



## Effect of Different Manures and Rates of Application on the Chemical Properties of a Floodplain Soil, in North Western Nigeria

M. Audu<sup>1</sup>, M. M. Sauwa<sup>1\*</sup>, A. Shehu<sup>1</sup>, M. Haliru<sup>1\*</sup>, S. A. Lukman<sup>1</sup> and B. S. Haliru<sup>2</sup>

<sup>1</sup>Department of Soil Science, Faculty of Agriculture, Usmanu Danfodiyo University, P.M.B. 2346, Sokoto, Sokoto State, Nigeria.

<sup>2</sup>Department of Crop Science, Faculty of Agriculture, Usmanu Danfodiyo University, P.M.B. 2346, Sokoto, Sokoto State, Nigeria.

### Authors' contributions

This work was carried out in collaboration between all authors. Author MA designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author MMS managed the literature searches and statistical analyses of data obtained, authors AS and BSH managed the experimental process while authors SAL and MH helped with laboratory analyses. All authors read and approved the final manuscript.

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### ABSTRACT

Application of manures at appropriate rates could sustain the chemical quality of floodplain soils under intensive continuous cultivation. Thus, a study was carried out at the Department of Soil Science, Faculty of Agriculture, Usmanu Danfodiyo University, Sokoto to assess the effect of different manures and rates of application on chemical properties of a floodplain soil in Sokoto, Northwestern, Nigeria. The treatments consist of three different manures (poultry droppings: PD, turkey droppings: TD and Quail droppings: QD), four rates of application (7.5 t ha<sup>-1</sup>, 15 t ha<sup>-1</sup>, 22.5 t ha<sup>-1</sup> and 30 t ha<sup>-1</sup>) plus a control, replicated 3 times, which were arranged in a completely randomized design (CRD). The parameters determined include organic carbon (OC),

\*Corresponding author: Email: [mmsauwa4u@yahoo.com](mailto:mmsauwa4u@yahoo.com), [halirumuazu@gmail.com](mailto:halirumuazu@gmail.com);

total nitrogen (TN), available phosphorus (AP) and exchangeable bases. The results revealed that, different manures and rates of application significantly ( $p \leq 0.05$ ) influenced chemical properties of the soil, particularly OC, TN and AP contents of the soil. The PD and QD manures significantly ( $p \leq 0.05$ ) improved chemical quality of the soil, with best improvement observed in PD manure, while the  $15 \text{ t ha}^{-1}$  and  $30 \text{ t ha}^{-1}$  rates, were found to have best improvements in chemical properties of the soil. However, the  $15 \text{ t ha}^{-1}$  rate seems more viable as it produces similar effects as that of the  $30 \text{ t ha}^{-1}$  rate. It is therefore concluded that, application of  $15 \text{ t ha}^{-1}$  PD or QD has the capacity of improving the soil chemical quality under intensive agricultural crop production, and is thus recommended as a means of replenishing productivity of the soil in the study area.

*Keywords: Floodplain soils; chemical properties; chemical quality Northwestern Nigeria; different manures; rates of application.*

## 1. INTRODUCTION

Fadama (floodplain) soils are naturally rich due to their greater water retention and nutrient reserves that could support crop production. This has motivated numerous farmers to intensively cultivate fadama lands for sustainable agricultural crop production. However, vast area of tropical lands that were once fertile have been rendered unproductive due to continuous cultivation and erosion which causes physical and chemical degradation of soils, likewise aluminium (Al) and manganese (Mn) toxicity [1]. Thus, the search for management practices capable of sustaining productivity of floodplain soils under continuous intensive cultivation, in Northwestern Nigeria became a continuing exercise. Among such practices include the use of organic and inorganic fertilizers.

Inorganic fertilizers are often expensive and not easily accessed by most farmers. This coupled with environmental and health problems associated with long term use of chemical fertilizers has necessitated the return to organic fertilization. Organic manures when applied to soils improve its physical, chemical and microbial properties [2]. Improvement in chemical properties of soils such as organic matter (OM), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg) due to organic fertilization had been reported by number of workers [3,4]. This could invariably result in, improved growth and yield of crops as previously observed by researchers in Southwestern Nigeria [4]. Thus, maintenance of productivity of floodplain soils under intensive cultivation, could be achieved through organic fertilization.

