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EFEECT OF DIFFERENT LAND USE ON SELECTED SOIL PHYSICAL PROPERTIES

Osakwe,U.C.*[1],Quadri S. A[1]., Aladeokin, M . T[1]., Adeyoriju, w[1]. and Ilo, S[1].
*[1] Department of Soil Science and Land Resources Management., Federal University Oye-Ekiti,

Ekiti State, Nigeria.

*Corresponding author: E-mail address: uju.osakwe@fuoye.edu.ngor
ujucosakwe@yahoo.co.ukTel; 08033130292

ABSTRACT

Deforestation is one of the anthropogenic activities that potentially reduce soil quality. Hence, a study was carried out in Ikole-Ekiti, Southwestern Nigeria to evaluate the effect of conversion of secondary forest (SFR) to cashew plantation (CPL), oil palm plantation (OPP) and leucaena plantation (LPL), on selected soil physical properties. Soil samples were taken from 0 – 15 cm and 15 – 30 cm depth, and the soil parameters evaluated were; particle size distribution, bulk density (BD), total porosity (TP), macroaggregate stability and microaggregate stability indices. The OPP indicated lowest sand (724 g/kg), compared to other land use types, while the highest clay (177 g/kg), lowest BD (1.3 g/cm^3 and highest TP (52 %) registered in OPP were significantly higher than SFR but similar to values in CPL. Again OPP recorded significantly highest percent aggregate stability (65 %) and mean weight diameter (0.9mm) compared to other land uses. The microaggregate stability indices were controlled by the total content of the fine particles in them, hence may not be used to predict soil erodibility. There was increase in clay and reduction in sand with depth. In conclusion,OPP or CPL showed more superior capacity to enhance soil physical health compared to LPL and SFR land use.

***Key words*:**Land Use, Secondary Forest, Plantation Crops, Soil Physical Properties**.**

INTRODUCTION

The exposure of soils to weather influences, and clearing activities associated with deforestation adversely affect soil quality and health (Shafiqul *et al.*, 2020). The rate of forest degradation and deforestation in Nigeria has been rising in spite of the Nigerian government policies prohibiting indiscriminate deforestation practices, illegal logging is on the increase and the worst-hit region is the southwestern parts (Oluwajuwon *et al.*, 2021). The Southwest (SW) Nigeria, in the rainforest agroecological zones is one of the most biodiverse regions of Nigeria (Fasona *et al.*, 2020). From statistics, an average of 11% of Nigeria's primary forests is lost annually since 2000, which is about twice the rate of the 1990s, and about 5% from 2010 to 2015 (FAO 2016; FAO2005).

Onyekwelu *et al.*, (2008) reported soil structure degradation, nutrient deficiencies and soil compaction as some of the consequences when rainforest soils are exposed by deforestation.Mamo *et al.,* (2000**)** showed decline in soil properties from conversion of native forests to secondary forest while Keller *etal.,* (2004) observed subtle changes in soil structure as a result of logging.

Soil aggregate stability is a measure of soil structure (Six *et al.*, 2000) and therefore can be destroyed by anthropogenic activities such as deforestation. Aggregation affect soil capacity to store and stabilize carbon (Six *et al.,* 2004; Kodesova *et al.,*2008) as well as soil water storage capacity and distribution in landscape (Berhe and Kleber, 2013). Aggregate stability is critical for infiltration, root growth and resistance to water and wind erosion.

The mean weight diameter (MWD) is an index of macroaggregate stability which gives information on structural stability of soils, erosion, infiltration and aeration (Hillel, 1998). Routhipor *et al*., (2004) reported significant negative correlation of MWD and erodibility. In addition,Igwe and Ejiofor (2004) indicated that soils with low MWD have potential to erode faster than those of higher MWD adding that soils with high stability and MWD is able to resist the impact of rainfall. The removal of forest canopy and exposure of the soils to direct impact of rain fall is a great challenge for sustaining macro aggregate stability of rainforest soils in the present scenario of climate change.

Furthermore, microaggregates measure colloidal stability of soils. Colloidal stability is crucial for prediction of soil erosion and therefore an important component in soil conservation (Basga *et al.,* 2018). It is well known that deforestation, resulting to reduced canopy under unpredictable weather events makes the soil vulnerable to dispersion. Therefore, dispersion indices such as water dispersible clay, water dispersible silt, dispersion ratio and aggregating indices can be used in land management to predict soil erosion under different land uses for best recommendation.

Clay dispersion is related to physical, chemical and biological degradation and consequently affects productivity (Igwe, 2009;Nguetenkenkam and Dultz 2014). High WDC can lead to surface sealing, crusting and reduced infiltration which might increase surface runoff (Igwe, 2003).

