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RESTORING THE PRODUCTIVITY OF A SEVERELY DEGRADED SOIL USING POULTRY MANURE FOR INCREASED MAIZE PRODUCTION IN THE TEACHING AND RESEARCH FARM OF COLLEGE OF AGRONOMY, NORTH CORE, JOSEPH SARWUAN TARKA UNIVERSITY, MAKURDI, BENUE STATE, NIGERIA.

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ABSTRACT

This field experiment was conducted in the 2019 cropping season at the Teaching and Research Farm of the College of Agronomy, North Core of the Josephn Sarwuan Tarka University Makurdi, Benue State, Nigeria. The objective was to restore the productivity of a severely degraded soil using poultry manure for increased maize production in the study area. The experiment consisted of five (5) treatments (0, 5, 10, 15 and 20 t/ha) of poultry manure replicated three (3) times in Randomized Complete Block Design (RCBD), with total area of 202.2m^2. Soil samples were taken before the trial and analysed using standard analytical procedures and the soil analysis result was compared with the standard table for Soil Degradation Assessment of FAO (1979) to establish the status of degradation of the soil in the study site. After incorporation of the poultry manure, after harvest, samples were again taken and analysed to assess the effect of the manure in the soil restoration and on crop performance. Data was collected on number of leaves, plant height, stem girth, leaf area, dry matter yield and dry root weight. Results revealed that, the application of poultry manure improved soil characteristics such as soil pH, organic matter, nitogen, phosphorus, exchangeable cations, cation exchange capacity and base saturation. This was also reflected on the crop performance. 15 t/ha poultry manure application gave the highest maize performance and soil improvement in the study area and is hereby recommended.

INTRODUCTION

Soil is a vital resource for the future of humanity, it needs to be protected and enhanced (Young *et. al*.,2015).More than half (52%) of all fertile, food producing soils globally are now classified as degraded, many of them severely degraded (UNCCD, 2015). Soils are our major natural resources because most of our food and clothing comes directly or indirectly from them. Soil degradation is a critical and growing global problem, with implications for a number of key policy areas including food security, climate change, food risk management, drought tolerance, drinking water quality, agricultural resilience in the face of new crop diseases and biodiversity (Young *et. al*., 2015). Soil degradation is one of the most important threats facing mankind which not only weakens productive capability of an ecosystem but also affects overall climate (Barrow, 1991). Soil degradation is the decline in soil characteristics originated by its inappropriate use typically for agricultural, pastural, industrial or urban causes (Johnson and Lewis, 1995). Degradation in soil is the decline in any or all of the characteristics which make soil suitable for food production. Soil degradation is a consequence of anthropogenic activity and environment disturbance that cause alteration in many aspect of soil properties and influence crop productivity (Mikha*et. al*. 2014). Zika and Erb (2009) estimated that annual dryland degradation could reduce global terrestrial net primary productivity by approximately 2%. Soil degradation processes include the loss of topsoil by the action of water and wind, chemical deterioration, compaction and biological deterioration of natural resources including the reduction of topsoil biodiversity (Lal, 2001). The addition of organic amendment as a nutrients source has been found to alleviate the influence of topsoil and soil organic matter losses due to erosion (Izaurralde*etal*., 2006; Larney and Anger, 2012).

Examples of soil degradation includes adverse changes in alkalinity, decline in soil fertility, adverse changes in acidity or salinity, extreme flooding, leaching, soil erosion and crop harvesting. According to Melero*etal*. (2007), one of the best ways of restoring soil productivity involves the addition of organic materials. Organic fertilizers such as animal manure, green manure and compost can be applied in the soil so as to increase crop yield. These types of fertilizers on the one hand improve the physical and biological properties of the soil and on the other hand serve as a source of mineral elements (Abdelrazzag, 2002). Poultry manure is a naturally nourishing fertilizer for plants. It is rich in nutrients such as Phosphorus, Nitrogen, Calcium, Potassium and Magnesium and it has been known for a long time for its excellent properties of promoting plants growth and replenishing of soil nutrients status. The regular addition of amendments such as animal manure and crop residue also helps to prevent soil erosion (Hornick and Parr, 1987).The organic matter contents of composted animal manure is high and when added to agricultural soils, it often improves soil physical, chemical and biological properties (Antonious, 2016).

In Nigeria, the rising cost of inorganic fertilizers coupled with their inability to recondition the soil, has directed attention to organic manures usage in recent times (Adewole*et.al*., 2016). High cost and scarcity of inorganic fertilizer pose constraints to its use especially among small-scale farmers in Africa (Ogbalu, 1999). Hence research attention recently shifted to use of animal wastes which are abundantly produced (Nwajiuba and Chimezie, 2000) and poses disposal and environmental problems.Poultry manure is preferred amongst other animal wastes because of its high concentration of macro-nutrients (Ducan, 2005).
Maize is widely grown all over the Nigeria. Nigeria is the largest producer of maize in Africa, however there are some factors militating against profitable production of maize in Nigeria (Farhad*etal*., 2009). One among them is low soil organic matter which results in low soil fertility status. Declining soil fertility had earlier been identified as the fundamental cause of declining crop yield in many parts of Africa (Sanchez *etal*., 1997). A study by Adeniyan and Ojeniyi (2005) and Ezeibekwe*et.al*. (2009) revealed that poultry manure improved growth and yield of maize relative to no fertilizer application. So the need to assess the effect of poultry manure on maize productivity and on soil properties in the study area is highly desirable in order to maximize yield using locally sourced materials and thereby reducing cost is highly advocated.The objectives of this study were to assess the restorative effect of poultry manure on degraded soil of the study area and to assess the effect of poultry manure on maize productivity.

