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ASSESSMENT OF SOIL CARBON AND TOTAL NITROGEN UNDER SHORT TERM AGRICULTURAL MANAGEMENT PRACTICES IN AN ALFISOL OF GUINEA SAVANNAH

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Abstract

Field experiments were conducted in the two consecutive rainy seasons of the year 2015 and 2016 at the Agronomy Research Farm, North core of the University of Agriculture Makurdi, in the Southern Guinea Savannah Zone of Nigeria. The soils are generally coarse textured and are well drained to moderately well drained. The experiment consisted of five management practices, which served as the treatments: Bare plot, Soybean, Maize, Mucuna and Grass Fallow. The experiment was laid out in randomized complete block design and replicated four times. The treatments generally increased total organic carbon content (27.02 and 27.78g/kg), particulate organic carbon (POC) (14.39 and 18.63g/kg), soil organic matter (44.83 and 47.76g/kg), and carbon stock (2663 and 2191kg/ha) compared with the bare fallow (20.13 and 13.32g/kg). There were highly significant differences at both depth and years except for POC at the second depth (18.63g/kg) in the first year. Total nitrogen was not significant in the first year but was significant in the second year at 0-10cm soil layer. The particulate organic nitrogen (PON) was significantly affected by the management practices in the first year at both soil depths while in the second year PON was significantly different at soil both depths. The carbon to nitrogen ratio was significantly different in both years and depth except at the depth 10-20cm of the first year. Humic acid was not significantly different among the treatments in both depths and years. The management practices possibly influenced the changes observed in both carbon and nitrogen in the short term. Thus, Mucuna and Grass Fallow may be recommended as best practices in this area.

Key Words: Alfisol, humic acid, organic carbon, nitrogen, soil management.

Introduction

Soils provide essential ecosystem services (Wall *et al*., 2012), many of which are related to the content of soil organic carbon (Schmidt *et al*., 2011). Soil organic carbon (SOC) is the most often reported attribute and is chosen as the most important indicator of soil quality and agricultural sustainability. The soil carbon cycle has been greatly affected by human activity either through direct farming or indirectly through anthropogenic climate change (Amundson *et al*., 2015). Soil is a vital natural resource that is non-renewable on the human time scale (Jenny, 1980) and is a living, dynamic, natural body that plays many key roles in terrestrial ecosystems. The maintenance of soil health is essential for sustained productivity of food, the decomposition of wastes, storage of heat, sequestration of carbon, and the exchange of gases. However, only a limited area of the soil can actually be used for growing food, and when improperly managed it can be eroded, polluted or even destroyed (Brady and Weil, 2000).

Today, the agricultural soil is facing many challenges, due to loss of natural ecosystems, degradation of soils and pollution due to population growth, and increasing demand for food (Lal, 2007). Continuous exploitation of soil in order to feed the teaming population has caused the biological environment of the soil, to deteriorate and degrade its properties (Chen *et al*., 2020) and rendered most land in the tropic marginal. According to Olowokere and Akinbinu (2021), tropical soils are highly weathered and of low activity clay, low in nitrogen and organic matter. The continuous use of conventional tillage without conservation practice disrupts soil structure and increase the rate of SOC decomposition and decline in organic matter content of soil. The decline in soil organic matter is the main processes causing soil degradation (Kostov, 2016). This has subjected the land to low productivity and reduced economic return (Peter *et al*., 2018). The sustainability of agriculture is under threat from accelerated soil erosion, which have highly modified its forms (Lorenz and Lal, 2018), resulting in poor nutrient availability. The case is also worsened in this tropical area, due to the fact that most farmers rely much on the mineral and organic properties of soils to sustain crop production.

