SELECTED PROPERTIES OF SOILS IN RELATION TO CONSERVATION TILLAGE PRACTICES AND FERTILIZER COMBINATIONS IN UMUAKA, IMO STATE, NIGERIA.

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ABSTRACT

Assessment of selected soil physical and chemical properties under different conservation tillage practices and fertilizer combinations in Umuaka, Imo State, Nigeria, was carried out using various treatments: fallow (No tillage); zero tillage and manure (ZM); conventional tillage, fertilizer and manure (CFM); conventional tillage and fertilizer (CF), and minimum tillage and manure (MM).. The NPK 15:15:15 fertilizer application rate for inorganic fertilizers was 350 kg.ha^{-1}, while organic manure (poultry manure) was applied at the rate of 500kg.ha^{-1}. Triplet soil samples were collected from three (3) depths of 0-15, 15-30 and 30-45cm from the study area The experiment was laid out in a randomized complete block design with 3 replications. The data generated from the study was subjected to analysis of variance and mean differences were separated using fishers least significant at P=0.05. The study revealed that sand fraction dominated soil particle size distribution in the study area. The values of soil bulk density, hydraulic conductivity, total porosity, moisture content, infiltration rate, aggregate stability, pH, organic carbon content, Nitrogen, Phosphorus, Potassium, Calcium and magnesium ranged from 1.37-1.42 g.cm^{-3}, 0.21-0.33cm/s, 46.41-48.47%, 8-11.67%, 8- 12.33cm.hr^{-1}, 9-15%, 4.84-5.82, 0.84-1.36%, 0.25-0.27%, 3.39-4.33mg.kg^{-1}, 0.24-0.33cmol^{+}.kg^{-1}, 0.88-1.8lcmol^{+}.kg^{-1} and 0.61-0.94cmol^{+}..kg^{-1} respectively. The analyzed soil properties showed significant difference when compared the no tillage was compared with the other treatments and Correlation analyses showed that soil bulk density had a negative relationship with the analyzed soil properties while other analyzed soil properties had positive relationship when compared with one another. This implies that increase in soil bulk density reduced the other soil properties. This study showed that tillage practices such as zero tillage and minimum tillage with the applications of manure improved soil physico-chemical properties and should be encouraged where long-term cropping systems are practiced.

Key Words: Assessment, Soil, Conservation, Tillage, Fertilizer, Umuaka ,Imo, Nigeria

INTRODUCTION

Soil management practices are integral components of the overall agricultural systems through which the environment is controlled for production. Consequently, these management practices are important indicators of agricultural productivity. The system of soil management practices adopted for any eco-region reveals the levels at which the farmer manages of the environment (Amanor, 1994). Therefore, proper land use and management can be useful in improving soil characteristic, reducing soil degradation and in turn achieving the agricultural sustainability (Fayed and Rateb, 2013).

Soil physical properties significantly influence how soils functions in an ecosystem and how they can best be managed. The success of agricultural productivity often hinges on the physical properties of the soil. The occurrence and growth of many plant species are closely related to the soil physical properties (Brady and Weil, 2002). These properties are known to influence the emergence, early shoot and root growth of crops and include the texture, structure, bulk density as well as the gravel content of the soil (Chen et al., 2008).

Soil tillage is an agronomic practice that requires considerable expense and high- energy inputs, and desired to create favourable conditions for plant growth and development. One of the main goals of soil tillage is to influence soil processes, and modify its physical, chemical and biological properties (Badalikova and Knakal, 2000). Various soil tillage practices have its effect on the soil environment and subsequently on soil fertility, and as such require the management of the soil in such a way as to prevent irreversible degradation processes. Agricultural practices that prevent irreversible degradation of soil, such as reduced tillage, lower tillage intensity, combining more field operations, and leaving crop residues on the soil surface have become quite popular (Tebrugge and During, 1999). These soil tillage and planting systems are generally known as minimum tillage and soil erosion control practices. An improved soil environment will ensure that as the world human population continues to increase, the increasing challenge on the food security as a means of sustaining this teeming population is meet with minimum damage to the environment even as more land is put under cultivation (Owino*et al.*, 2006).