Among most commonly used organic amendments in Nigeria are poultry manure and cow dung. However, with growing population and increasing demand for these manures, the need

to explore more manure options for sustainable agriculture became crucial. Therefore, this research aimed at investigating the effect of different manures and rates of application on soil chemical properties, in view of adding to the organic resource base of Northwestern Nigeria.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The experiment was conducted at the Department of Soil Science and Agricultural Engineering, Faculty of Agriculture, Usmanu Danfodiyo University, Sokoto. Sokoto State is located in the Northwestern part of Nigeria, and lies on latitude  $13^{\circ}\text{N}$  and  $15^{\circ}\text{E}$ , 315 m above sea level. The vegetation of Sokoto is characterized by scattered trees and grasses with mono-modal type of rainfall. The rainfall is erratic and scanty in nature, which lasts for about 4 months and is highly variable over the year [5,6]. The area experiences two distinct seasons which are wet and dry seasons. The climate of the area is characterized with high temperature in most parts of the year. The average annual minimum and maximum temperatures are  $15^{\circ}\text{C}$  and  $40^{\circ}\text{C}$  [7].

### 2.2 Organic Manures

The organic manures used were sourced from the veterinary centre Aliyu Jodi Road, Shagon Goro and Kofar Atiku areas all in Sokoto Metropolis, Nigeria. Both manures were collected under battery cage system. The manures were slightly chopped using pestle and mortar before application to the soil.

### 2.3 Treatments and Experimental Design

A bulk composite sample was initially collected (at 0-20 cm soil depth) from floodplain area of

Kwalkwalawa Village, Usmanu Danfodiyo University, Sokoto. 5 kg soil of the bulk sample was filled in each treatment pot, and individual treatments (different manures and rates, plus a control) were assigned, incubated (watered and left for 2 weeks), thoroughly mixed and used for the pot experiment that lasted for 8 weeks. The treatments consisted of 3 organic manures from different sources (poultry droppings (PD), turkey droppings (TD), Quail droppings (QD)) and four rates : 7.5 t/ha, 15 t/ha, 22.5 t/ha, and 30 t/ha corresponding to 19 g/5 kg soil, 38 g/5 kg soil, 57 g/5 kg soil and 76 g/5 kg soil respectively, plus a control (no manure application) laid out in a completely randomized design (CRD).

## 2.4 Soil Sample Collection and Preparation

At the end of the pot experiment (8 weeks), 3 random soil samples at 0-20 cm soil depth were collected from each treatment pot, thoroughly mixed to obtain composite samples. The composite soil samples obtained from each treatment pot, were then taken to the Chemical Laboratory of Department of Soil Science, Faculty of Agriculture, Usmanu Danfodiyo University, Sokoto, air dried, gently crushed and sieved through 2 mm sieve and kept for analysis. Part of the initial composite soil sample obtained and samples of manures used were also collected, prepared and analyzed before commencement of the research.

## 2.5 Determination of Soil Chemical Properties

The composite soil samples collected were analyzed for chemical properties using standard methods. Organic carbon (OC) using oxidation method of [8], pH using glass electrode pH meter [9], total nitrogen (TN) by kjeldahl digestion method [10]. Available phosphorus (AP) was determined using bray-1-method [11], while exchangeable bases were extracted with neutral 1 molar (NH<sub>4</sub>OAC) ammonium acetate [12]. Potassium (K) and sodium (Na) in the extract were read using flame photometer, while calcium (Ca) and magnesium (Mg) were determined using EDTA titration method. The cation exchange capacity (CEC) of the soil samples was determined using normal neutral ammonium acetate [13].

## 2.6 Data Analysis

Data obtained was subjected to analysis of variance (ANOVA) procedure for CRD using statistix 9.0 [14], and means were separated using least significance difference (LSD) test, at 5% level of probability.

## 2.7 Physical and Chemical Properties of Soil and Manures Used

Initial physical and chemical properties of soil and manures used for the experiment are presented in Tables 1 and 2 respectively. Table 1 revealed that, the soil is slightly acidic, non-saline, having low content of organic carbon (OC), total nitrogen (TN), available phosphorus (AP), calcium (Ca) and CEC. The soil is however, high in potassium (K) and medium in magnesium (Mg) contents [15]. Therefore, soil response to the different organic manures is thus anticipated.

With regards to the chemical properties of the manures used, all manures have appreciable amounts of total nitrogen (TN), available phosphorus (AP) and exchangeable cations (Table 2). Thus, all manures had the tendency of improving soil chemical conditions to withstand agricultural crop production.