Sustainable agricultural production requires increasing net primary productivity per unit input to maintain the ecosystem services (Brussaard *et al*., 2007). Finding ways to increase organic matter content is highly desirable to increase agricultural productivity and sustainability (Lal, 2004). This can be realized through management practices that will maintain and enhance the soil carbon pool and its biodiversity (Lal, 2009). Soil organic matter is one of the largest stores of soil carbon and nitrogen of any ecosystems that plays a vital role in the availability of nutrients for plants (Marzi *et al*., 2020). Soil carbon (C) and soil nitrogen (N) are the two primary elements influencing soil fertility, and regulating plant growth (Cui *et al*., 2020).

Also SOC and total soil nitrogen are important components for agricultural production (Xue and An, 2018). Soil organic matter (SOM) is a heterogeneous and dynamic substance that varies in C and N content (Tong *et al*. 2014). Soil organic carbon and total nitrogen in the soil are closely associated with a wide range of physical, chemical, and biological properties of soil and thus, they play an important role in soil processes and functioning and they are used as significant indicators of soil quality (de Moraes Sá *et al*., 2018). Soil organic carbon is the basis of soil fertility. It releases nutrients for plant growth, promotes the structural, biological, and physical health of the soil, and is a buffer against harmful substrates (Wang *et al*., 2021). Nitrogen is generally the most common growth-limiting nutrient in ecosystems (Garousi *et al*., 2021). In scientific studies, SOM is quantified through C and N forms with an emphasis on labile forms because they respond more sensitively to the changes in SOM mainly due to the response to agricultural management changes (Bendi *et al*., 2015).

The balance between inputs and losses of nutrients and carbon mainly contributes to the stability of soil systems (Amundson *et al*., 2015). The greater the C levels in soil the better the soil aggregation, moisture retention, and potential for crop production. Concentrations of organic C and N are good indicators of soil quality and productivity (Doran and Parkin, 1994). Their concentrations in the soil can be influenced by management practices, such as tillage, cover cropping and land use type (Hubbard *et al*., 2013). As global population continues to increase and land under cultivation is exhausted, more attention must be given to how to manage marginal agricultural land for improved productivity and sustainability. Therefore, crop management practices that will significantly increase SOC stocks, and reduced carbon dioxide emissions to the atmosphere should be encouraged. Information is required on management practices that contribute to maintaining or increasing SOC in the soil that will enhance soil productivity. Agricultural land and the continuous use of conventional tillage disrupt soil structure and increase the rate of SOC decomposition due to exposure. Improving agronomic and ecological benefits of greater SOC storage requires more information on management practices that increase C inputs and mitigate the loss of accrued benefits. There is a dearth of information on agricultural management practices (such as crop rotation and tillage practices) information on field trials that allows monitoring changes in soil properties under various types of treatment over time is scarce.

Therefore, objective of this study was to access changes in soil organic carbon and nitrogen, under the different crop management practices for the two cropping seasons in Makurdi, North Central Nigeria.

Materials and Methods

Experimental Sites

The experiment was carried out at the Agronomy Research Farm, (North core) of the University of Agriculture Makurdi, in the Southern Guinea Savanna Zone of Nigeria located on longitude 07° 47.699 N and latitude 008° 36.947 on an elevation of 102 m. The study area is a warm tropical climate, characterized by wet and dry seasons. Temperatures are high throughout the year with the mean annual maximum temperature ranging from 22 to 32°C. The relative humidity average ranges from 60 to 80% being lowest in the dry season months of December to February and highest during the rainy season months of June to September. The wet season commences from late April and ends in October with mean annual rainfall of about 1,137mm. The duration of rainfall is normally between 200 and 300 days (Idoga *et al*., 2005). A rainfall pattern of this characteristic indicates a fairly heavy rainfall, which can increase the rate of erosion potential in the area with less vegetation cover. The soils are underlain by sand-stone and normally moderately deep with a few of them being shallow. The soils are generally coarse textured and are well drained to moderately well drained (Fagbami and Akamigbo, 1986). The vegetation consists mainly of trees, shrubs and grasses that cover and protect the soil surface from effects of rainfall.