In most parts of Africa, including Nigeria, increased population and other socio-economic pressures, have resulted to the reduction of fallow period in order to accommodate the increasing high demand for food (Asfaw, 2007). Thus many farmers have resorted to continuous cropping system as a traditional farming system to accommodate the teeming population. Therefore it is important to conduct a study to assess the implications of different conservation practices of soil, so as to evaluate its effect on some soil properties that determines plant growth. The major objective of this study was the assessment of selected properties of soils in relation to conservation tillage practices and fertilizer combinations in Umuaka, Imo State, Nigeria,

MATERIALS AND METHOD

Site Description

This study was carried out at Umuaka Agro Service Center Orlu. Lying between The study site is located within Latitudes 4°40' and 8°15'N and Longitudes 6°40' and 8°15'E. It falls within the humid tropics, with mean daily temperature is about 27 °C and average annual rainfall of about 2400 mm and a mean relative humidity of 75 – 80%. There is a distinct dry season of about 3 months. Imo State has rainforest vegetation characterized by multiple tree species. Soil of the study site has been classified as Typic Paleudult / Dystric Nitosol according to FAO and correlated with World reference base for Umuaka (Federal Department of Agricultural land Resources, 1985). Soil color is dark brown with a weak fine granular structure. Earthworm activity is evident. It is well drained and on a flat topography of elevation of 91 m above sea level. Farming is a major economic activity here.

Treatments

The treatments were represented as T1= No Tillage (Bush Fallow);T2 = Conventional Tillage + Fertilizer + Manure (CFM);T3 = Conventional Tillage + Fertilizer (CF);T4 = Minimum Tillage + Manure (MM) and T5 = Zero Tillage + Manure. The NPK 15:15:15 fertilizer application rate for inorganic fertilizers was 350 kg.ha^{-1} , while organic manure (poultry manure) was applied at the rate of 500kg.ha^{-1} The treatments were replicated three (3) times.

Soil Sampling

Soil samples for the determination of selected soil physical and chemical properties were collected randomly for each of the treatments. Triplicate soil samples were collected from depths of 0-15cm, 15-30cm and 30-45cm using soil auger attached to a core sampler for each of the study sites, while soil samples for bulk density determination and hydraulic conductivity was collected with core samplers of known volume at the different depths. The soil samples were air-dried and sieved with a 0.02-mm diameter sieve.

Analysis of Soil Properties

Infiltration rate was determined in the experimental field using a double ring infiltrometer (Bouwer, 1986), Saturated hydraulic conductivity Ks was determined by the constant-head method (Klute and Dirksen 1986). Particle size distribution was determined by hydrometer method according to the procedure of Gee and Bauder (1986). Bulk density, using core sampler, as described by Blake and Hartge, (1982).Water-stable aggregation distribution was determined by placing the soil sample on a nest of sieves, immersing directly in water, and agitating the sieves up and down for 15 min. Samples remaining on each sieve were dried and proportions of wet stable aggregates >2.00, 2.00 -1.00, 1.00 - 0.25, and <0.25 mm were calculated. The fraction of micro- aggregates was taken as those <0.25 mm (Oades and Waters 1991).

Moisture content was determined gravimetrically and calculated using equation 1:

$$\theta m = \frac{\text{wet soil sample} - \text{dry soil sample}}{\text{Dry soil sample}} X \frac{100}{1} - - \text{equ. 1}$$

Where $^{\theta}$m = gravimetric moisture content (saturated) (%).

Total porosity was calculated from values of bulk density obtained by clod method (Blake and Hartge, 1986), at an assumed particle density of 2.65g/cm^3. Mathematically, it is expressed as in equation 2::

$$Tp = 1 - \frac{Bd}{Tp} X \frac{100}{1} - - - - - \text{equ. 2}$$

Where TP = Total porosity (%)

BD Bulk Density (g/cm^3)

PD = Assumed Particle Density (2.65g/cm^3)

Soil pH in water, with soil to water ratio of 1:2.5, soil/water ratio using pH meter. Total carbon was measured by Walkley and Black wet digestion method (Nelson and Sommers, 1982). Total Nitrogen, using micro-kjeldahl digestion procedure method as described by Bremner, (1996). Available phosphorus was estimated using Bray II solution (Bray and Kurtz, 1954). Exchangeable cations (Ca, Mg and K) were extracted using 1N NH_4OAC and K determined on flame photometer while Ca and Mg were determined using Atomic Absorption Spectrophotometer (AAS).