Many research work has shown decline in MWD and micro stability indices with conversion of forests to other agricultural uses (Osakwe *et al.,* 2018). Other studies showed that conversion of forests to other land uses increased the bulk density, reduced porosity, and infiltration rates (Gülser *et al.*, 2021; Sun *et al.*,2015; Qi *et al.*, 2018).

Currently, most of the primary forests that possess high biodiversity and ecosystem sustainability are largely secondary forests and previous land use studies focused more on primary forests and rarely on the secondary forests which are more prevalent. Therefore, studies should shift to alternative land use cover to secondary forest that may improve and conserve soil qualityand as wellcushion the adverse effect of more intense exposure of land to weather influences.Tree crop cultivation such as cashew, oil palm and leucaena may be explored to meet such challenge.These crops are cash crops and has an added advantage of economic gain. Cashew is a tropical nut tree crop and grows well in poor, nutrient-deficient soils and does not need intensive labor for most part of the year except during the harvest seasonDendena *et al.*(2014). Itis a source of food, income industrial raw material and foreign exchange for countries in Africa Adeigba*et al.*,(2015) and there is a growing demand of the nuts all over the world (Sempore*et al.*, 2021). Improvement in soil physical parameters compared to adjacent forest land were recorded in older cashew plots indicating that little or no need for fertilization in replanting of older cashew plants (Oloyede*et al.*, 2019).

Also, Luecaenais a deep rooted nitrogen-fixing tropical tree crop, used as ruminant forage, green manure, fuelwood, and craft-wood (Brewbaker, 2004). The unripe pods and seeds serve as medicine and food for natives. It is used in land reclamation, erosion control, water conservation, reforestation and soil improvement programs (Duke,1983). Some researchers reported that improved soil physical properties such as infiltration rates, reduced dispersible clay and improved bulk density and total porosity compared to other land use types (Imogie*et al.*, 2008; Patrick2019). Some engineers have used it in slope bio engineering, the use of living plant materials for slope stabilization in soil erosion control.They reported that it played a major mechanical and hydrological role in stabilizing slopes and protecting against soil erosion (Normanizer*et al.*, 2008).

Oil palmis equally a multipurpose tropical tree crop. Their importance ranges from being a major source of oil in homes to several industrial uses and they contribute to national economy. The oil from the fleshy fruits are good source of vitamin A and carotenes.Oil palm showedsignificant improvement in soil properties compared to forest(Rusman *et al.*,2019) while Nadeesha *et* *al.* (2016) did not find any difference in soil physical properties comparedwith the forest.

We therefore hypothesize that conversion of secondary forest to cashew, oil palm and leucaena plantations will improve soil aggregate stability and some soil physical properties. The aim of this study is to quantify soil aggregate stability indices and some physical properties in a secondary forest, cashew, leucaena, and oil palm plantation of a sandy loam soil of south western Nigeria and compare the variations in the afore mentioned soil quality indices among the land use types relative to the secondary forest.

MATERIALS AND METHODS

Description of Study Site

The research was conducted at Ikole-Ekiti (Latitude: 7° 47’ 29” N. Longitude: 5° 30’ 31” E) in the rainforest zone of Ekiti State, southwest Nigeria. Itis characterized by binomial rainfall pattern with mean annual rainfall of 1600 mm and average annual temperature of 24.2 °C. The soils are derived from Basement complex of Southwestern Nigeria (Shittu, 2014).The topography is characterized by gentle undulating plain topography with an increasing sparse natural vegetation.

Land use history

The cashew, luecaena and oil palm plantations were established by Ekiti State Agricultural Program (ADP) in 1996 while the forest is a secondary forest.

Experimental Design

The experiment was a 4 x 2 factorial experiment replicated three times in Randomized Complete Block Design (RCBD). The numbers represent four land use types (cashew, leucaena , oil palm plantations and secondary forest) and two sampling depths (0 – 15 cm and 15 – 30cm).

Soil Sampling

A stratified random sampling method (Peterson and Calving, 1986) that involved dividing each land use area (27m by 27m) into three replicates from which soil samples were taken. Soil samples were collected randomly from 0-15 cm and 15 – 30 cm at 10 point in each replicate and made composite. A total number of 6 composite samples were collected at each land