Treatments and Crop Husbandry

The experiment consisted of five soil management practices: Bare plot, Soybean, Maize, Mucuna and Grass Fallow. The experiment was laid out in randomized complete block design and replicated four times. The experimental plots were marked out after land clearing. Each treatment plot had an area of 12m^2 (4m ×3m) with total area of the experimental site of about 330m^2. The land was tilled using manual hoe, except for the untilled grass plots. The bare plot was tilled, pulverized and plant roots were removed.

Soil Sampling and Analysis

Soil samples for routine analysis before the experiment were collected from the upper surface soil layer (0-15cm) and sub-surface soil layer (15-30 cm) using soil auger. Two samples were collected from every plot and bulk together to have one composite sample before and at the end of each year. The sample was ground and sieved using 2mm sieve before analysis. Core samples before land preparation and at the end of each year, were also taken from the plots for determination of bulk density, porosity and chemical properties. Soil samples were also collected at two depth (0-10 cm) and (10- 20 cm) layers of the soil, per plot from each of the four replications using soil auger for determination of particulate organic carbon, and particulate organic nitrogen. Also, disturbed soil samples were collected at the same depths for organic carbon, nitrogen and other chemical properties. The sampling was carried out at the end of each season. The samples were air dried in the laboratory and processed before analysis.

Particulate Organic Carbon and Nitrogen Determination

The physical fractionating method of soil aggregate-size fractions (wet sieving) for particulate organic carbon, which has been an effective technique for evaluating soil aggregation and degradation induced by management practices (Six *et al*., 2002) was considered.

Organic Carbon Stock

The contents of SOC and its fractions were transformed into values of stocks using the following equation as reported by (Ussiri *et al*. (2006) as:

C pool (Mg ha^{-1}) = %C/100 × bulk density (Mg m^{-3}) × hectare area (m^2) × soil depth (m).

Organic carbon (kg/ha) = ($C/100 \times BD \times d \times 10^4 ha^{-1}$)

Where, C is concentration of organic carbon (g kg^{-1}), *BD* is bulk density (Mg m^{-3}) and *d* is sampling depth.

Soil Carbon Analysis

Analyses of total carbon and total particulate organic carbon fractions in aggregate size classes were determined in duplicates by the wet oxidation method of Nelson and Sommers (1982).

Total Nitrogen

Total N and particulate organic nitrogen were estimated by the Kjedahl digestion and distillation method as described by Kjeldahl digestion (Nelson and Sommers, 1982).

Determination of Humic Acid Concentration

The determination of humic acid (HA) concentration was by alkaline extractions method as described by Schnitzer (1986).

Data Analysis

Data collected were subjected to analysis of variance and differences among means were evaluated by the least significant difference LSD test. All statistical analyses were performed using GENSTAT (2014) statistical package software.

Results

The effects of management practices on carbon constituents (total organic carbon (TOC), particulate organic carbon (POC), organic matter, inorganic carbon and carbon stock are presented in table 1. The management practices significantly (p<0.005) affected total carbon concentrations in soil at depths of 0–10 cm and 10–20 cm in both 2015 and 2016 cropping seasons. The total carbon in the soil depth 0 – 10cm increased from (11.70 and 7.78g/kg) in bare fallow to (27.02 and 27.78g/kg) in grass plot, with mean value (21.06 and 21.68g/kg) in 2015 and 2016. The mean values for each treatment, showed increase in the second year except, for bare fallow and maize treatments (7.78 and 23.03g/kg). At the soil depth of 10 – 20cm, the same trend was observed with lowest TOC also in the bare fallow (13.40 and 5.55g/kg) and highest in the grass fallow (19.30 and 18.91g/kg). In the 10–20cm soil layer, TOC concentrations was significantly lower compared to the 0–10cm layer, with values in the order: grass fallow > mucuna > soybeans > maize > bare fallow in 2015, while in 2016, the values were in the order: grass fallow > soybeans > mucuna> maize > bare fallow, respectively. The soil organic matter content followed the same trend as in the total carbon. Total soil organic matter concentrations in the 0–10cm soil layer differed significantly (p<0.005) among treatments and followed the order: grass fallow > mucuna > maize> soybeans > bare fallow in 2015 while in 2016, the values were in the order: grass fallow > mucuna > soybeans > maize > bare fallow respectively. The addition of leaf litters and roots significantly increased TOC concentrations in the two depths in the cropped treatments compared to the bare fallow treatment. The particulates organic carbon pools comprised a larger proportion of the total organic carbon pool. The POC concentrations in the 0–10 cm soil layer also differed significantly

