. The different land-use types were a woodlot, *Cajanus cajan* plot, nursery plot, vegetable plot, and cassava plot. Soil samples were collected from the land-use types at two depths (0-20 cm- topsoil; and 20-40 cm- sub-soil) in three replicates. Data collected were subjected to analysis of variance using Genstat statistical package and means separated using Least Significant Difference (LSD) at 5 % level of probability. The results show that in both the topsoil and sub-soil, particle size distribution, pH, organic carbon (OC), total N (TN), available P and exchangeable K were significantly different amongst various land use types and soil depth. The highest proportion of sand (92.10 %) was recorded in the woodlot while the lowest value (85.60 %) was found in the cassava plot. The highest proportion of silt (7.10 %) was recorded in the cassava plot while the lowest value (2.60 %) was observed in the woodlot and vegetable plot. Clay fraction was highest in cassava (7.30%) and lowest in nursery and *C. cajan plots* (4.80 %). The values of sand, silt, and clay in the topsoil are 91.20, 3.20, and 5.60 %, respectively while it is 88.40, 5.60, and 6.00 % for sand, silt, and clay in the sub-soil. Results obtained also showed that the pH value was highest (7.42) in the vegetable plot while the lowest value (6.22) was recorded in the cassava plot. This trend was observed for OC, TN, P, and K in the vegetable plots. The values recorded are 1.23 %, 0.10 %, 20.73 mg kg^{-1} and 0.36 cmol kg^{-1} for OC, TN, P and K, respectively. The impact of sampling depth on pH, OC, TN, and K revealed that they reduced with depth. On the contrary, P values were observed to increase with the sampling depth. This investigation thus revealed that land-use types and sampling depth greatly influenced soil properties in this area and recommends agronomic practices that will boost the organic matter contents as well as the nitrogen level of these soils.

1.0 Introduction

The soil is the basis for agriculture, natural plant communities, and natural climate regulation, with 75% terrestrial organic carbon storage (Lal, 2004; Lemenih and Itanna, 2004). Vegetation has the lion's share in the sustenance of such ecosystem services of both surface and subsurface soil. Land-use changes have several undesirable consequences like the decline in soil fertility, soil carbon, and nitrogen stocks (Lemenih, 2004; Lemenih and Itanna, 2004; Tesfaye *et al*., 2016; Henok *et al*., 2017).

Land use and soil management practices influence the soil nutrients and related soil processes, such as erosion, oxidation, mineralization, and leaching, etc. (Celik, 2005; Liu *et al*., 2010). As a result, it can modify the processes of transport and re-distribution of nutrients. In non-cultivated land, the type of vegetative cover is a factor influencing the soil organic carbon content (Liu *et al*., 2010). Moreover, soils through land-use change also produce considerable alterations (Fu *et al*., 2000). Land-use changes are capable of influencing the physical, chemical, and biological properties of soil. Karlen *et al*. (2003) observed that land use types influence soil organic matter, soil pH, and mineralogical properties of soils. Land use practices also affect the distribution and supply of soil nutrients by directly altering soil properties and influencing biological transformations in the root zone (Murty *et al*., 2002). It is essential also to note that soil properties also vary with depth (Adugna and Abegaz, 2015; Kassa*et al*., 2017).

Moreover, some studies show that the extent of soil quality, soil organic carbon, and nitrogen stocks vary with native vegetation, climate, soil type, management practice, land-use history, and time since conversion (Craswell and Lefroy, 2001; Lemenih, 2004; Lemenih and Itanna, 2004). For instance, soil fertility, soil organic carbon, and nitrogen stocks' decline (owing to land-use changes) have been reported on the surface and the subsoil (Don *et al*., 2011; Lemenih, 2004). Similarly, (Senjobi and Ogunkunle, 2011) confirmed that soil properties varied from one land-use type to another.
Although several studies have been carried out to study both the physical and chemical properties of soil in Oyo State College of Agriculture and Technology (OYSCATECH), Igboora, Nigeria, there is no available data on the impact of land-use types on soil properties. Furthermore, understanding the effects of land use on soil properties is essential to establishing appropriate management options that will sustain soil resources and restore degraded soils in OYSCATECH. Therefore, the objective of this study was to examine the effects of land-use types and sampling depth on some selected soil properties within Oyo State College of Agriculture and Technology, Igboora, Nigeria.