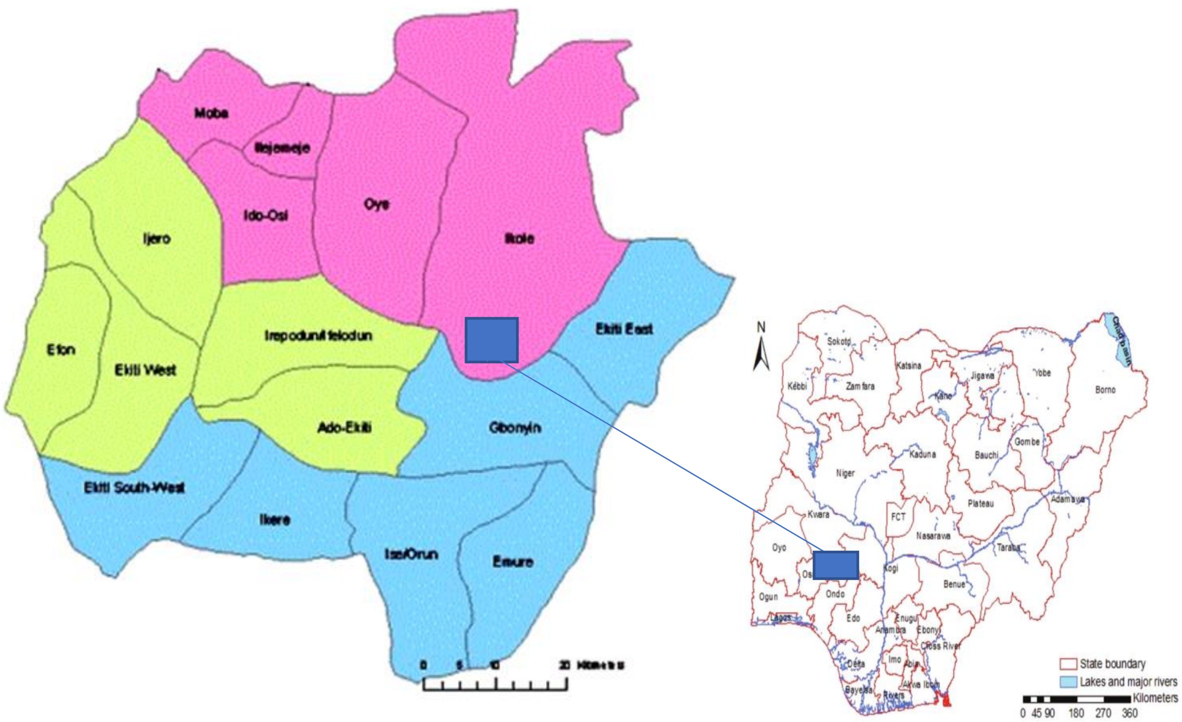

Fig. 1b: Map of Ekiti State showing study location (Ikole)   Figure 1a Map of Nigeria

use with a total of 24 composite samples. Core samplers were used to collect soil samples randomly in 5 places in each replicate across the two depth.A total of 120 core samples and 24 composite samples were collected in well labeled polythene bags for laboratory analysis.

The 24 samples were air dried and passed through a 2 mm sieve and < 2mm soil was used for required laboratory analysis.

Laboratory Analysis

Particle size distribution and microaggregate stability indices

Particle size distribution of less than 2mm fine soil fraction was measured by the Hydrometer method (Gee and Bauder, 1986). Measurement of microaggregate stability involved the determination of the amount of clay in calgon dispersed and water-dispersed samples using bouyoucos hydrometer method of particle size aalysis described by Gee and Bauder (1986). The micro stability indices were calculated as follows:

CDI = [% clay (water) / % clay (calgon)]

CFI = [% clay (calgon) - % clay (water)] / [% clay (calgon)].

WDC = % clay in water

WDS = % silt in water

ASC = [% clay + % silt (calgon)] – [% clay + % silt (water)]

DR = [% clay + % silt (water)]/ [% clay + % silt (calgon)]

Where, CDI, clay dispersion index,

CFI, Clay Flocculation Index, WDC, water dispersible clay, WDS, water dispersible clay, ASC, aggregated silt plus clay, DR, dispersion ratio

Macroaggregate stability indices

The distribution of water stable aggregate was estimated by the wet sieving technique described in detail by Kemper and Rosenau (1986). Air dried sample was sieved to obtain the aggregates by placing the 4mm sieve on 2mm sieve. The soil sample between the two sieves was used as the aggregates. To separate the water stable aggregate, three different sieves were used 2mm, 0.25mm and 0.053mm. 50 gm of>4mm dry aggregates was placed on the topmost sieve and presoaked pre-soaked for 5mins in water. The sieves and their contents were oscillated vertically, once per second, in the water 40times. Care was taken to ensure that the soil particles on the topmost sieve were always below the water. The resistant aggregates on each sieve were oven dried at 1050 for 24hr and weighed. The mass of <0.053mm was obtained by difference between the initial sample weight and the sum of sample weight collected on the 2, 0.25 and 0.053mm sieve nests.

The percentage ratio of aggregate in each sieve represented the water stable aggregate of sizes >2.00 mm, 2 -0.25mm, 0.25 - 0.053mm and <0.053mm and was computed as follows:

The sand correction was done by dispersing the water stable aggregate collected from each sieve with sodium hexameta phosphate (calgon). Thereafter, the mixture was allowed to stand for 24hrs and shaken with mechanical shaker. The suspension was then washed back through the 0.053mm sieve and rinsed with distilled water. The sand left on the sieve was oven dried and weighed.