Field Layout and Data Analysis

There were 5 treatments replicated 3 times and the experiment was laid out in Randomized Complete Block Design (RCBD). The Data collected were subjected to Analysis of Variance (ANOVA), Significant means were separated using the Fisher Least Significant Difference (LSD) at a probability level of P = 0.05 as described by Onuh and Igwemma, (2007). Correlation between soil properties was determined using simple correlation analysis.

RESULTS AND DISCUSSION

Physical Properties of Soil under Different Conservation Tillage Practices and Fertilizer Combinations.

The effect of treatment on physical properties of soil at Umuaka is presented in Table 1

Soil Textural Class

The result of the soil textural class of the study area showed that soil texture at a depth of 0 – 15 cm for fallow, ZM, CFM, CF and MM were SCL, SL, SL, SCL and SL respectively while at the soil depth of 30 – 45 cm the soil textural classes were LS for fallow, SL for ZM, SCL for CFM, LS for both CF and MM. The soils were dominated by sand fraction followed by silt and clay. These textural classes could be as a result of the nature of the parent materials.

Soil Bulk Density

The result of the soil Bulk density at the soil depth of 0 - 15cm of the study area showed that there was significant difference when the fallow treatment was compared with the other treatments. At this level the bulk density values were 1.27, 1.33, 1.36, 1.38 and 1.35g/cm^3 for fallow, ZM, CFM, CF and MM respectively. These results showed that fallow had the least bulk density. However, there was no significant difference between soil bulk densities of ZM, CFM and MM when compared with each other, but bulk density of CF treated soil significantly differed from that from ZM treatment. At the soil depth of 15 - 30cm, there was equally significant difference from fallow when compared with the other treatments but there was no significant difference when the treatments were compared with one another.

Table 1: The Effects of Different Conservation Tillage Practices and Fertilizer Combinations on Soil Physical Properties in Umuaka Agro Service Center Orlu.

	BD (g/cm^3)	HC (cm/s)	P (%)	MC (%)	I.R (cm/hr)	A.S (%)	T.C
				0 - 15cm			
Fallow	1.27^c	0.55^a	52.08^a	17.0^a	12.67^a	21.0^a	SCL
ZM	1.33^b	0.39^b	49.81^b	13.0^b	10.33^b	17.0^b	SL
CFM	1.36^{ab}	0.27^c	48.68^{bc}	12.0^b	8.67^c	14.0^c	SL
CF	1.38^a	0.24^c	47.92^c	10.0^c	8.00^c	11.0^d	SCL
MM	1.35^{ab}	0.37^b	49.06^{bc}	12.0^b	12.33^a	14.0^c	SL
$LSD_{(0.05)}$	0.04	0.06	1.57	1.9	1.56	2.20	
C.V (%)	1.2	8.8	1.7	7.9	7.9	7.6	
				15 – 30cm			
Fallow	1.34^d	0.51^a	49.43^a	14.0^a		18.0^a	SCL
ZM	1.36^c	0.31^b	48.68^a	12.0^b		15.0^b	SCL
CFM	1.39^b	0.25^c	47.55^b	11.0^b		12.0^c	LS
CF	1.43^a	0.22^d	46.04^c	8.0^c		9.0^d	SCL
MM	1.39^b	0.32^b	47.55^b	11.0^b		12.0^c	
$LSD_{(0.05)}$	0.10	0.02	0.76	1.4		1.24	
C.V (%)	0.8	3.6	0.81	6.7		5	
				30cm – 45cm			
Fallow	1.36^c	0.45^a	48.68^a	14^a		15^a	LS
ZM	1.41^b	0.28^b	46.92^b	10^b		13^a	SL
CFM	1.43^{ab}	0.23^c	46.04^{bc}	9^b		10^b	SCL
CF	1.45^a	0.18^d	45.28^c	6^c		7^c	LS
MM	1.41^b	0.26^{bc}	46.79^b	10^b		10^b	LS
$LSD_{(0.05)}$	0.02	0.04	0.85	1.1		2.00	
C.V (%)	0.79	7.1	0.97	6.1		9.6	

NOTE: BD Bulk Density; HC= Hydraulic Conductivity; P Porosity; MC Moisture content; JR infiltration Rate; As = Aggregate Stability; T.C = Textural Class; ZM = Zero tillage and manure; CFM = Conventional tillager fertilizer; MM =Minimum tillage and manure; LSD = Least significant Different (P = 0.05), CV= Coefficient of variation

Furthermore, at depth of 30 - 45 cm, the bulk density of fallow revealed similar trend with those of the immediate level above but CF differs significantly with fallow, ZM and MM. The variability in bulk density values as seen in Table 1 may be due to the influence of soil texture, organic matter content and cultivation practices. The correlation analysis as shown in Table 3 indicated that bulk density had a negative relationship with all the soil properties.

