Effects of Poultry Manure Rates on Selected Soil Properties, Growth and Yield of Cucumber (*Cucumis sativus* L.) in Ifite Ogwari, Southeasthern Nigeria

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ABSTRACT

This study investigated the effects of different rates of poultry manure on soil physicochemical properties, growth parameters and crop yield of cucumber in Nnamdi Azikiwe University, Ifite-Ogwari campus, Anambra State, Nigeria. The experimental design was a Randomized Complete Block Design (RCBD) with five treatments (0 t/ha, 5 t/ha, 10 t/ha, 15 t/ha, and 20 t/ha of poultry manure) with four replications . The experiment was conducted at the experimental research farm of Crop Science and Horticulture. Soil samples were collected before and after the experiment at 6 weeks after planting and analyzed for pH, available phosphorus, total nitrogen, organic carbon, exchangeable cations, and other parameters. The results indicated that the application of poultry manure significantly influenced soil physical properties, with the highest total porosity and moisture content observed at the highest application rate (20 t/ha). Moreover, soil chemical properties such as pH, available phosphorus, total nitrogen, organic carbon, and exchangeable cations varied significantly among treatments, with the highest values recorded at the highest poultry manure rate. Cucumber growth parameters, including the number of leaves, vine length, and fruit weight, exhibited significant improvements with increasing poultry manure application rates. Likewise, crop yield-related characteristics such as fruit length, circumference, and number of fruits increased significantly with higher poultry manure application rates. Based on the findings, the treatment with 20 tons/ha of poultry manure emerged as the most effective in improving soil physicochemical properties, cucumber growth, and crop yield hence could be recommended for enhancing agricultural productivity and sustainability in similar agroecological zones.

INTRODUCTION

Organic farming has captured the imagination of consumers and farmers alike, offering a promising alternative to conventional agricultural practices (Berry and Ray, 2023). Organic farming holds immense significance for the future of sustainable agriculture, contributing to various aspects of environmental and economic wellbeing such as; Environmental benefits (Seufert and Ram, 2011, FAO, 2017), improved soil health, reduced health risks (Smith-Spangler *et al*., 2012) and economic viability (Jones *et al*., 2023). Poultry manure, often relegated to the realm of backyard flocks, holds immense potential for organic farming. Its nutrient-rich composition and ability to enrich soil make it a valuable tool in building sustainable and productive agroecosystems. Compared to other animal manures, poultry manure is a rich source of organic matter, crucial for improving soil structure, water holding capacity, and microbial activity (Jones *et al*., 2023). It also contains beneficial microorganisms that contribute to nutrient cycling and plant health (Chastain *et al*., 1999). Cucumber possesses nutritional prowess and remarkable adaptability to organic practices which makes it a valuable crop for promoting healthy ecosystems and sustainable food production. Cucumber is known to also thrive in organic farming systems due to their inherent resilience and compatibility with natural pest and disease management practice such as Crop rotation (Seufert and Ram, 2011), pest and disease resistance (FAO, 2017), water efficacy (Grieve andKelling, 2010), and Soil fertility.

While the potential benefits of using poultry manure as an organic fertilizer are promising, its effects on soil properties, microbes, and cucumber yield in South-eastern Nigeria remain unclear. This region faces unique agricultural challenges, including soil degradation and declining crop yields. Hence, there is a need to investigate the impact of poultry manure on soil quality, microbial diversity, and cucumber (Cucumis sativus) yield in South-eastern Nigeria.

This research addresses crucial issues like soil degradation, sustainability, food security, environmental impact, and informed agricultural decisions in South-eastern Nigeria. By studying the effects of poultry manure on soil properties, growth and crop yield, this research contributes to local agricultural development and broader discussions on sustainable farming practices.