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$$\%\text{Aggregate stability} = \frac{\text{wt. of WSA- wt. of sand}}{\text{Wt. of sample- wt. of sand}} \times 100$$

Where WSA= Water stable aggregates.

The mean weight diameter (MWD), another measure of stability was calculated using this formula

$$MWD = \sum_{i=I}^{n} W_i X_i$$

Where Wi= weight of aggregate in the ith aggregate size range as fraction of dry weight of sample.

Xi= Mean diameter of any particular size range of aggregates separated by sieving

Bulk density and total porosity

Bulk density (BD) was measured by the core method, as described by Blake and Hartge (1986). Core samplers were used to collect soil samples and oven dried for 24 hours at 105°C. Fresh and oven dried weight was taken and was used to calculate bulk density, porosity and moisture content.

Calculations

$$(BD) = \frac{\text{oven dry mass of soil (g)}}{\text{volume of soil (cm}^3\text{)}}$$

Total porosity is the percentage of bulk volume not occupied by solids was calculated from bulk density (Bd) value assuming a particle density (Pd) of 2.65 g cm^{-3}.

Calculations

$$(Pt) = 1 - \frac{Bd}{Pd} \times 100$$

2.6 Statistical Analysis

The data generated was subjected to analyses of variance following the procedure outline for experimental design using GENSTAT Release 7.2 DE statistical software.

Treatment means were separated using Fishers least significant different at 5% probability level.

RESULTS AND DISCUSSIONS

Land use effect on soil physical properties

Effect of Different Land Use on Particle Size Distribution

The result of the particle size distribution and texture is shown in Table 1. The texture remained sandy loam in all land use. This is expected because texture is an intrinsic characteristics of the soil and may not change easily by management. This is in agreement with the report of other researchers Obi (2000). The particle size distribution showed that all plantations indicated higher clay compared to SFR (102 g/kg)with the highest contribution in OPP (177g/kg). Reduction in sand compared to SFR was only shown in OPP (729 g/kg) while silt in OPP was similar to the SFR. Reduction in sand with increase in fine particles implies enhancement of soil physical properties. Higher clay may induce aggregation and improve water and nutrient holding capacity.

Table 1: Effect of Land Use on Soil Particle Sizes and Texture.

Parameter	Sand	Silt	clay	Texture
Land use		g kg^{-3}		
CPL	760	66	173	SL
SFR	797	101	102	SL
LPL	791	60	150	SL
OPP	727	96	177	SL
LSD	24.0	29	26	

CPL - Cashew Plantation, SFR - Secondary Forest, LPL - Luecaena Plantation, OPP - Oil Palm Plantation

Effect of Different Land Use onSoil Bulk Density and Total Porosity

The result on the effect of land use on soil bulk density (BD) and total porosity (TP) is shown in Figure 2 and 3 respectively. Relative to the SFR, OPP depicted the best reduction in bulk density and increase in TP while CPL was not different from the SFR. Contrary to other plantations, the bulk density in luecaena increased by 11% compared to the SFR which is above the critical limits of BD that can restrict root growth according to Morris and Lowery Table of critical limits of bulk density for different soil textures. Accordingly, there was a corresponding decline in TP in LCP.The increase in BD and decline in TP may be attributed to grazing of cattle in the LCP which resulted to soil compaction. Tate *et al.*,(2004) reported about 40% increase in BD in grazing sites compared to un-grazed area. Increase in BD affect porosity, water redistribution in the profile, infiltration and nutrient availability among other soil processes (Ogbodo and Chukwu, 2012; Nwite *et al.*, 2016).