Soil Hydraulic Conductivity (Ks)

At the soil depth of 0 – 15 cm the result indicated there was significant difference when the hydraulic conductivity of soil from the fallow site was compared with results from the other treatments. Again there was significant difference when the Hc of CFM and CF were compared with ZM and MM treatments. The hydraulic conductivity of the study area ranged from 0-27 – 0.55 $cm.s^{-1}$ for fallow. Also at 15 – 30 cm, there was significant difference when CFM and CF values where compared with the other treatments. But there was no significant difference when the result from the fallow site was compared with the other treatments and when ZM was compared with MM. At this depth (30 — 45 cm), there was no significant difference in soil hydraulic conductivity of the fallow site was compared with the other treatments but the result revealed a significant difference when CFM was compared with those from fallow, ZM and CF treated sites. There was no significant difference when the other treatments were compared with one another. The simple correlation analysis (Table 3) showed that, hydraulic conductivity had a negative relationship with back density (r=0.884), whereas, it had a very strong relationship with the other soil properties.

Total Porosity

The mean values of total porosity of fallow, ZM, CFM, CF and MM at a depth of 0-15 cm were 52.08, 49.81, 48.68, 47.92 and 49.06% respectively. Statistically there was significant difference in the fallow total porosity when compared with results from ZM treatments and there was no significant difference when the total porosity results from fallow and ZM was compared with the other treatments. At the soil depth of 15 – 30 cm, the result showed that there was no significant difference when fallow treatment was compared with ZM treatment. but there was significant difference when the total porosity of fallow and ZM treatments were compared with the other treatments. However, CF treatment revealed the least soil porosity value. In soil depth of 30 – 45 cm, the statistical trend was the same as those seen at the depth of 0 – 15 cm, except that there was significant difference when CF treatment was compared with MM total porosity values. The correlation analysis indicated that porosity had a positive relationship with all the soil properties analyzed except soil bulk density (r = -0.999).

Soil Moisture Content

The treatment means of the study area for soil moisture content at the soil depth of 0 - 15cm, showed significant difference when the fallow treatment was compared with the other treatments but there was no significant difference when ZM, CFM and MM were compared with one another. however, CF soil moisture content was significantly different from the other treatments. At soil depths of 15 - 30cm and 30- 45cm followed the same statistical trend as those from the soil depth of 0 - 15cm. Treatment CF had the least soil moisture content and this may be as a result of exposure of the soil to solar radiation without the application of manure to serve as soil buffer. The correlation analysis indicates that soil moisture content had strong positive relationship with other soil properties except bulk density which revealed negative correlation (r = -0.952).

Soil Infiltration Rate

The result of the infiltration rate of study site revealed that there was only significant difference at the site treated with ZM when compared with the other treatments. There was no significant difference in the soil infiltration rate of fallow (12.67 $cm.hr^{-1}$) when compared with MM(12.33 $cm.hr^{-1}$) treatments also there was no significant difference when CFM (8.67 cm/hr) treatment was compared with CF (8.0 $cm.hr^{-1}$) treated site. The least water movement into the soil was recorded at CFM and CF sites. This could be as a result of wheel traffic during ploughing thus causing an increase in soil bulk density and reduction in soil pore space. The correlation analysis indicated that soil infiltration rate had positive relationship with other analyzed soil properties, except bulk density.

Soil Aggregate Stability

The aggregate stability of the soil ranged from 11 - 21% depth of 0 – 15 cm. at this depth Fallow significantly differed when compared with the other treatments and there was significant difference in soil aggregate stability when ZM treatment was compared with CF treatment. But CFM did not differ when compared with the aggregate stability of soil treated with MM. However, a similar as that observed from the upper depth was revealed at depth of 15 – 30 cm. However, at a depth of 30 - 45 cm, the result showed that there was no significant difference when fallow (15%) treatment was compared with ZM(13%) treatment, there was also no significant difference when the aggregate stability from CFM (10%)treated site was compared with the that recorded from MM (10%) treatment. Nevertheless CF with its least aggregate stability value of 7% significantly differed when compared with the other treatments. The correlation analysis presented in Table 3, showed that aggregate stability had a very strong negative correlation with Bulk density (r-O.953), whereas it had positive relationship with the other soil properties.