(p<0.005) among the management practices. The mean ranged from lowest (8.66 and 5.50g/kg) in bare fallow to highest (14.39 and 18.63g/kg) in grass fallow treatment in both years. The mean value of POC for the two years were (12.12 and 13.90g/kg), respectively. The POC generally increased in the second year in all the treatments except for bare fallow. The decrease is in the order: grass fallow > mucuna > soybeans > maize > bare fallow in both 2015 and 2016 respective

Table 1: Effect of Management Practices on Total Organic Carbon, Particulate Organic Carbon, Organic Matter, Inorganic carbon and Carbon Stock in 2015 and 2016

Treatment	Depth cm	TOC (g/kg)		OM g/kg)		POC g/kg)		IOC g/kg)		C Stock kg/ha	
	cm	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
BF	0 – 10	11.70	7.78	20.13	13.32	8.66	5.50	3.05	2.28	1497	1067
SB		18.10	24.00	34.20	41.27	13.25	14.38	6.70	9.63	2146	3306
MZ		23.40	23.03	40.22	39.60	12.95	13.27	10.43	9.75	2615	3102
MN		25.60	25.80	44.02	44.62	13.87	17.72	11.67	7.75	1974	3818
GF		27.02	27.78	44.83	47.76	14.39	18.63	11.61	8.32	3075	3739
CV		15.1	3.2	11.8	3.0	18.5	6.5	42.7	13.4	18.1	4.9
LSD		0.5037**	0.1082**	0.6791**	0.1770**	0.3659*	0.1397**	0.5847*	1.573**	768.9*	278.0**
BF	10 – 20	13.40	5.55	23.00	9.52	5.52	3.38	9.51	2.17	1802	700.0
SB		19.20	18.67	33.00	32.12	11.12	8.40	7.05	10.22	2642	2681
MZ		18.53	17.95	31.88	30.87	7.27	9.20	10.25	8.75	2359	2617
MN		21.23	15.42	36.48	26.52	7.30	8.18	14.65	7.25	3002	2255
GF		19.30	18.91	33.19	32.70	6.96	12.52	10.20	8.69	3509	2703
CV		10.3	6.3	10.3	6.1	31.8	21.9	25.6	18.1	11.2	10.7
LSD		0.298**	0.1505**	0.5133**	0.2491**	NS	0.2835**	0.4164*	0.2094**	561.4**	441.2**

BF=Bare fallow; SB= Soybean; MZ= maize; MN= Mucuna; GF=Grass fallow; **= $P \leq 0.01$;*=$P \leq 0.05$ ns=not significant, TOC = Total organic carbon, POC = Particulate organic carbon, OM = organic matter, IOC = inorganic carbon, C Stock = carbon stock

In the 10–20cm soil depth, POC concentrations were significantly lower in the 0–10 cm layer, with mean values of (7.64 and 8.33g/kg) in both years. The POC increased in the second year in all the management practices except for bare fallow which showed a decreased. The POC contributed the greatest amount to total TOC in the 0 – 10 cm depth compared to 10 – 20cm depth with more concentration in inorganic carbon.