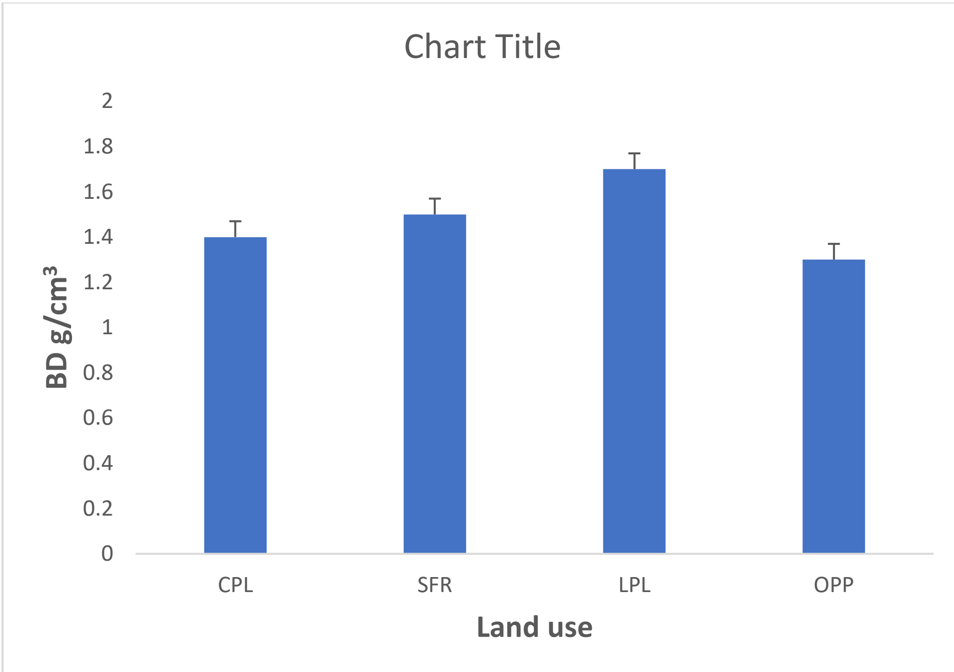

Fig. 2: The effect of land use on soil bulk density (BD)

CPL - Cashew Plantation, SFR - Secondary forest, LPL - Leucaena Plantation, OPP - Oil Palm Plantation

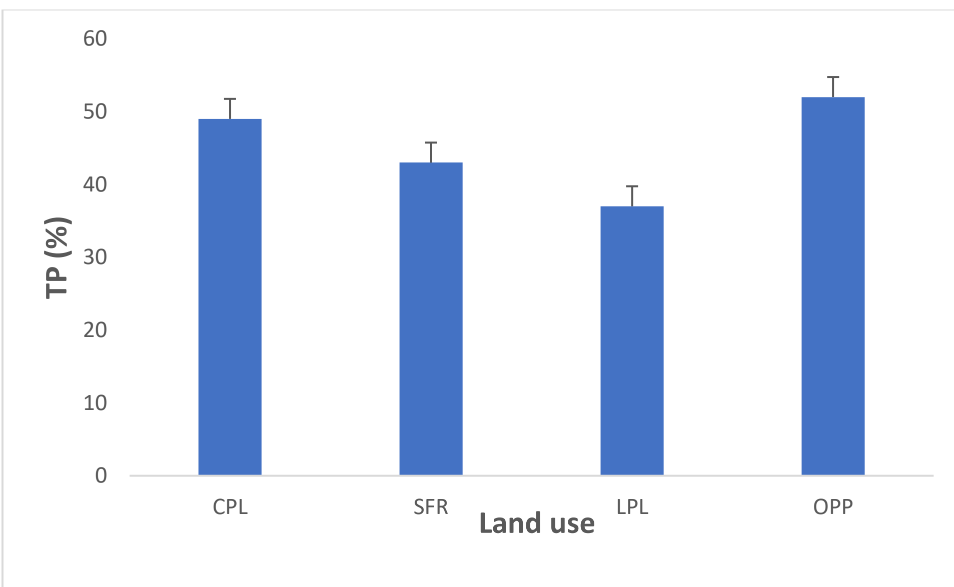

Figure 3: The effect of land use on soil total porosity (TP)

CPL - Cashew Plantation, SFR - Secondary Forest, LPL - Leucaena Plantation, OPP - Oil Palm Plantation

The Effect of Depth on Soil Physical Properties

The effect of depth on soil particle sizes, bulk density and porosity are shown in Table 2. There was significant increase and significant reduction in clay and sand with depth respectively.The higher clay at 15 – 30 cm might be due to clay eluviation. The two factors that predisposes the soil to clay eluviation among others are abundance of water and soil porosity. It is important to note that transportation of clay to lower depths may improve aggregation and consequently promote sequestration of soil organic carbon. Stabilization at this lower depth may be crucial for climate change mitigation. Nevertheless, climate-smart land management should consider the balance between SOC stabilization in top soils for productivity versus sequestration in lower depths for climate mitigation Tores *et al.*,(2017). Lowersand with depth may be expected because of lower exposure to erosion. Hence, the need for adequate soil cover to prevent or reduce soil erosion.

Furthermore, depth had no significant effect on the BD and TP probably because the two depths are within the top soil.