MATERIALS AND METHODS

Site Description

The experiment was carried out during the 2019 cropping season at the College of Agronomy Research Farm North Core, Joseph Sarwuan Tarka University Makurdi, Benue State, on a land located between Latitude 7.79613, 7.79597 N and longitude 8.61520, 8.61526 E at 108m above mean sea level. The experimental area is in the Southern Guinea Savanna Agro Ecological Zone of Nigeria. The soil is well drained, porous and brownish below the surface made of kaolinite clay. The soil type is loamy sand and has a pH range of 6.0 – 6.8

Experimental Treatments and Design

The experiment consisted of five (5) treatments (0, 5, 10, 15 and 20t/ha poultry manure) replicated three (3) times in a Randomized Complete Block Design (RCBD). The experimental plots were marked out after clearing and manually tilled using a hoe. Each treatment plot had an area of 3m x 3m (9m²) and were separated between blocks by 1m, as well as between side blocks and boundary with a total area of 202.5m².

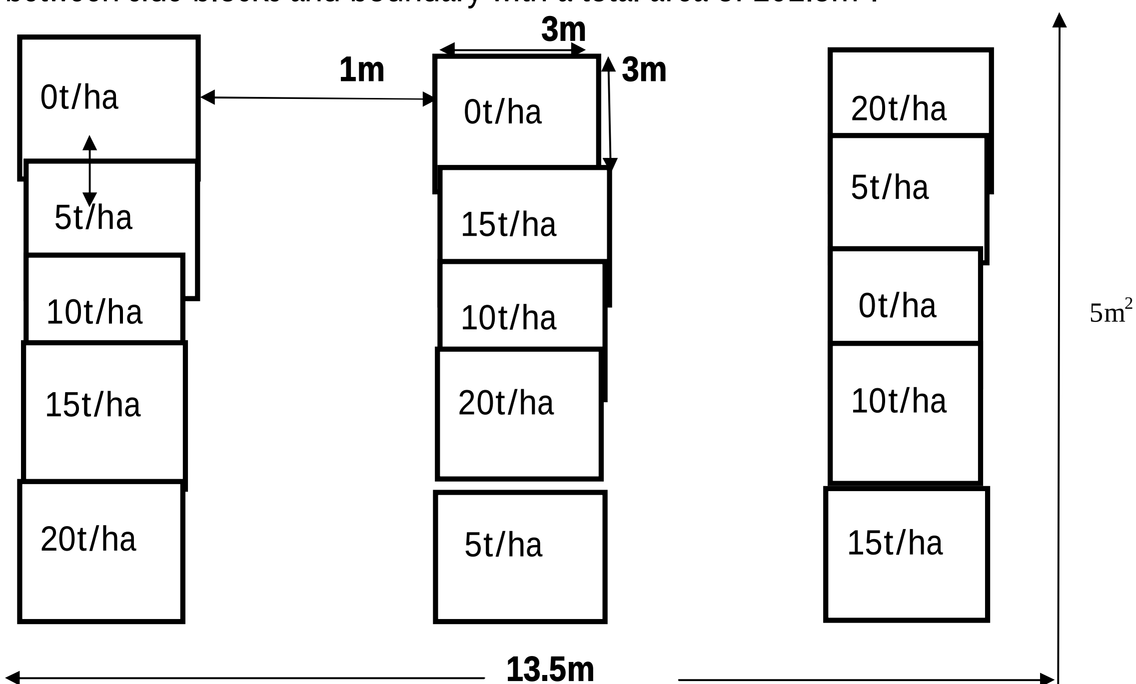

Figure1: Diagram of the Experiment Layout in 2019 showing the plots

Procedure

Poultry manure was obtained from AG's Poultry Farm in Judges Quarter Makurdi, Benue State. The manure was incorporated into the soil at the time of ridge making at different rates to serve as organic manure for the support of maize (*Zeamays*) production and soil amendment.

A portion of the poultry manure was air dried, crushed and analyzed at the Advanced Analytical Soil Testing Laboratory of the Department of

Soil Science College of Agronomy, Joseph Sarwuan Tarka University Makurdi, to ascertain the nutrient composition of the poultry dropping.

Land preparation and cultural practices

The vegetation cover was manually cleared, the land was measured and pegged using twine ropes and sticks in order to demarcate the land to form plots of same size (3m x 3m) for easy identification. Ridges were prepared at 0.5m high and 0.75m wide, and each experimental plot consisted of 3-ridges. Weeds were manually controlled. Application of insecticide known as Best (Lambda cyhalotrin) was done any time insect pests started manifesting on the farm.

