

Effect of Animal Manure Applications on Some Selected Soil Properties, Growth and Yield of Maize (*Zea mays*) in Obio Akpa, Akwa Ibom State, Nigeria

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Abstract

*This study was carried out at the Teaching and Research Farm of Akwa Ibom State University, to determine the influence of animal manures on soil properties and maize (*Zea mays*) growth and grain yield. The experiment was established in a randomized complete block design (RCBD) with four treatments including; control, goat manure, pig manure and poultry manure; each was replicated four times. Soil samples obtained before planting and at harvest were analyzed for physicochemical properties, while data obtained on plant growth and yield parameters were subjected to the Fisher's Least Significant Difference (LSD) test at $p < 0.05$. The soil nutrients and maize performance were significantly higher in the animal manure treated plots than the control. Pig manure had the highest organic matter (2.18%), total nitrogen (2.31%) and available phosphorus (11.0%) increase over the control resulting in better maize growth and grain yield. Poultry manure had significant effects on increasing soil pH (6.62) and base saturation (74.26%), while goat manure contributed to improvement of soil nutrient. Among the animal manure treatments, the maize yield significantly increased in these order; Poultry Manure (507.5g) > Pig Manure (407.5g) > Goat Manure (307g) > Control (207.5g). The study concludes that poultry manure is the most effective for increase in maize grain yield in the study area.*

1.0 Introduction

Maize (*Zea mays L.*), often referred to as the "Queen of Cereals," possesses the highest genetic yield potential among food crops (USDA, 2021). Unlike many cereals, it can be cultivated across diverse seasons and ecologies, with wide-ranging uses in food, feed, and industry. Maize has diversified into several types, including yellow and white grain maize, sweet corn, baby corn, popcorn, waxy corn, high amylase corn, high oil corn, and quality protein maize. Beyond its role as food, maize also serves as an important industrial raw material. Globally, maize is cultivated on over 160 million hectares across 166 countries, reflecting its adaptability to various soil types, climatic conditions, biodiversity, and management systems (USDA, 2021). It contributes

significantly to global food supply, accounting for about 40% of total annual cereal production, exceeding 800 million tons. The United States is the largest producer, contributing nearly 35% of global maize output, followed by China with over 20% (USDA, 2021). With an annual global production exceeding 1.2 billion tons, maize ranks as the third most important cereal after wheat and rice, underpinning food security, livestock production, and biofuel industries worldwide.

Soil fertility remains a key determinant of maize productivity. Organic amendments, particularly from animal manure sources, have long been recognized as sustainable alternatives to chemical fertilizers for enhancing soil fertility and crop performance with the links between availability of exchangeable calcium, magnesium and potassium in soil (Umoh *et al.*, 2023). However, the effects of different types of animal manure on soil properties and maize grain yield vary considerably due to factors such as manure types, nutrient composition, application rates, and inherent soil characteristics. Udoh *et al.*, (2016) and Udoh *et al.*, (2025) reported a positive yield increase of garden eggs and cucumber production with the applications of goat and poultry manure on coastal plain sand soil. They also affirmed the reduced acid condition of the soils due to manure applications. Effiong *et al.*, (2025) reported that application of banana peels with animal manure significantly increased soil nutrient and the yield of pepper. Many smallholder farmers lack adequate knowledge of appropriate manure use, resulting in suboptimal soil management and reduced yields (Zinyengere *et al.*, 2013). Many research has been reported that animal manures contain essential nutrient (N, P, K, Ca, Mg) for plant growth and development (Umoh *et al.*, 2021^a; Umoh, *et al.*, 2021^b; Ekwere *et al.*, 2023).

The interactions between manure application and key soil properties including nutrient availability, soil structure, and microbial activity have been explored in different studies but not to great depths in the Obio Akpa farming community of Akwa Ibom State Nigeria (Okon *et al.*, 2024; Udoh *et al.*, 2021; Zhang *et al.*, 2020). This knowledge gap constrains the effective integration of organic inputs into conventional farming systems, limiting both sustainability and productivity in maize cultivation in this region. Therefore, this study aims to determine the effects of different animal manures on selected soil properties and their subsequent impact on maize growth and grain yield in Obio Akpa, Akwa Ibom State.