Ta**ble 1:The Effect of Depth on Soil Particle Sizes, Bulk Density and Porosity.**

Parameter DEPTH	Sand	Silt g/kg	Clay	BD g/cm^3	Porosity %
0-15cm	787	75	138	1.4	46
15-30cm	751	84	163	1.5	44
LSD(0.05)	17.0	NS	18.2	NS	NS

BD - Bulk density

The Interaction Effect of Depth and Land Use on Soil Physical Properties

The interaction effect of depth and land use on soil physical properties is shown in Table 3. The result still followed the trend of lowest clay in SFR (75 g/kg) at 0 -15 cm which may suggest exposure of top soil to erosive force of rain fall due to removal of the primary forest canopy. Highest contribution to clay content (203 g/kg) was shown at the 15 – 30 cm depth in the CPL but was not different from clay in the OPP at both depths. The increase in clay content with depth is an indication that management practice should maintain adequate topsoil cover to avoid downward loss of colloidal particles as already discussed above. No significant effect of the interaction of land use and depth was observed in the silt content. Lowest sand was revealed in OPP at both depths, similar to CPL at the 15 – 30 cm depth. It was noted that the highest sand was at 0 – 15 cmdepth in the SFR similar to LPL. Reduction in sand and increase in clay inferred improvement in soil physical condition in a coarse textured soil.

Table 2: The Interaction Effect of Depth And Land Use On Soil Physical Properties

Depth	Parameter Land use	Sand	Silt g/kg	Clay	Texture	BD g/cm^3	Porosity %
0-15	CPL	797	59	143	SL	1.4	49
	SFR	824	101	75	LS	1.5	45
	LPL	804	46	150	SL	1.6	40
	OPP	724	93	183	SL	1.3	52
15-30	CPL	724	73	203	SCL	1.3	49
	SFR	770	101	128	SL	1.6	41
	LPL	777	73	150	SL	1.8	34
	OPP	730	100	170	SL	1.2	53
LSD(0.05)		34	NS	36		0.20	7.54

SCL - Sandy clay loam, SL -Sandy loam, LS - Loamy sand

CPL - Cashew Plantation, SFR - Secondary forest, LPL Leucaena Plantation, OPP, Oil Palm Plantation

The lowest BD and highest TP were depicted in OPP at both depths which were similar to CPL at 0 -15 and 15 – 30 cm depths. There was significant increase in BD (1.8 g/cm^3) and decline in TP (34 %) at 15 – 30 cm depth in the LPL. There was physical degradation of soil physical condition in LPL shown by increments in soil BD and decline in soil TP. This condition will reduce root growth and proliferation, reduce water infiltration and promote increase in soil erosion and runoff(Echavaria *et al.,* 2007).The entire results showed that OPP and CPL were more superior land use with respect to enhancing soil physical properties relative to the SFR, while LPL degraded the physical properties or was neutral in improving soil properties. Probably the cattle grazing caused soil compaction and affected the physical properties of the soil as noted earlier.

Land Use Effect on Aggregate Stability Indices

The Effect of Land Use on Microaggregate Stability Indices

The effect of land use on microaggregate stability indices is shown in Table 4. There was no significant effect of land use on CDI, CFI and DR. The WDC and WDS were controlled by their total contents in the land use types (Table 1). Hence SFR with the lowest clay and highest silt registered lowest WDC and highest WDS. It seems this was the reason for the non-significant difference observed in the CDI, CFI and DR. The result agreed with the findings of other workers that clay dispersion in water is dependent on the total clay content in each location. and the percentage of clay dispersed was controlled by such factors as clay mineralogy, calcium carbonate and organic matter content of the soil (Colchin *et al.*, 1985; Osakwe, 2014).

Table 4: TheEffect of Land Use on Micro Aggregate Stability Indices

Parameters Land Use	CDI	ASC g/kg	CFI	DR	WDC g/kg	WDS g/kg
CPL	0.30	163	0.69	0.32	50.4	26.2
SFR	0.25	117	0.74	0.41	24.9	60.5
LPL	0.34	122	0.65	0.42	50.4	36.7
OPP	0.28	172	0.71	0.36	50.4	50.0
LSD(0.05)	NS	26.0	NS	NS	5.00	22.4

Where, CDI - Clay Dispersible Index ASC, Aggregate Silt plus Clay, CFI - Clay Flocculation Index, DR -Dispersion Ratio, WDC - Water Dispersible Clay. WDS, Water Dispersible Silt
CPL, Cashew Plantation, SFR - Secondary forest, LPL - Leucaena Plantation, OPP - Oil Palm Plantation

These results imply that the microaggregate stability indices might not be used to predict soil erodibility in this location. Clay mineralogy may affect the behavior of clay minerals in water. However, OPP and CPL indicated significantly higher ASC compared to the SFR while the LPL was similar to the SFR. Fine materials are important since they promote accumulation of organic matter via aggregation. Guggenberge *et al., (*1999) reported that low silt plus clay content may limit capacity for physical protection of POM-C.

Effect of Land Use on Percentage Aggregate Stability and Mean Weight Diameter

Effect of land use on percent aggregate stability(AS) is shown in Figure4OPP and CPL showed significant improvement in AS compared to SFR but with higher contribution in OPP. In addition, LPL, had similar AS implying no improvement. The same trend was observed in the MWD (Figure5). The results partially supported the hypothesis that tree crops will enhance soil quality compared to SFR because leucaena had neutral or negative effect on soil properties compared to the SFR attributed to cattle grazing in the plantation. Overgrazing increases the BD, destroys the macropores, consequently affecting the macro aggregates. However, to make a rationale conclusion on Luecaena as a replacement tree crop, reducing grazing activities will be considered.