Planting date and planting materials

Maize (*Zeamays*) variety IWDC seeds were obtained from the commercial farm at Joseph Sarwuan Tarka University Makurdi and planted on the 29th July, 2019 at inter-row spacing 75cm and intra-row spacing of 50cm and planting rate of 3 seeds per hole. The plants were thinned down to two plants per stand.

Data collection

Crop data

At two weeks after planting, six plants were marked at random in each experimental unit for data collection on specified parameters. Subsequent it was done at 2 weeks intervals up to the 12th weeks after planting.
The following crop growth parameters were collected

- Number of leaves (cm)
- Plant height (cm)
- Stem girth (cm)
- Leaf area (cm^2)
- Dry matter yield and Dry root weight (kg/plot).

Soil Data

Soil samples were taken with the use of auger for soil physical and chemical analysis. Each soil sample was collected and packed in different labelled polythene bag according to the treatment. The samples were collected before and after the experiment. Before the experiment, soil samples were collected from each treatment at two depths (0 – 10 cm and 10 – 20 cm) representing the initial status of the soil. Soil samples were taken from each treatment at one depth (0 – 20cm) at the end of the experiment to represent the final state of the soil and separately analyzed to cross check with that of the initial state of the soil to see the dynamism of the properties of the soil in the various treatments.

Crop data analysis

All data collected on crop parameters were subjected of Analysis of Variance (ANOVA) and significant means were separated using Fisher's Least Significant Different (F- LSD) at 5% level probability.

Soil Analysis

Soil analysis was carried out at the Advanced Analytical Soil Testing Laboratory of the Department of Soil Science, Federal University of Agriculture Makurdi, Benue State. The soil were air dried, crushed using mortar and pestle and passed through a 2mm sieve. The sieved samples were then packed and taken to the laboratory and analyzed.

Particle Size Distribution

The Bouyoucos (1951) was used to determine the particle size distribution of the samples.

Cation Exchange Capacity (CEC)

The CEC was determined by neutral Ammonium Acetate method.

Organic Carbon

The wet oxidation method of Walkley and Black (1934) was used to determine the organic carbon content of the sample.

Total Nitrogen

Total Nitrogen was determined by the Macro-Kjeldahl digestion method (Jackson 1965).

Exchangeable Cations (EC)

The exchangeable cations solutions of these exchangeable cations were determined by atomic absorption Spectrophotometer (Mehlich, 1984).

Available Phosphorus

Bray-1 method was used to determine the extractable phosphorus (Bray and Kurtz, 1945)

Base Saturation

Base saturation was determined by dividing the sum of exchangeable bases by Cation Exchange Capacity (CEC) and multiplying by 100.

Status of Soil Degradation of the Study Area

The level of degradation of soils of the study area were assessed using the standard indicators and criteria for assessment of land (Soil) degradation by the Food and Agriculture Organization (FAO, 1979), as well as the guide for interpretation of analytical data (FAO, 2004). Analytical data from each sample was placed in a degradation class by matching the soil characteristics with the land degradation indicators (Tables 1 – 2). The four degrees of soil degradation used were: Class 1: None-Slightly Degraded Soil (NSD), Class 2: Moderately Degraded Soil (MD), Class 3: Highly Degraded (HD) and Class 4: Very Highly Degraded (VHD).

Table 1: Indicators and Criteria for Soil Degradation Assessment

Indicator	Degree of Degradation			
	1	2	3	4
Soil bulk density (kg/m³)	< 1.5	1.5 – 2.5	2.5 – 5	>5
Permeability (cm/hr)	< 1.25	1.25 – 5	5 – 10	>20
Content of N element (Multiple decrease) N(g/kg)	> 0.13	0.13–0.10	0.10-0.08	<0.08
Content of phosphorus element (mg/kg)	>8	8 – 7	7 – 6	<6
Content of Potassium element (cmol/kg)	>0.16	0.16-0.14	0.14-0.12	<0.12
Content of ESP (increase by 1% of CEC)	<10	10 – 25	25 – 50	<50
Base saturation (decrease of saturation in more than 50%)	<2.5	2.5 – 5	5 – 10	>10
Excess salt (Stalinization) (increase of Conductivity mmho/cm/yr)	<2	2 -3	3 – 5	<5
Content of humus (organic matter) (g/kg) soil	>2.5	2.5 – 2	2 – 1.0	<10

Source: FAO (1979)

Keys: Class 1: Non To Slightly Degraded; Class 2: Moderately Degraded; Class 3: Highly degraded; Class 4: Very highly degraded

Table 2: Interpretation Guide for Evaluating Analytical Data

(a) Exchange cations

Ca^{3+}	**Mg^{2+}**	**K^{+}**	**Na^{+}(cmol/kg)**	**Class**
<2	<0.3	<0.2	<0.1	Very low
2-5	0.3-1	0.1 – 0.3	0.1 – 0.3	Low
5-10	1-3	0.3 – 0.6	0.3 – 0.7	Moderate
10-20	3-8	0.6 – 1.2	0.7 – 2	High
>20	>8	1.2 – 2	>2	Very High