Chemical Properties of Soil under Different Conservation Tillage Practices and Fertilizer Combination in Umuaka

The effects of treatment on the selected chemical properties of soil of the study site are presented in Table 2.

Soil pH

Soil pH of the studied area showed that soil samples from the soil depth of 0 – 15 cm had soil pH values of 6.33, 6.07, 5.96, 5.63 and 6.0 for fallow, ZM, CFM, CF and MM respectively. There was significant difference when the fallow treated soil pH was compared with the other treatments, but among the treatments ZM, CFM and MM had no significant difference when compared with one another. The pH value from soil treated with CF had the highest level of acidity and it differed significantly when compared with ZM, CFM and MM treatments. At the soil depth of 15 – 30 cm, the result of the soil pH showed that CF treatment significantly differed when compared with Fallow, ZM, CFM and MM treatments. However, at the soil depth of 30 - 45cm the pH result showed relative stability hovering around slightly acidic state. There was no significant difference when Fallow treatment was compared with ZM, CFM, CF and MM treatments. Not-with-standing this similarity in pH value at this lower soil depth CF treatment significantly differed when compared with MM treatment. Vertical nutrient loss from the tilled and chemically fertilized treatment site may account for the reduced pH value reported from this depth. Correlation analysis in Table 3 indicated that soil pH had negative correlation with bulk density (r = -0.569), but had a positive correlation with the other soil properties.

Soil Organic Carbon

At the soil depth of 0-15cm the organic carbon only recorded significant difference when CF treated soil was compared with Fallow, ZM, CFM, CF and MM treatments. Again at a soil depth of 15-30 cm, CFM was significantly different when compared with CF treated plot in their organic carbon content but. Fallow treatment when compared with ZM and MM did not show any significant difference. At soil depth of 30-45 cm the soil organic carbon concentration followed the same statistical trend as was seen at the soil depth of 15 - 30cm. Table 3 showed that soil organic carbon concentration had a negative correlation with soil bulk density (r = -0.759) and positive correlation with the other soil properties.

Table 2: The Effects of Different Conservation Tillage Practices and Fertilizer Combinations on Soil Chemical Properties in Umuaka.

	pH (H_2O)	OC %	N (%)	P (mg/kg)	K ($cmol^+$/kg)	Ca ($cmol^+$/kg)	Mg ($cmol^+$/kg)
				0 - 15cm			
Fallow	6.33^{a}	1.50^{a}	0.29	5.47^{a}	0.39^{a}	2.07^{a}	1.26^{a}
ZM	6.07^{b}	1.39^{a}	0.28	5.22^{a}	0.39^{a}	1.99^{b}	1.09^{b}
CFM	5.96^{b}	1.40^{a}	0.32	4.23^{b}	0.32^{b}	1.75^{b}	0.90^{c}
CF	5.63^{c}	0.93^{b}	0.29	3.90^{b}	0.27^{c}	1.03^{c}	0.70^{d}
MM	6.00^{b}	1.43^{a}	0.31	5.13^{a}	0.37^{ab}	1.92^{ab}	1.11^{b}
$LSD_{(0.05)}$	0.19	0.12	N.S	0.82	0.06	0.21	0.08
C.V (%)	1.67	4.8	10.5	8.8	9.04	6.5	4.4
				15 – 30cm			
Fallow	6.01^{a}	1.38^{a}	0.26	4.90^{a}	0.33^{a}	1.80^{a}	1.18^{a}
ZM	5.87^{a}	1.32^{a}	0.26	4.23^{b}	0.32^{ab}	1.75^{a}	0.83^{c}
CFM	5.63^{a}	1.22^{b}	0.26	3.78^{bc}	0.28^{b}	1.65^{b}	0.84^{c}
CF	5.33^{b}	0.83^{c}	0.26	3.45^{c}	0.24^{d}	0.86^{b}	0.62^{d}
MM	5.72^{a}	1.36^{a}	0.27	4.12^{b}	0.30^{b}	1.72^{a}	1.93^{b}
$LSD_{(0.05)}$	0.46	0.08	N.S	0.57	0.02	0.17	0.08
C.V (%)	4.3	3.7	8.5	7.4	3.9	5.7	5.1
				30cm – 45cm			
Fallow	5.75^{a}	1.30^{a}	0.22	3.93^{a}	0.29^{a}	1.65^{a}	1.11^{a}
ZM	5.60^{a}	1.24^{ab}	0.22	3.55^{ab}	0.27^{ab}	1.69^{a}	0.78^{b}
CFM	5.35^{bc}	1.15^{b}	0.23	3.14^{b}	0.24^{ab}	1.47^{b}	0.65^{bc}
CF	5.19^{c}	0.77^{c}	0.22	2.83^{C}	0.22^{b}	0.75^{c}	0.52^{c}
MM	5.37^{b}	1.28^{a}	0.23	3.67^{a}	0.26^{ab}	1.50^{b}	0.78^{b}
$LSD_{(0.05)}$	0.17	0.10	N.S	0.52	0.05	0.10	0.13
C.V (%)	1.6	4.8	7.8	8.2	10.7	3.9	9.2