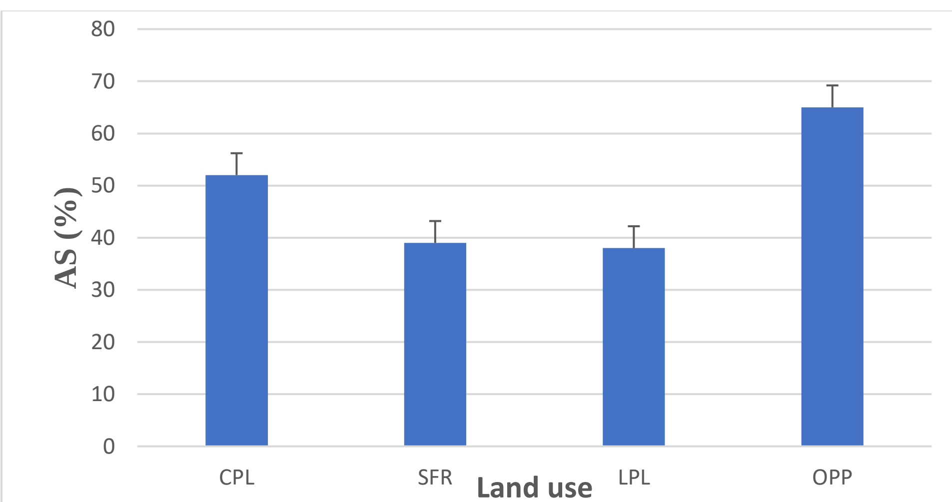

Fig.4: The Effect of Land Use on Percentage Aggregate Stability (AS)

CPL - Cashew Plantation, SFR - Secondary Forest, LPL - Leucaena plantation, OPP - Oil Palm Plantation

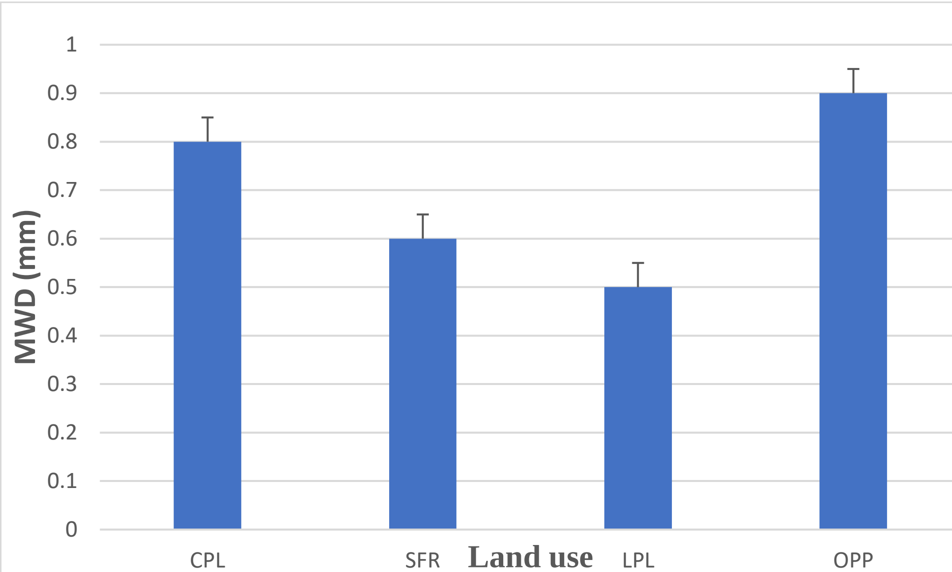

Fig. 5: The Effect of Land Use on Mean Weight Diameter (MWD)

CPL - Cashew plantation, SFR - Secondary Forest, LPL - Leucaena plantation, OPP - Oil Palm Plantation

The Effect of Depth on Aggregate Stability Indices

The effect of depth on microaggregate stability and macroaggregate stability was not significant except for about 14 % higher ASC at 15 – 30 cm depth compared to 0 – 15 cm depth (Table 5). Clay is a major aggregating agent, hence, increase in its content with depth may promote aggregation (Table 3). Other authors explained the mechanisms of aggregation and showed that clay is a crucial for aggregation and stability of soils (Hillel, 1998; Brady and Weil, 2008)