The concentration of inorganic carbon in the 0–10 cm depth differed significantly among the treatments in the first year. The highest mean values were 11.67, 11.62, 10.43 and 6.70g/kg in mucuna, grass fallow, maize and soybeans and the lowest mean value of 3.05g/kg respectively. In the second year (2016), the result generally showed a decrease in mean values in all the management practices except for soybeans plot. In the 10–20 cm depth the same trend follows as in the 0 – 10cm depth in both years.

The mean carbon stocks in the 0 - 10 cm depth based on the soil mass approach was significantly (p<0.05) affected by the management practices in the first year. The grass fallow gave the highest (3,075kg/ha) carbon stock while the lowest (1,497kg/ha) was from the bare fallow in 2015. In 2016, the mucuna plot had the highest mean value of 3818kg/ha, followed by grass fallow, soybeans and maize with mean values as 3,739, 3,306 and 3,102 kg/ha and lowest in bare fallow plot of 1,067kg/ha. The concentration of carbon stock significantly decreased in the 10 – 20cm layer in both years. It showed significant increase in the order: grass fallow, mucuna, soybean, maize and bare fallow with mean values of 3,509, 3,002, 2,642, 2,359 and 1,802kg/ha in the first year, respectively. In the second year, the order were grass fallow > soybeans >maize > mucuna > bare fallow plot. The general mean values for the two years were 2,663 and 2,191kg/ha.

The effects of different management practices on soil TN, PON, ratio of POC/PON and HA are presented in table 2. Total nitrogen concentrations varied widely among the treatments from 2.124 to 2.80 g/kg in the 0–10cm layer and from 1.67 to 2.07 g/kg in the 10–20 cm layer. Total N values were greater at the first soil layer than at depth of 10 – 20cm. In the second year, the concentration of TN was highest in grass fallow followed by mucuna, soybeans and maize with bare fallow being the lowest at 0 – 10cm depth. The mean values decreased slightly in the lower layer compared to the top layer. Total N concentrations reduced significantly with soil depth, following the TOC trend. Soil particulate organic nitrogen was significantly different ($p<0.05$) among the treatments in the first year and was not significantly different ($p<0.05$) in the second year. The general mean values for the two years were0.903 and 1.62 g/kg in the first and second year, respectively. The highest mean particulate organic nitrogen of 1.243g/kg and 1.275g/kg were obtained from the grass fallow and soybeans treatments while, the bare fallow had the lowest (0.368g/kg) in 2015. In the second year, the mean values of the treatments were not significantly different from each other with highest mean of 1.79g/kg from grass fallow and lowest from bare fallow. In the 10 – 20cm depth the mean values generally decreased with depth and was significantly different (p<0.05) only in the first year. The general mean values for the two years were 0.76g/kg and 1.49g/kg. The highest mean values were obtained from the maize, soybeans, grass fallow and mucuna in that order, while the bare fallow had the lowest in the first year (0.91, 0.89, 0.80, 0.70 and 0.48 g/kg), respectively. In the second year, the mean values were not statistically significant (p>0.05) among the treatments. The highest mean value was obtained under the bare fallow (3.05g/kg) and the lowest in soybean (1.04g/kg)

Ratio of particulate organic carbon to particulate organic nitrogen (POC/PON) in 2015 and 2016 was statistically significant (p<0.05) among the treatments in both years except for 10 – 20cm depth in 2015. The mean values of POC/PON ratio were significantly higher in 0-10 cm layer soil depth compared to the 10 – 20cm soil depth in both 2015 and 2016. The bare fallow gave the highest mean value (25.6 g/kg) and the grass fallow gave the lowest mean value (10.1 g/kg) in 2015. The ratio decreased in the order: bare fallow> mucuna> maize >soybeans>grass in the depth of 0 – 10 cm, while in 10 – 20 cm depth the order were: soybeans>bare fallow>mucuna>grass fallow >maize, respectively. In the second year the trend was different, mucuna gave the highest mean value (11.11 g/kg) and lowest mean value (3.66 g/kg) in bare fallow. In the 10 – 20 cm layer soil depth the decreasing order was: grass fallow, soybeans, mucuna, maize and bare fallow with mean ratio of 9.84, 8.11, 7.75, 7.71 and 3.29g/kg, respectively. The concentrations of carbon in humic acid (HA) fractions in the 0–10 cm and 10–20 cm depths are presented in Table 7. Mean values of HA varied from 1.33 to 1.68mg/kg, 1.0 to 3.67 mg/ kg, in 0 – 10cm soil depth and 1.33 to 3.00mg /kg, 1.33 to 3.67mg/kg, in 10 – 20cm soil depth in both 2015 and 2016 respectively. The concentration of HA was not statistically significant (p>0.05) among the treatments in both depths and years. In the second year, the concentration of HA increased in all the treatments except for the mucuna treatment in depth, 0 – 10cm. The bare fallow had much more humic acid content than the other treatments in the second year.