2.0 Materials and methods

2.1 Location

The study was carried out at the Oyo State College of Agriculture and Technology, Igboora, Nigeria. The land-use types were used as a guide for the sampling locations. The coordinates of the different land-use types used for the experiment were taken with a Geographical Positioning System (GPS) and are shown in Table 1. The area has a two modes rainfall pattern with rain usually commencing in late March or early April and ending in late October or early November with a short break in August. Thus, the farmers in this area could plant their crops either in the early or late crop seasons. The mean annual rainfall is about 1,455mm with maximum rainfall in July and September, while means monthly temperature range between 27^0C and 30^0C.

2.2 Soil sampling

Two sampling depths have been selected for the following reasons: the soil depth (0-20cm) is the average cropland plough layer in the study area, and the soil depths (20--40cm) constitute the average depth to which nutrient and clay particles are leached in a high rainfall area, and fine roots of trees have a role in nutrient addition and recycling (Kassa *et al*., 2017). The samples collected were air-dried and passed through a 2mm sieve.

2.3 Land use description

The wood lot plot was established in 2014 without fertilizer application since establishment. The site is grown to *Tectona grandis* only since 2014. The pigeon pea (*Cajanus cajan*) plot was established in 2018. Cassava and maize had been grown on the site before now. Nursery plots had existed for about 5 years with different varieties of crop and tree plants. Also, there was no use of fertilizer on the site since it was established.
Similarly, the vegetable plot was established about 5 years. It is used mainly for the cultivation of dry season vegetables such as amaranthus and celosia. The cassava plot grown to cassava was established in 2014. This is where Cassava: Adding Value for Africa II (CAVA II) is used as a research plot.

2.4 Soil analysis

Soil pH (1:2) in water was determined by a glass electrode pH meter (IITA, 1982). Organic carbon was determined by the chromic acid oxidation method (Walkey and Black, 1934). Total N was by regular macro Kjeldahl procedure. Available P was by Bray -1 P method, and P content determined colorimetrically from a spectrophotometer using the ammonium molybdate method (Bray and Kurtz, 1945). Exchangeable potassium (K) was extracted using 1 N neutral ammonium acetate solution. Potassium in the extract was determined using a flame photometer. Particle size analysis was by the use of the hydrometer method (Bouyoucous, 1951). The percent of sand, silt, and clay of the soil were used to determine the textural class using USDA textural triangle.

2.5 Statistical analysis

All data collected were analyzed using Genstat discovery edition 4 statistical package and means separated using Least Significant Difference (LSD).

3.0 Results and Discusion

3.1 Impacts of land-use types on the particle size distribution

The particle size properties of the experimental land-use types are shown in Table 1. The sand proportion (92.1 %) of soils from the wood lot plot was more than that from other land uses. This value was significantly higher than all other land uses at a 5 % level of probability. In terms of silt fraction, soils from the cassava plot had the highest value of 7.10 %. Similarly, clay fraction (7.30 %) from soils in the cassava plot was higher than that from other land uses. All these values were significantly different at the 5 % level of probability. Thus, all the soils belonged to the sand textural class except the soils from the cassava plot, which was sandy loam according to USDA textural triangle. This result was supported by Karlen *et al*. (2003) who stated that land-use changes are capable of influencing the physical, chemical, and biological properties of soil. Senjobi and Ogunkunle, 2011 also confirmed that soil properties varied from one land-use type to another.