Table 5: The Effect of Depth on Aggregate Stability Indices

Parameters Depth	CDI	ASC (g/kg)	CFI	DR	WDC (g/kg)	WDS (g/kg)	AS (%)	MWD (mm)
0 – 15cm	0.32	133	0.68	0.37	43.2	36.6	49	0.7
15-30cm	0.28	154	0.72	0.38	44.8	50.1	48	0.7
LSD(0.05)	NS	18.3	NS	NS	NS	NS	NS	NS

Where, CDI - Clay Dispersible Index ASC, Aggregate Silt plus Clay, CFI - Clay Flocculation Index, DR - Dispersion Ratio, WDC - Water Dispersible Clay. WDS, Water Dispersible Silt

The Interaction of Depth and Land Use on Aggregate Stability Indices

The result of the interaction of depth and land use on microaggregate indices is presented in Table 6. No significant effect of land use was observed in all the microaggregate stability indices evaluated relative to the SFR at both depths except significant increase in ASC recorded in CPL and OPP at both depths. The lowest ASC recorded at 0 -15 cm in LPL was at par with the SFR at both depths and LPL at 15 – 30 cm depth. The reduction in ASC in LPL reiterates that grazing adversely affected the aggregation of soil fine particles and consequently may affect other soil processes. At the macroaggregate scale, OPP showed best significant enhancement in the percentage AS at both depths while CPL minimally improved the AS also but only at 15 – 30 cm depth. Also, LPL recorded similar percent AS relative to the SFR. On the contrary, there was no significant contribution by LPL to AS. compared to the SFR. It is possible that soil compaction as a result of trampling effect of grazing animals in the LPL, increased the bulk density and porosity (Figure 1 and 2), and consequently affected macro aggregation. Lower stability implies loss of macro aggregates which influence porosity, infiltration and root development.

Furthermore, the MWD(1.0 mm) was only enhanced in OPP at the 0 -15 cm depthcompared to the values in the SFRat both depths. Also, the lowest MWD (0.50 mm) registered in LPL at both depths were at par with MWD recorded in SFR at both depths.Soils with lower MWD will be more easily detached by erosive forces while aggregates with higher MWD will display greater resistance to disruptive impact of raindrop.

Table 6: The Interaction Effect of Depth and Land Use on Aggregate Stability Indices

Parameters Depth	LAND USE	CDI	ASC g/kg	CFI	DR	WDC g/kg	WDS g/kg	AS %	MWD Mm
0-15cm	CPL	0.35	133	0.64	0.34	50.4	19.3	49	0.8
	SFR	0.29	114	0.70	0.35	21.6	40.5	41	0.7
	LPL	0.34	106	0.65	0.46	50.4	40.0	37	0.5
	OPP	0.27	179	0.72	0.35	50.4	46.7	70	1.0
15-30cm	CPL	0.25	193	0.74	0.30	50.4	33.3	55	0.8
	SFR	0.22	121	0.78	0.47	28.2	80.5	37	0.6
	LPL	0.33	139	0.66	0.38	50.4	33.3	39	0.5
	OPP	0.30	166	0.69	0.38	50.4	53.3	60	0.8
	LSD(0.05)	NS	37	NS	NS	NS	NS	12	0.2

Where, CDI - Clay Dispersible Index ASC, Aggregate Silt plus Clay, CFI - Clay Flocculation Index, DR - Dispersion Ratio, WDC - Water Dispersible Clay. WDS, Water Dispersible Silt CPL - Cashew Plantation, SFR - Secondary Forest, LPL - Leucaena Plantation, OPP - Oil Palm Plantation

CPL, Cashew plantation, SFR, Secondary forest, LPL, Leucaena plantation, OPP, oil palm plantation

Summary and Conclusion

Replacement of secondary forest with tree plantation crops showed quantitative evidence of improvement with respect to soil aggregate stability and some physical properties but in some of the plantation crops.

The soil under the oil palm plantation indicated the highest mean weight diameter, percent aggregate stability, aggregated silt plus clay, porosity, lowest bulk density and sand relative to the secondary forest, followed by the soils under cashew plantation. On the contrary there was no significant improvement in the Leucaena plantation attributed to grazing activities which possibly affected the physical health of the soil.

Notably, clay dispersion index, clay flocculation index, dispersion ratio, water dispersible clay and water dispersible silt were not affected by secondary forest conversion to the three plantation land use types but rather was controlled by the total contents of clay and silt in them. Also, the higher amount of clay and aggregated silt plus clay in 15 – 30 cm depth compared to 0 – 15 cm depth was attributed to the process of clay eluviation and illuviation.

Our research partially fulfilled the hypothesis that replacing secondary forest with plantation crops would enhance soil aggregate stability and soil physical properties in the studylocation. It was true for oil palm and cashew plantation but not for Leucaena. Therefore, there would be need for validation before such decision is taken. In addition, good management of these plantations may further boost the soil quality for climate change mitigation, increase tree crop production, and with the added benefit of food security and financial gain for the farmers

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