(b) Cation Exchange Capacity | **(c) Percentage Base Saturation (%)**

Range	**Class**	**Range**	**Class**
<6	Very low	0-20	very low
6-12	Low	20-40	low
12-25	moderate	40-60	moderate
25-40	high	60-80	high
>40	very high	>80	very high

(b) Hydraulic Conductivity | **(e) Organic matter Rating**

Range (cm/hr)	**Class**	**Range (%)**	**Class**
<0.13	Very low	<2	Very low
0.13-0.51	Low	2-4	Low
0.15-2.0	Moderately low	4-10	Medium
2.0-6.3	Moderately	10-20	High
6.3-12.7	Moderately rapid	>20	Very high
12.7-25.4	Rapid		
>25.4	Very Rapid		

(f) Soil pH | **(g) Organic Carbon**

Range	**Rating**	**Range (%)**	**Class**
<4.5	Extremely acidic	<0.4	Very low
4.5 – 5.0	Very strongly acidic	0.4-1.0	Low
5.1 – 5.5	Strongly acidic	1.0 – 1.5	Moderate
5.6 – 6.0	Moderately acidic	1.5 – 2.0	High
6.1 – 6.5	Slightly acidic	>2.0	Very High
6.6 – 7.3	Neutral		
7.4 – 7.8	Slightly alkaline		
7.9 – 8.4	Moderately alkaline		
8.5 – 9.0	Strongly alkaline		
>9.0	Very strong alkaline		

(h) Total Nitrogen Metson (1961) | **(i) Available Phosphorus** Enwezoe*et. al. (1989)*

		Bray 1 (mg/kg)		**Bray 2**	
		Range	**Class**	**Range**	**Class**
<0.1	Very low				
0.1 – 0.2	Low				
0.1 – 0.5	Medium	<8	Low	<15	Low
0.5 – 1.0	High	8-20	Medium	15-25	Medium
+0.1	Very high	>20	High	>25	High

Source: *Special programme for Food Security, Federal Ministry of Agriculture and Rural Development (SPFS FMARD) FAO(2004).*

Table 3:Chemical Status of the Poultry Manure applied to the Experimental Plots in 2019.

Sample ID	pH	OC	OM	N	P	K	Ca	Na	Mg	Mn	Fe	Zn	Cu
		(%)	(%)	(%)	(mg/kg)	Cmol/kg				g/kg^{-1}			
P.D	7.12	3.14	5.43	1.05	1.16	1.23	2.67	0.26	2.30	42.11	198.70	24.80	6.15

Key: *P.D = Poultry Droppings, OC= Organic Carbon, OM = Organic Matter*

RESULTS AND DISCUSSION

The chemical status of soil properties in the study area in 2019 is presented on Table 4. It shows that the soil pH ranges from neutral to slightly acidic, all soils were Very Low in organic manure. A similar trend was obtained with nitrogen, all soils were Very Low. Phosphorus, potassium, sodium and calcium were Low in the soils, magnesium was Moderate. While the cation exchange capacity and base saturation was very Low in the soils. The status of soil degradation of the experimental site in 2019 as shown on Table 5 indicates that with regards to organic manure, all soils were Very Highly Degraded. All soils were Highly Degraded with regards to nitrogen. Considering phosphorus all soils were Very Highly Degraded. With respect to potassium, all the soils were None-Slightly Degraded. While they were all Very Highly Degraded with respect to base saturation. The effect of poultry manure application on soil physical and chemical properties of the degraded soil of the College of Agronomy Research Farm North of the JOSTUM revealed that the pH was from slightly acidic to neutral. This trend changed at the end of the experiment as the soil tended to become more acidic.
Awo and Agwu (2005) reported that animal manures have a high capacity for increasing soil pH. This could be due to the increased availability of acidifying agents in poultry manure.

The organic matter content of the soil increased in the treatments where the poultry manure was applied. This was not the same with the control, where there was a decrease at the end of the experiment which could be ascribed to nutrient uptake by the maize planted on the field. Yolanda *et al.* (2007) got similar results in Mexico. Soremi*et al.* (2007) confirmed that application of poultry manure significantly increased organic carbon which is in effect increased organic matter. Agbedee*t al.* (2008) working on poultry manure in the forest savanna transition zone of Southwest Nigeria also obtained increased soil organic matter. There was increase in the nitrogen status upon application of poultry manure. Several studies (Ewulo*et al.,* 2008, Oagile and Mufwanzala, 2010 and Busari*et al.,* 2008), have pointed to increased nitrogen upon application of varying rates of poultry manure in different localities. This trend was also observed in phosphorus. For example, Ewulo*et al.* (2008) upon application of 25 t/ha poultry manure got the highest leaf phosphorus content relative to the control at Akure. Poultry manure also improved available Phosphorus on an Alfisol in Southwest

Nigeria (Adeleye*et al.,* 2010). With reference to the exchangeable cations, there was significant increase in the CEC upon application of poultry manure. In support of these findings, recent studies had shown that poultry manure increased soil exchangeable cations (Oades*et al,* 1989, Soremi*et. al.,* 2017., Oagile and Mufwanzala, 2010).