Table 2: Effect of Management Practices on Soil Total Nitrogen, Particulate Organic Nitrogen, Ratio of POC/PON and Humic Acid in 2015 and 2016

Treatment	Depth cm	TN g/kg		PON g/kg		POC/PON		HA m/kg	
		2015	2016	2015	2016	2015	2016	2015	2016
BF	0 – 10	2.61	1.54	0.368	1.50	25.6	3.66	1.33	2.67
SB		2.80	1.86	1.275	1.53	10.6	9.41	1.68	2.67
MZ		2.32	1.84	0.840	1.64	15.6	8.16	1.66	2.00
MN		2.43	2.31	0.790	1.64	18.1	11.11	1.68	1.00
GF		2.12	3.01	1.243	1.79	10.1	10.42	1.58	3.67
CV		15.4	10.7	13.5	11.9	33.1	13.7	16.9	45.6
LSD		NS	0.01974*	0.01918**	NS	8.34*	1.817*	NS	NS
BF	10 – 20	1.67	1.47	0.48	3.05	11.85	3.29	1.33	2.67
SB		1.74	1.71	0.89	1.04	12.66	8.11	2.67	2.33
MZ		1.85	1.50	0. 91	1.20	8.28	7.71	2.00	2.67
MN		2.07	1.36	0.70	1.07	10.33	7.75	2.33	1.33
GF		2.04	2.04	0.80	1.08	9.16	9.84	3.00	3.67
CV		35.6	22.9	16.9	141.5	34.2	22.7	32.2	45.9
LSD		NS	NS	0.02017*	NS	NS	2.537*	NS	NS

BF = Bare fallow; SB = Soybean; MZ = maize; MN = Mucuna; GF=Grass fallow **= $P \leq 0.01$;*=$P \leq 0.05$ ns=not significant; TN =Total nitrogen; PON = Particulate nitrogen; HA = Humic acid

Discussion

The extent to which short-term management practices influences soil organic carbon dynamics are often difficult to detect, and can be best evaluated by separating SOC into fractions. These include particulate organic carbon, mineral-associated inorganic carbon and the humified soil organic carbon. Also Guimaraes *et al.,* 2013, share the same opinion that alterations in the different fractions of SOM are more effective in indicating changes in soil use than total soil organic matter content. The differences observed in the accumulation of total carbon in the soil, may be due to the dynamics of the management practices. According to Guimaraes *et al*. (2013), TOC concentrations can be very different as a result of different management practices even in the same soil. Accumulation of TOC at the soil surface could be as a result of root network and crop residues added to the soil. This result is at par with that of Kern and Johnson (1993) and Ladha *et al*. (2011), who reported that increased in TOC accumulation in the treatments with crop management is likely to be associated with factors such as reduction in soil disturbance, undisturbed left–over stubbles on the surface, and their slow decomposition, as well as increased soil water retention. The concentration of TOC decreases with depth (10–20 cm) in both first and second year compared to the 0–10 cm soil layer. This result is in agreement with the finding of Shahmir *et al*. (2017) who recorded decreased in percentage of SOC with soil depth under different land use types. The TOC was highest in grass fallow followed by mucuna plot, soybeans and maize. This might be due to aggregate stability and is at par with the finding of (Shahmir *et al*., 2017).