Table 1: Effects of land use types on the particle size distribution

S/N	Land Use	Coordinate	Sand (%)	Silt (%)	Clay (%)	Textural class
1.	Wood lot	(7.412272, 3.300341)	92.10	2.60	5.30	Sand
2.	Cajanus cajan plot	(7.411805, 3.297708)	90.60	4.60	4.80	Sand
3.	Nursery plot	(7.411290, 3.298667)	90.10	5.10	4.80	Sand
4.	Vegetable plot	(7.410771, 3.298374)	90.60	2.60	6.80	Sand
5.	Cassava Plot	(7.410712, 3.293495)	85.60	7.10	7.30	Loamy Sand
	LSD		0.60	0.48	0.30	

3.2 Impacts of sampling depth on the particle size distribution

The particle size distribution at different sampling depths is presented in Table 2. The results showed that the topsoil (0-20 cm) had the highest sand fraction (91.20 %). However, in terms of silt and clay, the sub-soil (20-40 cm) had the highest values of 5.6 % and 6.00 %, respectively. Thus, the result shows that the particle size distribution of sand decreased with the sampling depth. On the contrary, the silt and clay fractions increased with depth. This observation revealed that the soil particle size distribution significantly ($p<0.01$) changes with soil depth in all the land use types. A similar observation has been reported by Adugna and Abegaz (2015) in Northeast Ethiopia that particle size distribution varied with sampling depth. Kassa *et al*. (2017) also noted sub-soil to constitute the average depth to which nutrients and clay particles are leached in high rainfall areas.

Table 2: Effects of soil sampling depth on the particle size distribution

Soil depth (cm)	Sand (%)	Silt (%)	Clay (%)	Textural Class
0 – 20	91.20	3.20	5.60	Sand
20 – 40	88.40	5.60	6.00	Sand
LSD	0.38	0.30	0.19	

3.3 Impacts of land-use types and sampling depth on the particle size distribution

Table 3 shows the impact of land use and sampling depth on the particle size distribution. The topsoil from soils in the nursery plot had the highest sand fraction of 93.60 %, which was significantly ($p<0.01$) higher than all other land uses and sampling depth. The lowest value of sand fraction (82.60 %) was observed from the sub-soil of the soils in the cassava plot. On the other hand, the sub-soil of soils from the nursery and cassava plots gave the highest value of 8.60 % in terms of silt fraction while the topsoil of both soils from nursery and vegetable had the lowest silt fraction of 1.60 %. Similarly, the sub-soil of the cassava plot had the highest clay fraction of 8.80 %. It is noteworthy that except in soils from the wood lot and *Cajanus cajan* plot, sand fraction from all other land-use types decreased with depth. This result proves that it is essential to note that soil properties vary with depth as stated by Adugna and Abegaz, 2015 and Kassa*et al*., 2017.

On the contrary, silt fraction from other land-use types except wood lot and *C. cajan* increased with depth. The clay fraction of soils from the cassava plot also increased with depth. However, except in soils from the wood lot where clay fraction decreased with depth, all other land-use types did not show any significant difference with sampling depth. Particle size distribution changes with depth and land uses have been reported by Azeez *et al*. (2013); Adugna and Abegaz (2015).

Table 3: Impact of land-use types and soil depth on the particle size distribution

S/N	Land use	Soil depth (cm)	Sand (%)	Silt (%)	Clay (%)	Textural class.
1	Wood lot	0 – 20	91.60	2.60	5.80	Sand
		20 – 40	92.60	2.60	4.80	Sand
2	Cajanus cajan plot	0 – 20	90.60	4.60	4.80	Sand
		20 – 40	90.60	4.60	4.80	Sand
3	Nursery plot	0 – 20	93.60	1.60	4.80	Sand
		20 – 40	86.60	8.60	4.80	Loamy sand
4	Vegetable plot	0 – 20	91.60	1.60	6.80	Sand
		20 – 40	89.60	3.60	6.80	Loamy sand
5	Cassava Plot	0 – 20	88.60	5.60	5.80	Loamy sand
		20 – 40	82.60	8.60	8.80	Loamy sand
	LSD		0.85	0.68	0.43	

3.4 Impacts of land-use types on soil pH, organic carbon (OC), total nitrogen (TN), available P, and exchangeable K

The pH of soils from the nursery had the highest value of 7.61 while the lowest value of 6.22 was recorded in the cassava plot (Table 4). The values were significantly different at $p<0.05$. The lowest value of 6.22 pH value recorded in soils from cassava plot may be attributed to high fertilizer application compared to other land-use types. However, the values still fall within the optimum range for most crops in this region.