NOTE: OC = Organic Carbon, N= Nitrogen; P = Phosphorous K = Potassium; Ca = Calcium; Mg = Magnesium.

Soil Nitrogen

Throughout the entire profile total nitrogen from all the treatments did not show any significant difference when fallow treatment was compared with the other treatments and when the treatments were compared with one another. However, correlation analysis as presented in Table 3 showed that soil nitrogen content has a positive relationship with all the other soil properties, except soil bulk density with which it showed a negative relationship (r = -0.5 86).

Soil Phosphorus

At soil depth of 0-15 cm, the treatment mean values of soil phosphorus content for Fallow, ZM, CFM, CF and MM were 5.47, 5.22, 4.23, 3.90 and 5.13 $mg.kg^{-1}$ respectively. Statistical analysis showed that there was no significant difference when phosphorus concentration from Fallow treatment was compared with those from ZM and MM treatments. There was also no significant difference CFM was compared with CF treatment, but both were significantly different when compared with Fallow, ZM and MM treatments. Further at a depth of 15-30 cm, there was 0. $mg.kg^{-1}$, 1-12 $mg.kg^{-1}$ and 0.78 $mg.kg^{-1}$ significantly more phosphorus in the Fallow plot than when compared with ZM , CFM and MM . Also CF differed significantly when compared with ZM and MM treatments. At this l depth of 30 – 45 cm, there was no significant difference in the soil phosphorus concentration when results from the Fallow plot were compared with, ZM and MM treatments. Also CFM revealed no significant difference when compared with ZM treatment but there was significant difference when CF treatment was compared with the other treatments. correlation analysis as presented in Table 3 showed that soil phosphorus of study site had a positive relationship with the other soil properties but it revealed a negative correlation with soil bulk density (r = -0.936).

Soil Potassium

Soil potassium concentration at al depth of 0-15cm for Fallow, ZM, CFM, CF and MM were 0.39, 0.39, 0.32, 0.27 and 0.37 $Cmol.Kg^{-1}$ respectively. Statistical analysis showed that there was significant difference when the potassium concentration from Fallow site was compared with those from ZM and MM treatment sites. However, CF with the least potassium concentration differed significantly when compared with the other treatments. At a depth of 15-30 cm, only CF treatment produced significantly different concentration of potassium. At this depth of 30-45 cm also only CF revealed significant difference when compared with the fallow site. The concentration of potassium was similar at this depth irrespective of the different treatments. Correlation analysis results showed that soil potassium in Umuaka had a positive correlation with all the other soil properties, except bulk density that showed a negative relationship (r = -0.925).

Soil Calcium

The result of the soil calcium concentration of the study showed that a soil depth of 0-15cm there were 2.07, 1.99, 1.75, 1.03 and 1.92 $Cmol^{+}.Kg^{-1}$ for Fallow, ZM, CFM, CF and MM respectively. The result showed that there was significant difference when the calcium concentration of the fallow site was compared with ZM, CFM and CF sites but there was no significant difference when compared with MM treatments. In addition calcium concentration from the CF treated site was significantly different when compared with the calcium concentration from ZM, CFM and MM treatments. Further at a soil depth of 15-30cm, there was significant difference when CF treatment was compared with Fallow (1.80 $Cmol^{+}.Kg^{-1}$), ZM (1.75 $Cmol^{+}.Kg^{-1}$), CFM (1.65 $Cmol^{+}.Kg^{-1}$) and MM (1.72 $Cmol^{+}.Kg^{-1}$) and there was no significantly difference when fallow site was compared with ZM, CFM and MM treatments. As one examines the soil down the profile at a soil depth of 30-45cm, the results showed that the calcium concentration of the CF treatment with the least soil calcium content was significantly different from the other treatments. However .fallow treatment site did not differ significantly when compared with ZM treated site. Correlation analysis showed that soil calcium content had positive relationship with all the soil properties analyzed, except bulk density which had negative correlation (r = -0.771).