In the first year, TOC of soybeans was lower compared to the maize in contrast to the second year were the mean value of soybeans was higher. The reason may be due to high rates of decomposition as indicated in carbon-nitrogen ratio Also, in the second year at 10 – 20cm depth, mean value of TOC in mucuna plot was low compared to other treatments plot with cover and this may due to few number of roots produced by the mucuna crop. This result agrees with Barthes *et al.* (2004) who reported the percentage of mucuna, residual carbon for the above-ground biomass (about 40%) and that of roots (8%). The relatively high TOC of 11.70g/kg in the bare fallow in 2015 may be due to the remains of plant roots. According to Ghimire *et al*. (2017), roots decompose more slowly than aboveground plant parts. The decrease in TOC content from 11.70g/kg in 2015 to 7.78g/kg in 2016 under bare fallow practice may be due to the continuous increase rate of mineralization as observed in C/N ratio. Also, the decrease in TOC in bare fallow in the second year corroborate the result of Piccolo (1996), who reported that reduction of SOM with progressive cultivation is commonly attributed to microbial oxidation of the partially decomposed organic materials or clay–humic complexes, which were previously protected in soil aggregates. The TOC concentration, degradation rates was high due to high N content, which increased the loss of the more labile fraction in the surface layer. The soil organic matter content followed the same trend as in the total carbon (TOC). The addition of leaf liters and roots significantly increased TOC concentrations in the two depths in the cover treatments compared to the bare fallow treatment. The cover management practices (GF,SB,MU and CN) reduce the SOM mineralization rate and improves soil water retention, protects soil from direct solar irradiation, and reduces temperature at the soil surface(Guimaraes *et al*.,2013). The constant disturbance of bare fallow through weeding and exposure to weather condition may have resulted in depletions of SOM concentrations, thereby decreasing contents of POC as well as microbial presence (Kiani *et al*., 2017). Soil TOC content was significantly depleted in the bare fallow compared to the cropped treatments in the second year. This is in agreement with the result of (Kocyigit and Demirci, 2012), who reported that in agricultural ecosystems, decrease in SOC are mainly induced by frequent soil disturbance e.g. tillage, fertilization and weed control and crop removal. The result is also in agreement with that of Yihenew and Getachew (2013), who reported that the lowest organic carbon was registered in cultivated land and highest in the natural forestland.

The particulates organic carbon pools which consist of insoluble plant debris made up a larger proportion of the total carbon pool, and contribute majorly to the changes in soil structure (Kantola *et al*., 2017) over the short duration of time. This high POC observed in grass fallow, may be due to the aggressive root system that is working as a system of soil carbon accumulation and recovery (Figueiredo *et al.,* 2010). The high biomass production and nitrogen accumulation of Mucuna and grass fallow and its accelerated decomposition, could have contributed to the higher carbon stocks under these management practices. This result agrees with (Carvalho *et al*., 2014), who observed that increase in soil carbon stocks is a function of C and N inputs and the chemical composition of plant tissues and decomposition, microbial biomass and activity, management practices, and soil and climatic factors.

The concentration of carbon stock significantly decreased in the 10 – 20cm layer in both years. These may be due to decrease in both bulk density and soil organic carbon. Also the decrease in carbon stock observed in the bare fallow in both years and depth may be attributed to repeated disturbance of soil surface through manual weeding resulting in higher rates of organic carbon decomposition and loss of carbon (Anderson-Teixeira *et al.,* 2013). Also, the reduction of SOC stocks observed under bare fallow can be explained by a degradation process of unsustainable soil management practices that resulted in continuous decrease in soil organic carbon (Parras-Alcantara *et al*., 2013).