2.0 Materials and Methods

2.1 Description of Study Area

The study was conducted in 2024 at the Teaching and Research Farm of Akwa Ibom State University, Obio Akpa Campus, Nigeria. The site is geographically located between longitudes 7°30' and 8°00'E and latitudes 4°30' and 5°30'N. The area falls within the humid tropical rainforest zone and experiences a bimodal rainfall pattern, with a wet season spanning April to October and a dry season from November to March. The soils of the region are formed from highly weathered parent materials, dominated by kaolinite and amorphous forms of aluminum and iron (Udoh *et al.*, 2021). These soils are typically acidic, low in inherent fertility, and require periodic nutrient supplementation to maintain productivity. Despite these limitations, they are well-suited for the cultivation of a wide range of tropical crops when appropriately managed (Effiong *et al.*, 2025; Essien *et al.*, 2021).

2. 2 Land Preparation and Experimental Design

Land clearing was done manually using machetes and weeding hoes. The experimental site was marked out for the planting of maize, tilled, using a spade. The study was laid out as a randomized complete block design with 4 replications. There were three (3) treatments and four (4) rates (T_0 – Control) T_1 – 50g) T_2 – (100g) T_3 – 150g) of animal manures. The spacing was 0.75 x 0.7m and each plot measured 3 x 3m.

2.3 Soil Sampling and Preparation

Soil samples were collected at 0-15cm depth randomly across the four blocks for analysis. The samples were air-dried, crushed, and sieved through a 2mm mesh and stored in a polythene bag, properly tied and labeled for routine laboratory analysis, using standard laboratory procedures as described by Udo *et al.*, (2009).

2.31 Laboratory Analysis

Soil samples were analyzed for specific parameters following the procedures outlined below according to Udo *et al.*, (2009). Soil pH was measured using a glass electrode pH meter with a 1:2.5 soil-water ratio. Total nitrogen was determined using the Macro-Kjeldahl digestion method. Available phosphorus was determined using Bray-P1 method. Organic carbon was determined using Walkley Black wet oxidation method. The value was multiplied by 1.724 to obtain organic matter content. Exchangeable cation (Sodium, Potassium, Calcium, and Magnesium) were determined by using spectrophotometer and flame photometer. Exchange acidity was measured as described by Udo *et al.*, (2009). Effective cation exchange capacity (ECEC) was calculated by the summation of total exchangeable cations and exchangeable acidity as outlined by Udo *et al.*, (2009) and the percentage base saturation was determined by summation of total exchangeable cations $\times 100 / \text{ECEC}$ and the percentage base saturation was determined by summation of total exchangeable cation $\times 100$ as described by Udo *et al.*, (2009)

2. 4 Data Collection

Data were collected on plant parameters on each plot at 2, 4, 6, 8, and 10 WAP. Plant height were measured using a measuring tape ensuring accuracy and consistency. The measurement was taken from the base of the plant (at soil level) to the tip of the plant. Length of fruit (cm) was measured using a measuring tape. Harvested fruit cobs were weighed using a digital balance. The total number of cobs harvested from each plant was also recorded.

2. 5 Data Analysis

The data collected were analyzed using the Statistical Package for Social Sciences (SPSS) software version 25. Analysis of variance (ANOVA) was performed to test for significant differences among treatment means. Where significant differences were found, means were separated using Fisser (LDS) at 0.05 probability level. Additionally, regression analysis was conducted to establish the relationship between the different fertilizer/manure treatments and the growth and yield parameters of maize.

3.0 Results and Discussion

3.1 The Physicochemical Properties of Soil before Planting and after Manure Application

Table 3.1 shows the initial physicochemical properties of soils used for the experiment. The textural classification of the soil in the study area was sandy loam with high proportion of sand 78.0%, silt 8.0%, clay 1.4% respectively. The chemical properties of the soils were low in nutrients. The pH of the soils was acidic (5.02) total nitrogen content was 1.04%. The N content was low as value was below the critical limit of 2.15% and the low level of nitrogen content in soil attribute to high leaching of essential nutrient in soils due to excessive rainfall and erosion. (Essien *et al.*, 2019) The low nitrogen status of the soil may have a serious implication on the fertility of the soil, and the plants need this nutrient in large quantity for growth and development. Organic matter content was low 1.62% in the initial soil properties. This value was lower than 10% given by Enwezor (1990) as ideal for crop production. Available P was (9.00mg/kg) in the initial soil analysis and this was above the critical rate of 5.05mg/kg USDA (2021) Exchangeable Mg content in the soil was low (0.72cmol/kg) in the initial soil properties (Table 3.1). Exchangeable K was high (1.63 cmol/kg) in the initial soil properties, the values was low at than the critical level of (0.2 cmol/kg) as reported by Ayoola *et al.*, (2008). Exchangeable cations were dominated in decreasing amount in the order Ca > K > Mg > Na reflecting the decreasing energy to supply plant with nutrient. Similar finding was observed by (Umoh *et al.*, (2021) and Ibia *et al.*, (2024) Effective cation exchangeable capacity ECEC was 4.57 cmol/kg in which the value was below the critical value of (20cmol/kg) regarded to be suitable for crop production (Ayoola *et al.*, 2008). Base saturation was 74.2%. The electrical conductivity (EC) of the soil before treatment application was low (0.09 ds/m) much lower than 2 ds/m reported by USDA (2021) for classifying soil as saline similar finding was observed by Udoh *et al.*, (2021).