The results of OC of all the land use types (Table 4) showed that OC was highest in soils from the vegetable plot (1.23 %) while the lowest value of 0.45 % was observed from samples collected from the wood lot. This observation is in contrast with earlier reports of Azeez *et al*. (2013); Kassa *et al*. (2017). Furthermore, the topography of the experimental sites may also be another contributing factor to the high amount of OC observed in the vegetable plot since OC is known to be accumulated down the slope. It is equally important to note that the OC in the soils under investigation was low compared to the critical levels established by Agboola and Ayodele, 1985.

The distribution of TN amongst the various land use types is also presented in Table 4. The results showed that soils from nursery and vegetable plots had the highest value of 0.1 %, which is significantly higher than the values obtained in other land-use types. The highest value of TN recorded in all the land use types was below the established critical values

(Agboola and Ayodele, 1985; FMARD, 2012).

The available P of soils from vegetable soils had the highest value of 20.73 mg $kg^{-1,}$ which was significantly ($p<0.01$) higher than all other land use types (Table 4). The highest value of available P from vegetable plot has also been reported by Azeez *et al*. (2013). The lowest value of available P (8.91 mg kg^{-1}) was recorded in soils from wood lot. The P values in all the soils were comparatively adequate for this region.

The results in Table 4 showed that soils from the vegetable plots had the highest value of exchangeable K (0.36 cmol kg^{-1}) while the lowest value (0.11 cmol kg^{-1}) was recorded in soils from wood lot. These values were significantly different at $p < 0.01$. This observation may be attributed to the feeding pattern of the crops grown on these land-use types.

Table 4: Impacts of land use types on some chemical properties of the soil

S/N	Land use	pH	OC (%)	TN (%)	P(mg kg^{-1})	K (cmol kg^{-1})
1	Wood Lot	6.91	0.45	0.06	8.91	0.11
2	Cajanus cajan plot	6.88	0.85	0.07	19.48	0.27
3	Nursery plot	7.61	0.69	0.10	20.05	0.21
4	Vegetable plot	7.42	1.23	0.10	20.73	0.36
5	Cassava plot	6.22	0.63	0.06	17.18	0.25
		0.36	0.04	0.01	2.20	0.06
	LSD					

3.5 Impacts of sampling depth on soil pH, organic carbon (OC), total nitrogen (TN), available P, and exchangeable K

The pH of the soils decreased with the sampling depth, as reported in Table 5. This trend is following the findings of Azeez *et al*. (2013); Kassa *et al*. (2017). The OC distribution with the sampling depth also decreased with depth (Table 5). This observation may be attributed to the high accumulation of litters on the soil surface compared to the sub-soil. This confirms the earlier submission of Adugna and Abegaz (2015) that the surface layer is the most biologically active of the soil profile. The TN of the soils also decreased with sampling depth, just like in the case of pH and OC (Table 5). The variation in the distribution of TN was significantly affected by the sampling depth. The leaves that fall on the top layer of the soil may have accounted for the high TN value recorded in the topsoil (Kassa *et al*., 2017). Available P however, increased with sampling depth. This is contrary to an observation made by Azeez *et al*. (2013); Adugna and Abegaz (2015) who reported a decrease in depth in soils under different land use. Exchangeable K decreased with a depth of soil, and this is in line with the findings of Adugna and Abegaz (2015).

Table 5: Impacts of soil sampling depth on some soil chemical properties

Soil Depth (cm)	pH	OC (%)	TN (%)	P (mg kg^{-1})	K (cmol kg^{-1})
0 – 20	7.23	0.98	0.09	16.51	0.26
20 – 40	6.78	0.55	0.06	18.03	0.22
LSD	0.23	0.02	0.01	1.39	0.04

5.6 Impacts of land-use types and sampling depth on soil pH, organic carbon (OC), total nitrogen (TN), available P, and exchangeable K

The pH of all the soils from the five land-use types and sampling depth varied significantly ($p<0.01$) as given in Table 6. The highest pH value of 8.00 was recorded in the topsoils from nursery and vegetable plots while the lowest pH value of 6.20 was recorded in soils from the sub-soil of the cassava plot. Thus, the pH in all the land use types and sampling depth ranged from slightly acidic to slightly alkaline. Azeez *et al*. (2013) had reported a decrease in soil pH with sampling depth under different land uses. Moreover, the lowest value of pH observed in soils from cassava plot can be attributed to depletion in base-forming cations like $Ca2^{+}$, $Mg2^{+}$, and Na^{+} through a continuous nutrient uptake by plants as a result of repeated cultivation of the land as reported by Kassa *et al*. (2017).