## 3. RESULTS AND DISCUSSION

### 3.1 Effect of Different Manures on Chemical Properties of the Soil

Results of the effect of different organic manures on the chemical properties of the soil are presented in Table 3. The results showed that, manures had significant ( $P \leq 0.05$ ) influence on chemical properties of the soil. The soil total nitrogen (TN), available phosphorus (AP), magnesium (Mg) and potassium (K) contents, were all significantly improved by manure application. On average, Poultry dropping (PD) gave the best improvement in TN (0.17%), AP (1.35 mg/kg), Mg (0.79 cmolkg<sup>-1</sup>) and K (1.55 cmolkg<sup>-1</sup>) contents of the soil, followed by Quail droppings (QD) compared with the other treatments. The control (CTR) and Turkey droppings (TD), had the least values of most soil chemical properties (Table 3). However, other chemical properties of the soil such as organic carbon (OC), cation exchange capacity (CEC)

**Table 1. Initial physical and chemical properties of the soil used**

Parameter	pH (H <sub>2</sub> O,1:1)	EC μScm <sup>-1</sup>	OC (g/kg)	TN (%)	AP (mg/kg)	K .....Cmolkg <sup>-1</sup> .....	Na	Ca	Mg	CEC
Soil	6.61	345.1	1.54	0.07	0.44	1.92	1.26	0.55	0.40	6.72
Texture	<b>Sand (%)</b>	<b>Silt (%)</b>	<b>Clay(%)</b>							
	42.0	37.4	20.6							

PD-poultry droppings, TD-turkey dropping, QD-Quail droppings, EC-Electrical conductivity, OC-organic carbon, TN-total nitrogen, AP-available phosphorus, K-potassium, Na-sodium, Ca-calcium, Mg-magnesium, CEC-cation exchange capacity

**Table 2. Chemical composition of manures used**

Parameter	pH (H <sub>2</sub> O,1:1)	EC μScm <sup>-1</sup>	OC (g/kg)	TN (%)	AP (mg/kg)	K	Na	Ca	Mg	CEC
PD	8.19	908.8	-	2.93	0.73	180.5	40.0	1.15	1.30	-
TD	8.32	1561.6	-	3.28	0.70	92.3	20.9	0.95	1.55	-
QD	7.39	1171.2	-	2.60	0.92	153.8	34.8	1.00	1.60	-

PD-poultry droppings, TD-turkey dropping, QD-Quail droppings, EC-Electrical conductivity, OC-organic carbon, TN-total nitrogen, AP-available phosphorus, K-potassium, Na-sodium, Ca-calcium, Mg-magnesium, CEC-cation exchange capacity

**Table 3. Effect of different manures on chemical properties of the soil in Sokoto, Nigeria**

Treatments	pH (H <sub>2</sub> O,1:1)	OC (g/kg)	TN (%)	AP (mg/kg)	Ca	Mg	Na	K	CEC
PD	6.51a	1.75a	0.17a	1.35a	0.59a	0.79a	0.69a	1.55a	49.28a
TD	6.40a	1.59a	0.10c	0.99c	0.59a	0.72b	0.66a	1.42b	48.10a
QD	6.45a	1.65a	0.12b	1.23b	0.60a	0.71b	0.67a	1.43b	48.56a
CTR	6.40a	1.52a	0.07d	0.81d	0.58a	0.71b	0.65a	1.39b	48.06a
SE(±)	0.11	0.11	0.01	0.01	0.06	0.07	0.17	0.05	1.19

1- Means followed by the same letter (s) in the same column are not significantly different at 5 % probability level

2- PD-poultry droppings, TD-turkey dropping, QD-Quail droppings, CTR-control, SE- standard error, OC-organic carbon, TN-total nitrogen, AP-available phosphorus, K-potassium, Na-sodium, Ca-calcium, Mg-magnesium, CEC-cation exchange capacity

and pH were not significantly ( $P \geq 0.05$ ) influenced by manure application (Table 3). Generally, manure treated pots had higher values of most chemical properties of the soil compared with the control, which implies improvement in chemical quality of the soil by the manures (Table 3).

The improvement in soil chemical properties observed due to manure application is been anticipated, as decomposition of organic matter contained in the different manures which invariably results in the released of nutrients to the soil, thus, the increases in most of the chemical properties of the soil observed (Table 3). This result is in line with the findings of previous studies that amendment of soil using organic manure (poultry manure) improved soil OM, N, P, K, Ca and Mg contents through

decomposition and release of nutrients to the soil [16,17,4]. Similarly, [18] also observed improved chemical quality of a severely degraded sandy soil due to manure application in southern Nigeria. In addition, [19] reported improvement in chemical properties of soil due to application of Poultry manure. It is however striking that, Turkey droppings (TD) despite having highest nitrogen content initially (Table 2), recorded the least value of total nitrogen (TN) after the experiment compared to PD and QD treatments (Table 3). This could however be due to better ease of decomposition and mineralization of PD and QD manures compared to the TD, which might have resulted in release of nutrients (including nitrogen) to the soil. This is in accordance with observation made by [20] that, organic matter in poultry manure is more readily available and in best forms than in other

manures tested (Cow and Sheep manure), which invariably resulted in more nutrient elements contribution of the manure (poultry manure) to the soil.