Table 3.1 also shows the effect of goat manure, pig manure and poultry manure used for the pot experiment on soil properties. The pH of the manures (goats, pig and poultry) were nearly neutral ranging from 6.04 (Pig Manure) to 6.62 (Poultry Manure) respectively. Poultry manure had highest available phosphorus, electrical conductivity (EC) and potassium (K) among all the manure used for the experiment. Pig manure had the highest organic matter, magnesium and total nitrogen content among all the manure used for the experiment. Manure treated soils had the highest potassium and nitrogen content over the control. The observation is in line with the work of Umoh *et al.*, (2022) who reported that, application of animal manures increased N, P, K, Ca, Mg level in soils and also significantly improved yield of maize.

3.2 Effect of Different Animal Manures on Maize Plant Height

Plant height of maize increased with increasing weeks after planting, and was significantly higher at 10 WAP (Table 3.2). Soils treated with poultry manure had the tallest plant while the control was the shortest the differences were in this order- Poultry manure (137.5 cm) Pig manure (127.5 cm) Goat manure (117.5cm) control (81.50cm). These result indicated that the application of animal manures in soil significantly increases the vegetative growth of maize; this is in tandem with the observation by Umoh *et al* (2022). The number of leaves shown in Table; 3.3 also followed a similar pattern of increase, animal manure treated soils had higher number of leaves over the control. Stem girth of maize at 10WAP was significantly ($p < 0.05$) higher in all the treatments as shown in Table 3.4. Maize treated with poultry manure had a significantly larger stem girth than the maize treated with pig manure, goat manure and the control at all the

weeks of measurement. Udoh *et al*; 2021 had similar finding that eggshell ash application on acidic soils increase cocoyam yield. For the leaf area; poultry manure treated plants had the largest leaf area compared with other treatments across all weeks of measurement (Table 3.5).

Table 3.1 Physicochemical properties of the initial soil and after experiment

Soil properties	Soil	Goat manure	Pig manure	Poultry manure
	Initial		After Experiment	
pH 1:2.5	5.02	6.22	6.04	6.62
EC (ds/m)	0.09	0.15	0.14	0.16
OM (%)	1.62	1.91	2.81	2.75
TN (%)	1.04	4.98	7.31	7.17
Av. P (mg/kg)	9.00	10.5	11.00	9.75
Ca (cmol/kg)	1.2	1.32	4.80	5.20
Mg (cmol/kg)	0.72	1.20	1.44	1.16
Na (cmol/kg)	0.02	0.04	0.04	0.03
K (cmol/kg)	1.63	1.02	1.04	1.05
EA (cmol/kg)	1.57	-	-	-
ECEC (cmol/kg)	4.57	-	-	-
B.Sat (%)	74.2	-	-	-
Sand (%)	78.0	-	-	-
Silt (%)	8.0	-	-	-
Clay (%)	1.4	-	-	-
Textural class	SL	-	-	-

EC = Electrical Conductivity, OM = Organic Matter, TN = Total Nitrogen, Av. P = Available Phosphorus, CA = Calcium, Mg = Magnesium, Na = Sodium, K = Potassium, EA = Exchangeable Acidity, ECEC = Effective Cation Exchange Capacity, Bsat= Base Saturation, SL = Sandy loam

Table 3.2 Effect of animal manure application on maize plant heights (cm)