Soil Magnesium

The results of soil magnesium concentration at a depth of 0-15cm showed that there was significant difference when the fallow treatment was compared with those from ZM, CF, CFM and MM treated sites. But there was no significant difference when ZM treatment was compared with the magnesium concentration from the MM treated site. However there was significant difference when CFM treatment was compared with CF treatment. Further down at the depth of 15-30cm, the result showed that Fallow (1.18 $Cmol^{+}.Kg^{-1}$) differed significantly from other treatments. MM (0.93 $Cmol^{+}.Kg^{-1}$) also differed significantly from the magnesium contents of others of other treatments, whereas there was no significant difference when CFM (0.84 $Cmol^{+}.Kg^{-1}$) was compared with ZM (0.83 $Cmol^{+}.Kg^{-1}$) treatment. However, CF (0.62 $cmol^{+}/kg$) differed significantly when compared with other treatments. Again at a depth of 30-45 cm, the result showed that there was significant difference in soil magnesium content when the Fallow treatment site was compared with ZM, CFM, CF and MM treatments whereas there was no significant difference when the other treatments were compared with one another. Simple correlation analysis revealed that soil magnesium concentration had positive relationship with all the analyzed soil properties, except soil bulk density which showed negative relationship (r = -0.904).

Table 3: **Simple Correlation between Selected Properties of the Studied Soils**

	BD	**HC**	**PO**	**MC**	**IR**	**AS**	**pH**	**OC**	**N**	**P**	**K**	**Ca**	**Mg**
BD	1	-.870**	-.999**	-.952**	-.863**	-.953**	-.569*	-.759**	-.586*	-.935**	-.925**	-.771**	-.905**
HC			.875**	.923**	.871**	.918**	.630*	.713**	.235	.818**	.770**	.714**	.944**
PO				.956**	.872**	.958**	.570*	.761**	.576*	.937**	.925**	.777**	.906**
MC					.740*	.961**	.630*	.832**	.820**	.855**	.839**	.831**	.943**
IR						.912**	.580*	.932*	.884**	.919**	.846**	.783**	.930*
AS							.671*	.799**	.856**	.886**	.882**	.830**	.915**
pH								.765**	.698*	.598*	.664**	.773**	.697**
OC									.780**	.767*	.805**	.979**	.845**
N										.668**	.656**	.697**	.745**
P											.977**	.783**	.901**
K												.835**	.878**
Ca													.842**
Mg													1

** => significant at 0.01
* => significant at 0.05

CONCLUSION

Results of this study on the Assessment of selected soil properties under different conservation tillage practices and fertilizer combinations in Imo State, Nigeria, following a long term cropping systems revealed that soil properties under Zero tillage and manure (ZM) and Minimum tillage and Manure (MM) showed better soil property as compared to those of conventional tillage, fertilizer and manure (CFM) and conventional tillage and fertilizer (CF). This study has shown that soils of Imo State are dominated by sand fraction, acidic in nature and have poor soil qualities. For this soil to provide good crop yield, organic manure application and conservation tillage practices such as zero or minimum tillage should be adopted to improve soil quality, especially where long- term continuous cropping systems are being practiced. This study showed that soil bulk density had negative significant relationship with all the soil properties. Therefore, tillage practices that increase soil bulk density, such as conventional tillage with the application of organic manure should be discouraged, to help restore the soil quality.

RECOMMENDATIONS

Tropical soils are generally known to have poor soil quality due to the fact that it is highly weathered and leached, and also being formed from Coastal Plain Sand. Therefore, based on the findings of this study, the following recommendations are made: Farmers that practice long-term cropping system should be encouraged to practice minimum tillage in order to avoid soil compaction and its adverse effects. And there is the need to incorporate organic manure into the soil to improve the soil quality.

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