The effect of poultry manure application on plant performance shows that the highest number of plant leaves was possibly by maize stands that received 5 t/ha of poultry manure possibly because the manure established and maintained soil physical condition for plant growth. This is consistent with the reports of Lombin*et al.* (1992), Mangila*et al.* (2007), and Enujeke E.C (2013) which indicated that poultry manure is essential for establishing and maintaining the optimum soil physical condition for plant growth. It is also synonymous to the findings of Agbede*et al.* (2008) and Ewulo*et al.* (2008) who reported that poultry manure is the only cheap and effective source of nitrogen(N) for sustainable crop production, but improves soil physical properties by reducing temperature, bulk density and increasing total porosity if higher rates are applied.

Maize plants that received poultry manure application rate of 15 t/ha had longer plant height than others. This is consistent with the findings of Adekiya and Ojeniyi (2002) which attributed increased growth of crop plants to the release of more nutrient elements through the moisture that has been made available by the manure. It is also in harmony with the report of John *et al.* (2004) who indicated that poultry manure released essential elements which promoted high photosynthetic activities that enhanced growth and yield of watermelon.The highest stem girth was obtained at T4 (15 t/ha) and lowest at T1 (0 t/ha) which is the control, also the highest leaf area was obtained at T3 (10 t/ha) and the lowest was obtained at T1 (0 t/ha). The highest dry matter yield was observed at T4 (15 t/ha) and lowest at T1 (0 t/ha). The highest dry root weight was obtained at T5 (20 t/ha) and lowest was at T1 (0 t/ha) which is the control. However this shows that application of poultry manure increases maize/crop yield. This is in consonance with the findings of the Alofe*et al.* (1995) which reported that poultry manure application significantly increased soybean over NPK fertilizer. Aliyu (2000), Adekiya and Ojeniyi (2002), Agbede*et al.* (2008) indicated that higher rates of poultry manure increases crop yield. Enujeke (2013) reported that poultry dropping and cattle dung increased root growth of maize. Akande and Adediran (2004) found that poultry manure at 5 t/ha significantly increased tomato dry matter yield.

Table 4: Physical and Chemical Properties of the Experimental Sitebefore the Experiment in 2019

Sample	Depth (cm)	pH (Water)	Sand (%)	Clay (%)	Silt (%)	OC (%)	OM (%)	N (%)	P (mg/kg)	K	Na	Mg	Ca	EB	EA	CEC	BS (%)
										←			Cmolkg^{-1}			→	
0t/ha	0-20	6.61	68.30	19.20	12.50	0.54	0.93	0.080	3.80	0.24	0.23	2.75	2.89	6.11	1.06	7.17	85.22
5t/ha	0-20	6.65	68.72	18.23	13.05	0.49	0.85	0.075	3.83	0.26	0.24	2.76	2.90	6.16	1.00	7.16	86.03
10t/ha	0-20	6.41	67.86	19.11	13.03	0.59	1.02	0.088	4.08	0.28	0.26	2.85	3.02	6.41	1.03	7.44	86.16
15/ha	0-20	6.39	69.08	17.42	13.50	0.55	0.95	0.084	3.90	0.25	0.23	2.72	2.96	6.16	1.11	7.27	84.73
20t/ha	0-20	6.38	68.58	17.17	14.25	0.54	0.93	0.086	3.93	0.27	0.25	2.87	3.08	6.47	1.05	7.52	86.04

Key: *OC = Organic Carbon, OM = Organic Matter, EB = Exchangeable Bases, EA = Exchangeable Acidity, CEC = Cation Exchange Capacity, BS = Base Saturation*

Table 5:Degradation Status of the Soil in the Experimental Site in 2019

PROPERTIES	STATUS
Organic Matter (g/kg)	VHD
Nitrogen (g/Kg)	HD
Phosphorus (mg/kg)	VHD
Potassium (Cmol/kg)	NSD
Bas Saturation (%)	VHD

Key:*VHD = Very Highly Degraded, HD = Highly Degraded, NSD = None-Slightly Degraded*

Table 6:Chemical Status of Soil Properties in the Study Area in 2019

Sample	Depth (cm)	pH (Water)	OM (%)	N (%)	P (mg/kg)	K	Na	Mg	Ca	CEC	BS (%)
						←			$Cmolkg^{-1}$	→	
0t/ha	0-20	N	VL	VL	L	L	L	M	L	VH	VH
5t/ha	0-20	N	VL	VL	L	L	L	M	L	VH	VH
10t/ha	0-20	SA	VL	VL	L	L	L	M	L	VH	VH
15/ha	0-20	SA	VL	VL	L	L	L	M	L	VH	VH
20t/ha	0-20	SA	VL	VL	L	L	L	M	L	VH	VH

Key: *N = Neutral, SA = Slightly Acidic, L = Low, VL = Very Low, M = Moderate, VH = Very High, OM = Organic Matter, CEC = Cation Exchange Capacity, BS = Base Saturation*

Table 7: Physical and Chemical Properties of the Soil after the Experiment in 2019