In addition, physical observation of particles of the different manures tested, revealed TD manure particles been coarser than PD and QD manures. This might provide more surface area (in PD and QD manures) for action by microbial organisms leading to faster decomposition and release of mineral elements to the soil. This conforms with earlier assertion made by [21] who maintained that, the smaller the organic matter particle, the greater the surface area exposed to decomposition, hence the faster the rate of decomposition. However, the implication of this finding is that, manure particles size could be more important in determining its mineral elements contribution to the soil than its initial mineral composition.

In general, a noteworthy development in the above findings is that application of PD or QD manure improves soil chemical quality, with best improvement observed in PD manure. This could result to improved growth and yield of crops as observed by previous workers [4,22].

### 3.2 Effect of Manure Rates of Application on Chemical Properties of the Soil

Results of manure rates of application effect on soil chemical properties are presented in Table 4. The results revealed that, rates of application of

manures significantly ( $P \leq 0.05$ ) affected chemical properties of the soil. Application of 15 and 30 t/ha rates, significantly improved organic carbon (OC) and calcium (Ca) contents of the soil, while all the rates of application except control (no manure: CTR) significantly improved total nitrogen (TN) and available phosphorus (AP) contents of the soil. Other chemical properties of the soil were not significantly ( $P \geq 0.05$ ) improved by rates of application (Table 4). The results observed were similar to the findings of [23], who found that, addition of 25 t/ha of organic manure resulted in appreciable improvement in chemical properties of soil in south-western, Nigeria. Similarly, [24] observed application of 20 t/ha organic manure to have significant positive effect on soil chemical quality in North-eastern, Iran.

Generally, there was no consistent trend observed in rates effects on chemical properties of the soil (Table 4). This could be attributed to the non-consistent trend in chemical composition of the manures used (Table 2), which might have generated varied responses. However, a trend towards best improvement in chemical properties of the soil due to application of 15 t/ha and 30 t/ha organic manures was observed. This is confirmed by higher values of most chemical properties in 15 t/ha and 30 t/ha rates compared with other rates and control (Table 4). This suggest the suitability of the 15 t/ha and 30 t/ha for improving the chemical properties of the soil for sustainable crop production. However, the 15 t/ha rate seems more viable than the 30 t/ha, as it produces similar effects as those of 30 t/ha.

**Table 4. Effect of manure rates of application on chemical properties of the soil in Sokoto, Nigeria**

Treatments	pH (H <sub>2</sub> O,1:1)	OC (g/kg)	TN (%)	AP (mg/kg)	Ca	Mg	Na Cmolkg <sup>-1</sup>	K	CEC
7.5 t/ha	6.56a	1.33c	0.13a	1.16a	0.59ab	0.69a	0.67a	1.43a	48.82a
15 t/ha	6.50a	1.80a	0.13a	1.18a	0.61a	0.77a	0.65a	1.46a	48.84a
22.5 t/ha	6.33a	1.74ab	0.13a	1.20a	0.55b	0.73a	0.66a	1.49a	49.55a
30 t/ha	6.40a	1.78ab	0.13a	1.21a	0.62a	0.77a	0.70a	1.49a	47.38a
CTR	6.40a	1.52bc	0.07b	0.81b	0.58ab	0.71a	0.65a	1.39a	48.06a
SE±	0.12	0.09	0.01	0.07	0.02	0.07	0.10	0.07	2.77

1- Means followed by the same letter (s) in the same column are not significantly different at 5 % probability level,

2- PD-poultry droppings, TD-turkey dropping, QD-Quail droppings, CTR-control, SE- standard error,

OC-organic carbon, TN-total nitrogen, AP-available phosphorus, K-potassium, Na-sodium, Ca-calcium, Mg-magnesium, CEC-cation exchange capacity

#### 4. CONCLUSION

The study revealed that poultry droppings (PD) and Quail droppings (QD), significantly ( $P \leq 0.05$ ) improved chemical properties of the soil compared to the other treatments, with best improvement observed in PD manure. The study further revealed that, the 15 t/ha and 30 t/ha rates, gave the best soil chemical quality. However, 15 t/ha seems more viable than 30 t/ha, as it produces similar effects as those of 30 t/ha. Based on these findings, the following conclusions were drawn:

- (i) Application of 15 t/ha PD or QD manures, has the potential of improving the soil chemical conditions to withstand intensive cultivation.
- (ii) Quail bird droppings (QD) is found to be another promising organic amendment capable of improving soil chemical quality, in semi arid regions.

#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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