The impact of land use and sampling depth on OC distribution as presented in Table 6 showed that the highest OC (1.45 %) was recorded in soils from the topsoil of the vegetable plot while the lowest value (0.21 %) was recorded in the sub-soil of the wood lot. These values were significantly different from all other land-use types and soil sampling depth. In all the land use types, the amount of OC decreased with depth. As reported earlier by Azeez *et al*. (2013); Adugna and Abegaz (2015); Kassa *et al*. (2017). This observation may be as a result of litter addition to the top layer of the soils under the different land-use types.

The amount of TN as influenced by the different land-use types and sampling depth is as shown in Table 6. Topsoils from the nursery had the highest value of 0.12 % while the lowest TN (0.04 %) was recorded in the sub-soil of the wood lot. It is important to note that the TN decreased with depth in all the land use types except that of the cassava plot. This may be attributed to exposure of the land under cassava plot to the effect of surface erosion and leaching due to continuous cropping as well as the use of heavy machines on the land. These findings are consistent with the findings of Adugna and Abegaz (2015).

The available P of the different land-use types showed that it decreased with depth in soils from the wood lot and vegetable plot (Table 6). On the other hand, the available P from the nursery and cassava plot increased with depth while that of the *C. cajan* plot showed there was no difference. However, the highest P-value of 27.04 mg kg^{-1} was recorded in the sub-soil of the nursery plot while the lowest P-value of 7.85 mg kg^{-1} was recorded in the sub-soil of the wood lot. The highest available P values in the sub-soil under different land-use types have been reported by Azeez *et al*. (2013); Kassa *et al*. (2017).

The exchangeable K decreased with depth in soils from the wood lot and vegetable plot while it increased with depth in

C. cajan and nursery plots. However, no difference was observed in the cassava plot (Table 6). The results also revealed that the highest K value of 0.49 cmol kg^{-1} was recorded in the topsoil of vegetables while the lowest value of 0.09 cmol kg^{-1} was recorded in the sub-soil of the wood lot.

Table 6: Impacts of land use types and soil sampling depth (cm) on some soil chemical properties

S/N	Land use	Soil depth (cm)	pH	OC (%)	TN (%)	P (mg kg^{-1})	K (cmol kg^{-1})
1	Wood lot	0 – 20	6.93	0.68	0.08	9.96	0.13
		20 – 40	6.89	0.21	0.04	7.85	0.09
2	Cajanus cajan plot	0 – 20	7.01	1.08	0.09	19.48	0.25
		20 – 40	6.75	0.62	0.05	19.48	0.28
3	Nursery plot	0 – 20	8.00	0.96	0.12	13.06	0.17
		20 – 40	7.22	0.41	0.07	27.04	0.24
4	Vegetable plot	0 – 20	8.00	1.45	0.11	23.36	0.49
		20 – 40	6.84	1.00	0.08	18.11	0.23
5	Cassava Plot	0 – 20	6.23	0.73	0.05	16.69	0.25
		20 – 40	6.20	0.52	0.07	17.67	0.25
	LSD		0.51	0.05	0.02	3.12	0.09

4.0 Conclusion

This study concludes that soil properties are affected by land-use types and sampling depth. The physical and chemical properties of soils are affected by both the land use types and soil sampling depth. The sand fraction of the investigated soils decreased with soil sampling depth, while silt and clay fractions increased with soil depth. The pH of the soils varied with soil use types. The pH, OC, TN, and K decreased with soil depth while P increased with depth in all the soils. Both the OC and TN are below the critical levels for this area. It is therefore recommended that agronomic practices that will boost the organic matter contents, as well as the nitrogen level of these soils, should be encouraged.

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