Sample	Depth (cm)	pH (Water)	Sand (%)	Clay (%)	Silt (%)	OC (%)	OM (%)	N (%)	P (mg/kg)	K	Na	Mg	Ca	EB	EA	CEC	BS (%)
										Cmolkg^{-1}							
0t/ha	0-20	6.13	68.80	19.20	12	0.45	0.79	0.067	2.66	0.18	0.16	2.00	2.10	4.44	1.10	5.54	80.14
5t/ha	0-20	6.09	69.64	16.36	14	1.10	1.90	0.097	4.30	0.28	0.26	2.93	3.20	6.67	1.13	7.80	85.51
10t/ha	0-20	6.16	68.08	17.42	14.5	0.98	1.69	0.086	3.65	0.24	0.21	2.80	2.98	6.23	1.10	7.33	84.99
15 t/ha	0-20	6.20	67.80	19.20	13	1.11	1.92	0.098	4.60	0.27	0.24	2.96	3.18	6.65	1.17	7.82	85.70
20t/ha	0-20	6.11	68.36	18.64	13	1.00	1.73	0.088	3.70	0.25	0.22	2.88	3.00	6.35	1.12	7.47	85.01

Key: *OC = Organic Carbon, OM = Organic Matter, EB = Exchangeable Bases, EA = Exchangeable Acidity, CEC = Cation Exchange Capacity, BS = Base Saturation*

Table 8: Percentage Change in the Status of the Soil Parameters after the Experiment in 2019

Sample	Depth (cm)	pH (H_2O)	OC (%)	OM (%)	N (%)	P (mg /kg)	K	Na	Mg	Ca Cmolkg^{-1}	EB	EA	CEC	BS (%)
0 t/ha	0-20	-7.26	-16.67	-15.05	-16.25	-30.00	-25.00	-30.44	-27.27	-27.34	-27.33	3.77	-22.73	-5.96
5t/ha	0-20	-8.42	124.40	123.53	29.33	12.27	7.69	8.33	6.16	10.34	8.28	13.00	8.94	-0.60
10t/ha	0-20	-3.90	66.10	65.69	-2.27	-10.54	-14.29	-19.23	-1.75	1.33	-2.81	6.80	-1.48	-1.36
15/ha	0-20	-2.97	101.81	102.11	16.67	17.95	8.00	4.35	8.82	7.43	7.96	5.41	7.57	1.15
20t/ha	0-20	-4.23	85.19	86.02	2.33	-5.85	-7.41	-12.00	0.35	2.60	-1.86	6.67	-0.66	-1.20

Key: *OC = Organic Carbon, OM = Organic Matter, EB = Exchangeable Bases, EA = Exchangeable Acidity, CEC = Cation Exchange Capacity, BS = Base Saturation*

Table 9: Effect of Poultry Manure Application on Number of Leaves of Maize at Makurdi in 2019

Treatment	Weeks After Planting		
	4	**8**	**12**
T1	5.06	7.39	10.11
T2	7.72	14.22	14.72
T3	6.83	13.61	13.33
T4	7.33	13.94	13.83
T5	7.17	13.72	13.83
F-LSD(0.05)	1.547	2.059	0.966

Key: *PM = Poultry Manure, T1 = 0t/ha of PM, T2 = 5t/ha of PM, T3 = 10t/ha of PM, T4 = 15t/ha of PM, T5 = 20t/ha*

Table 10: Effect of Poultry Manure Application on Plant Height (cm) of Maize at Makurdi in 2019

Treatment	Weeks After Planting		
	4	8	12
T1	14.70	50.30	102.40
T2	57.70	174.30	193.30
T3	42.10	153.80	192.10
T4	43.70	161.90	200.30
T5	44.50	157.20	182.20
F-LSD(0.05)	18.67	50.98	32.36

Key: *PM = Poultry Manure, T1 = 0t/ha of PM, T2 = 5t/ha of PM, T3 = 10t/ha of PM, T4 = 15t/ha of PM, T5 = 20t/ha*

Table 11: Effect of Poultry Manure Application on Stem Girth (cm) per plot of Maize at Makurdi in 2019

Treatment	Weeks After Planting		
	4	**8**	**12**
T1	1.48	3.08	3.07
T2	5.08	7.67	7.51
T3	3.83	7.60	7.47
T4	4.06	8.24	7.89
T5	4.11	7.99	7.74
F-LSD(0.05)	1.720	1.112	0.817

Key: *PM = Poultry Manure, T1 = 0 t/ha of PM, T2 = 5 t/ha of PM, T3 = 10 t/ha of PM, T4 = 15 t/ha of PM, T5 = 20 t/ha*

Table 12: Effect of Poultry Manure Application on Leaf Area (cm^2) per plot of Maize at Makurdi in 2019

Treatment	Weeks After Planting		
	4	8	12
T1	35.00	179.00	594.00
T2	266.00	494.00	1584.00
T3	288.00	364.00	1586.00
T4	226.00	353.00	1436.00
T5	207.00	381.00	1488.00
F-LSD(0.05)	97.9	77.1	305

Key: *PM = Poultry Manure, T1 = 0 t/ha of PM, T2 = 5 t/ha of PM, T3 = 10 t/ha of PM, T4 = 15 t/ha of PM, T5 = 20 t/ha*

Table 13: Effect of Poultry Manure Application on Dry Matter Yield (DMY) and Dry Root Weight (DRY)per plot of Maize at Makurdi in 2019 at 16 Weeks After Planting