Treatment	2 WAP	4 WAP	6 WAP	8 WAP	10 WAP
T ₁ Control	18.45 ^b	25.58 ^d	32.55 ^d	61.25 ^d	81.50 ^d
T ₂ goat manure	29.38 ^a	39.03 ^c	45.40 ^c	87.50 ^c	117.50 ^c
T ₃ pig manure	21.80 ^a	40.55 ^b	47.63 ^b	95.25 ^b	127.50 ^b
T ₄ poultry manure	29.55 ^a	43.58 ^a	52.45 ^a	102.50 ^a	137.50 ^a
LSD (<0.05)	8.33	1.31	0.91	3.49	2.95

Table 3.3 Effect of animal manure application on number of leaves of maize

Treatment	2 WAP	4 WAP	6 WAP	8 WAP	10 WAP
T ₁ Control	5.25 ^b	8.75 ^{bc}	11.00 ^{cd}	8.50 ^d	10.75 ^d
T ₂ goat manure	5.50 ^b	10.00 ^a	11.75 ^{bcd}	12.50 ^{bc}	14.75 ^c
T ₃ pig manure	6.00 ^b	9.75 ^{ab}	12.25 ^b	13.25 ^b	17.75 ^b
T ₄ poultry manure	7.25 ^a	11.50 ^a	13.75 ^a	14.50 ^a	20.75 ^a
LSD (<0.05)	1.69	2.20	1.11	0.86	1.48

Mean with the same superscript along the same column are significantly (p < 0.05) different

Table 3.4 Effect of animal manure application on stem girth (cm) of maize

Treatment	2WAP	4WAP	6WAP	8WAP	10WAP
T ₁ Control	1.80 ^d	0.262 ^c	0.30 ^d	0.87 ^b	1.20 ^b
T ₂ goat manure	2.40 ^c	0.33 ^d	0.39 ^c	0.78 ^c	1.15 ^c
T ₃ pig manure	2.50 ^b	0.57 ^b	0.68 ^b	0.72 ^d	1.13 ^d
T ₄ poultry manure	2.70 ^a	0.73 ^a	0.79 ^a	0.97 ^a	1.24 ^a
LSD (<0.05)	0.13	0.18	0.56	0.69	1.00

Table 3.5 Effect of animal manure application on leaf area of maize (cm²)

Treatment	2 WAP	4 WAP	6 WAP	8 WAP	10 WAP
T ₁ Control	25.53 ^d	40.45 ^d	202.50 ^d	535.00 ^d	558.00 ^c
T ₂ goat manure	35.83 ^c	59.85 ^c	350.00 ^c	905.00 ^c	894.50 ^b
T ₃ pig manure	38.58 ^b	69.93 ^b	377.50 ^b	995.00 ^b	1007.50 ^b
T ₄ poultry manure	42.45 ^a	76.93 ^a	407.50 ^a	1065.00 ^a	1087.75 ^a
LSD (<0.05)	1.20	1.93	10.19	10.90	45.50

Table 3.6 Effect of Animal Manure Application on Maize Yield

Treatment	Cob Number/plot	Number of Row / Cob	Grain Weight (g/plant)
T ₁ Control	26.0 ^d	10.7 ^c	207.5 ^d
T ₂ goat manure	31.5 ^c	12.7 ^b	307.5 ^c
T ₃ pig manure	36.5 ^b	15.7 ^a	407.5 ^b
T ₄ poultry manure	41.5 ^a	16.5 ^a	507.5 ^a
LSD (<0.05)	1.83	1.35	9.9

Means with the same superscript along the same column are significantly (p <0.05) different

Soils treated with poultry manure were significantly higher in maize yield than other treatment as shown in table 3.6. Poultry manure treated soil produce the highest numbers of grain per cob and grain weight. The yield parameter obtained was significantly higher compare to control plot with the lower grain yield. Among the treatments, the increased in grain yield was obtained as follows: Poultry manure, (507.5g) Pig manure (407.5g) Goat manure (307.5g) control (207.5g). The results indicated that application of poultry, pig and goat manure increased the yield of maize. Similar finding was observed by Umoh *et al.*, (2022) who reported that using soil amendment on acid soil can significantly improve maize production.

4.0 Conclusion and Recommendations

Animal manure application in soils significantly increased some essential nutrient elements (N, P, K, Mg) in soil and also increase the pH level and organic matter contents in these order pig manure > Poultry manure > Goat manure. The study also revealed a significantly increase in growth and yield parameter including plant height, stem girth, number of leaves and grain yield. Among the manure treatment, the yield increased in this order; poultry (507.5g/ha) > Pig manure (407.5g/ha) > Goat manure (307.5g/ha) > control (207.5g/ha) and poultry manure is recommended for maize production in the study area.

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