Soil total nitrogen is an important component of SOC, and greatly influences SOC decomposition and humification rates (Guimaraes *et al*., 2013). The high level of TN observed in the management practices may be due to the retention of plant residues on the soil surface (Guimaraes *et al*., 2013). There was no significant difference in the first year but was significantly different in the second year. The mean values decreased in all the treatments in the second year except in the grass fallow. Also, high TN observed in bare fallow in the first year may be due to the relatively high particulate organic. According to Stevenson (1994) about 95% of TN is present in organic forms. Also, the increase in TN may be due to increase in soil moisture content. This agrees with the finding of Abera *et al*., 2012, that nitrification increased linearly with increase in soil moisture content. Total N concentrations reduced significantly with soil depth, this is at par with (Guimaraes *et al*., 2013), who recorded significant reduction in TN concentrations with soil depth.

The processes governing global biogeochemical cycles of carbon and nitrogen according to Babbin *et al*. (2014) are best understood via temporal and spatial variation in particulate organic carbon, particulate organic nitrogen and their ratio.

High POC: PON ratio, according to Wasak and Drewnik (2015) suggests relatively weakly decomposed plant-derived material, while low POC/PON ratio suggested a relatively high contribution of humified as well as microorganisms derived SOM. High POC/PON ratio had an inhibitory effect on microbial activity and encourages retention of aromatic compounds. This humified SOM is believed to serve as a factor that glues soil particles together inside micro aggregates (Six *et al.,* 2001). The highest mean value (25g/kg) obtained in the bare fallow in 2015, indicates that nitrogen is more limited and tends to be immobilized (Scharenbroch and Lloyd, 2006). The generally low values obtained in the POC: PON ratio in the second year may be attributed to high nitrogen that lead to mineralization of soil organic matter. Nitrogen mineralization was higher in the bare fallow plot possibly due to higher microbial soil respiration and microbial biomass (Deressa. 2015) that decreased active pool of soil organic matter due to decomposition. Higher microbial respiration released more nitrogen to the soil solution. The decreases in the POC/PON ratio are indications of soil organic stabilization and humification (Quideau and Bockheim, 1996; Scharenbroch and Lloyd, 2006).Humic acid according to Martens (2000) is believed to be important in controlling soil properties including soil structure. In the second year, the concentration of HA increased in all the treatments except for the mucuna treatment in depth, 0 – 10cm. This increase in the second year may be responsible for the increase in aggregate stability, which is in line with Piccolo *et al*. (1997) who reported that increased in HA enhanced aggregate stability. The grass fallow had much more increase in humic acid than the other treatments in the second year, mostly due to high level of humification and roots concentration. The higher concentration of C in the humic fraction of the soil surface layer in the second year could be as a result of intensive microbial activity and consequently a higher SOM decomposition rate. The mucuna treatment has a lower degree of humic acid compared to other treatments in the second year and this may be due to few roots produced by mucuna. This is in line with Quideau (2002), who reported that root turnover forms the major source of humus in the soil. It was further stated that in grassland ecosystems, up to two-thirds of organic matter is added through the decay of plant roots. According to Guimaraes *et al*. (2013), this may be due to greater content of non-humic substances (labile fraction), and probably due to non-decay inputs. This was also supported by Martins *et al.* (2011), who observed that low level of humification is related to higher labile C contents in soil. This labile fraction of SOM may be physically protected within soil aggregates (Milori *et al.*, 2002) in mucuna plot. The differences observed in bare fallow between the first and second year, may be due to the high rates of humification as observed in C/N.

Conclusion

The short-term management practices influenced soil organic carbon, particulate organic carbon, total nitrogen and particulate nitrogen dynamics. The accumulation of carbon and nitrogen in the soil, vary according to management practices. Both organic carbon and nitrogen form the larger proportion in the soil and mostly influences the changes observed in soil aggregation. The bare fallow indicates soil degradation compared to the cropped treatments and this was evident in the low C/N ratio. For sustainable production soil surface cover should be encouraged.

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