Treatment	DMY		DRW	
	(kg/plot)	(t/ha)	(kg/plot)	(t/ha)
T1	0.03	0.00003	0.07	0.00007
T2	2.80	0.0028	1.16	0.00116
T3	2.35	0.00235	1.11	0.00111
T4	2.95	0.00295	1.10	0.00110
T5	2.75	0.00275	1.51	0.00151
F-LSD(0.05)	0.957	0.000957	0.838	0.000838

Key: *PM = Poultry Manure, T1 = 0t/ha of PM, T2 = 5t/ha of PM, T3 = 10t/ha of PM, T4 = 15 t/ha of PM, T5 = 20t/ha*

CONCLUSION

Although the soil of the study area was very highly degraded, the application of poultry manure improved the soil characteristics such as pH, organic matter, nitrogen, phosphorus, exchangeable bases, exchangeable acidity, cation exchange capacity and base saturation. This led to a significant increase in production of maize. It can be recommended that 15 t/ha of poultry manure be applied to the severely degraded soils of the study area to restore their productive capacity for accelerated maize production.

REFERENCES

Abdelrazzag, A. (2002). Effect of Chicken Manure, Sheep Manure and Inorganic Fertilizer on Yield and Nutrient uptake by onion. Park, *Journal of BiologicalScience*, 5:226-268.

Adeleye, E.O., Ayeni, L.S. and Ojeniyi, S.O. (2010). Effect of Poultry Manure on Soil Physico-chemical Properties, Leaf Nutrient Contents and Yield of Yam (*Dioscorearotundata*) on Alfisol in Southwestern Nigeria. *Journal of American Science,* 6 (10) 871-878.

Adewole, M.B. Otitoju, O.M. and Okoya, A.A. (2016). Comparative Assessment of Different Poultry Manures and Inorganic Fertilizer on Soil Properties and Nutrient Uptake of Maize (*Zeamays* L.). *African Journal of Biotechnology*, 15(22). 995-1001.

Adekiya, A.O. and Ojeniyi, S.O. (2002). Evaluation of Tomato Growth and Soil Properties under Methods of Seedling Bed Preparation in an Alfisol in the Rainforest Zone of Southwest Nigeria. Bioresource Technology. 96:509-516.

Agbede, T.M. Ojeniyi, S.O. and Adeyemo, A.J. (2008). Effect of Poultry Manure on Soil Physical and Chemical Properties, Growth and Grain Yield of Sorghum in Southwest, Nigeria. *American-Eurasian Journal of Sustainable Agriculture*, 2(1): 72-77.

Akande, M.O. and Adediran, J.A. (2004). Effects of Terralyt plus Fertilizer on Growth Nutrients Uptake and Dry Matter Yield of two Vegetable crops. *Moor Journal of Agricultural Research*, 5:12 - 107.

Aliyu, L. (2000). The effects of Organic and Mineral Fertilizer on Growth, Yield and Composition of Pepper (*Capsicum annum L*). *Biological Agriculture and Horticulture*, 18:29-36.

Alofe, C.O., V.I.O. Olowe and Bameke, I.O. (1995). Response of Soybean Cultivar `Doko´ to Poultry Manure , NPK Fertilizer and Row Spacing in a Humid Tropical location. *Tropical Oilseeds Journal*, 2:144-147.

Ano, A.O. and Agwu, J.A. (2005). Effect of Animal Manure on Selected Soil Chemical Properties. *Nigeria Journal of soil science,* 15, 14-19.

Barrow, C.J. (1991). Land Degradation: Development and Breakdown of Terrestrial Environment. Cambridge University Press. Pp 295.

Bouyoucus, C.J. (1951). Hydrometer Method for Making Particle Size Analysis of Soil. *Soil Science Society of America Proceedings*, 26, 464-465.

Bray, R.H. and Kurtz, L.T. (1945). Determination of Available forms of Phosphorus in Soils. *Soil Science Society of America,* 59, 39-45.

Busari, M.A. Salako, F.K. and Adetunji, M.T. (2008). Soil Chemical Properties and Maize Yield after Application of Organic and Inorganic Amendments to an Acidic Soil in Southwestern Nigeria. *Spanish Journal of Agricultural Research*: 6(4), 691-699.

Duncan, J. (2005). Composting Chicken Manure. WSU Coorperative Extension, King County Master Gardener and Cooperative Extension Livestock Advisor.

Enujeke , E.C. (2013). Effect of Poultry Manure on Growth and Yield of Improved Maize in Asaba Area of Delta State, Nigeria. *Journal of Agriculture and Veterinary Science* , 4:24-30.

Ewulo, B.S. Ojeniyi, S.O. and Akanni, D.A. (2008). Effect of Poultry Manure on selected Soil Physical and Chemical Properties, Growth, Yield and Nutrient Status of Tomato. *African Journal of Agricultural Research,* 3 (9) :9-14.

Ezeibekwe, I.O. Ogbonnaya, C.I. and Onuoha, C.I. (2009). Comparative Effect of Poultry Manure and Urea on the Growth and Yield of Maize

(*Zea mays* L.). Report and opinion. *Marsland Press Science journal*, 1(4):37-40.

Food and Agriculture Organization (FAO) (1979). A Provisional Methodology for Land Degradation Assessment. FAO.Rome.

Food and Agriculture Organization (FAO) (2004). A Provisional Methodology for Land Degradation Assessment. FAO. Rome.

Farhad, W. Saleem, M.F. Cheema, M.A. and Hammad, H.M. (2009). Effect of Different Manures on the Productivity of Spring Maize (*Zea mays* L). *The Journal of Animal and Plant Sciences,* 19(3):122-125.

Hornick, S.B. and Parr, J.F. (1987). Restoring Productivity of Marginal Soils with Organic Amendments. *American Journal of Alternative Agriculture*, 2:64-68.

Izauuralde, R.C. Malhi, S.S. Nyborg, N. Solberg, E.D. Quiroga, M.C. and Jaka, S. (2006). Crop Performance and Soil Properties in two Artificially Eroded Soil in North-Central Alberta. *Agronomy Journal*, 98:1298-1311.

Johnson, D.I. and Lewis L.A. (1995). Land Degradation Creation and Destruction. Oxford: Blackwell.

John, L.W. jammer, D.B. Samuel, L.M .and Warner, L.W. (2004). Soil Fertility and Fertilizers: An Introduction to Nutrient Management. *Pearson Education*, India. Pp 106-53.

Lal, R. (2001). Soil Degradation by Erosion. *Land Degradation and Development,* 12:519-539.

Lombin, L.O. Adepetu, J.A. and Ayotade, K.A. (1991). Complementary Use of Organic Manures and Inorganic Fertilizers in Arable Crop Production: Organic Fertilizer in the Nigerian Agriculture: present and future. Proceedings of a National Organic Fertilizer Seminar, Kaduna- Nigeria, March 26-27.

Melero, S. Madejon, E. Ruiz, J.C. and Herencia, J.F. (2007). Chemical and Biological Properties of a Clay Soil under Dryland Agriculture System as affected by Organic Fertilization. *European Journal of Agronomy*, 26: 327-334.

Milkah, M.M. Benjamin, G.J. Stahlman, W.P. and Geier, W.P. (2014). Remediation/Restoration of Degraded Soil. Impact on Soil Chemical Properties. *Agronomy Journal*, 106:252-260.

Nwajiuba, C. and Chimezie, P. (2000). The Use of Livestock Wastes in Soil Fertility Regeneration in Imo State of Nigeria. Proceedings of the First Annual Conference of the College of Agriculture and Veterinary medicine, Abia State University held on 10th-13th September, pp.137-140.

Oades, J.M. (1989). An Introduction to Organic Matter in Mineral Soils. In: Minerals in Soil Environments (Eds J.B. Dixon and S.B. Weed) pp. 89-159. (Soil Science Society of America Madison, Wisconsin.).

Oagile, D. and Mufwanzala, N. (2010). Chicken Manure-enhanced Soil Fertility and Productivity: Effect of Application Rates. *Journal of Soil Science and Environmental Management*, Vol. 1(3)46-54.

Ogbalu, O.K. (1999). The Effects of Different Traditional Sources of Nutrients on the Infestation of Pepper fruits by the Pepper fruit fly in Nigeria. *Journal of Agronomy and Crop Science*, 182:65-71.

Ojeniyi, S.O. Oso, O.P. and Arotolu, A.A. (2001). Response of Vegetable to Woodash Fertilizer. Proceedings of 35th Annual Conference of *Agricultural Science of Nigeria*. Pp. 39-43.

Sanchez, P.A. and Miller, H. (1997). Organic Matter and Soil Fertility Management in Acid Soils of the Tropics. Trans 13th International Congress of Soil Science, Hanburg 6, 609-625.

Soremi, A.O. Adetunji, M.T. Adejuyigbe, C.O. Bodunde, J.G. and Azeez, J.O. (2007). Effects of Poultry Manure on Some Chemical Properties and Nutrients Bioavailabilty to Soybean. *Journal of Agriculture and Ecology Research International,* 11(3): 1-10.

UNCCD (2015). Desertification, Land Degradation and Drought (DLDD): Some Global Facts and Figures. United Nations Conventions to Combat Desertification

Walkley, A. and Black, I.A. (1934). An examination of the Degtjareff Method of Determining Soil Organic Matter and proposed Modification of the Chromatic Acid Titration Method of Soils. *Soil Science*, 37:29-38.

Yolanda, M.S. Fidel, P.M and Francisco, P.G. (2007). Effect of the Application of Cattle Manure on the Properties Chemistry of soil in Tizayuca, Hidalgo, Mexico. *International Journal of Applied Science and Technology,* 4(3) :67-72.

Young, R. Orsini, S. and Fitzpatrick, I. (2015). Soil Degradation: A major threat to humanity. *Sustainable Food Trust*, UK. 13pp. http://sustainablefoodtrust.org.

Zika, M. and Erb, K.H. (2009). The Global Loss of Net Primary Production resulting from Human induced Soil Degradation in Dryland. *Ecological Economics*. 69:310-318.