MATERIALS AND METHODS

Description of Site

The field experiment was carried out at the experimental research Farm of Crop Science and Horticulture, Faculty of Agriculture, Nnamdi Azikiwe University, Ifite-Ogwari in Ayamelum local government area, Anambra State. Ifite-Ogwari is located on latitude 6.6041°N and longitude 6.9507° East. Anambra's capital Awka is approximately 45 kilometres away from Ifite-Ogwari (Ewuim *et al.,* 2018). The experimental site is located on latitude 6°36'27" and longitude 6°57'23". The soil of the area is generally sandy with accumulation of clay and gravel in most subsurface horizons and moderately to imperfectly drained (Nnabuihe *et al*., 2023).

Experimental Design and Field Layout.

The experimental design was a Randomized Complete Block Design (RCBD) with four replications. There were five treatments which are the different poultry manure rates. They are; T1= 0 t/ha

T2= 5t/ha
T3= 10 t/ha
T4= 15 t/ha
T5= 20t/ha
Each treatments were replicated four times.

Management Practices

The land area of 68m² was cleared, tilled and pulverized for thorough mixing of the soil and then wooden peg was used to map out the experimental plot of 1 m by 1.5 m leaving a furrow of 0.5 m. The different treatments were applied to the experimental plot by broadcasting and then incorporating it into the soil. Two weeks interval was giving before sowing to allow for proper decomposition and mineralization of nutrient in the cow dung. Two seeds of cucumber was sown per hole at a spacing of 10 inches across and between the rows. The cucumber plant was staked 14 days after emergence with the use of bamboo stick and twine. Weeding practice was done manually with hoe at a regular interval mostly every 2 weeks so as to reduce competition among crops.

Data Collection

Both disturbed and undisturbed soil samples were collected for pre-treatment and post-harvest, using soil auger for the disturbed and core sampler for the undisturbed at 0-10 cm depth. The undisturbed core samples were soaked to saturation before oven-drying to determine bulk density, total porosity and moisture content; the disturbed samples were air dried, crushed and sieved with 2mm sieve to analyze for chemical soil parameters using standard analytical procedures. The pre-treatment samples were collected randomly, composited and prepared before the analysis. Post treatment samples were also be taken at test crop maturity, according to the various treatments after harvest. The soil samples collected were subjected to routine soil analyses to determine soil physical and chemical properties.

Plant data
Number of leaves was counted and Vine length were measured (cm) at 2, 4 and 6 weeks after planting. Fresh fruit weight (g), Length of fruit (cm), and Number of fruits were determined at harvest

Laboratory analysis
Bulk Density was determined using core method as described by Anderson and Ingram (1993). Particle Size Distributions was determined using Bouyoucus hydrometer method as described by Bouyoucus (1962). Soil texture was determined using textural triangular. Total Porosity indicates the percentage of the soil that contains pores. It is calculated as follows; soil porosity = (1-(Bulk Density ÷ Particle Density)) × 100. Soil pH was determined in H_2O and Kcl using glass electrode pH meter at a soil liquid ratio of 1:2.5 as explained by Udo *et al* (2009).Soil Organic Carbon/Organic Matter was determined by Walkley and Black wet oxidation method and modified by Nelson and Sommers (1996), the wet digestion method. Total Nitrogen was determined by Kjeldhal digestion method (Bremmer and Mulvaney (1996). Available Phosphorus was determined by Bray 1 method as described by Bray and Kurtz (1945). Exchangeable Bases (Ca, Mg, K and Na) was determined in 1N ammonium acetate saturation (NH_4AOC) extract method at pH 7 (Udo *et al*.,2009). Calcium and Magnesium was determined using atomic absorption spectrophotometer while potassium and sodium was determined using flame photometer. Exchangeable acidity (H^+ and Al^{3+}) was determined by 1N Kcl extraction method (Udo *et al*., 2009).Cation exchange capacity (CEC) was determined by summing base and acid cations (Chapman, 1982).

Statistical Analysis
Data collected was subjected to analysis of variance (ANOVA) for randomized completely Block Design (RCBD) using Genstat 4th edition and significant means separated using Fishers least significant difference (LSD) at 5% probability level, where significant difference occurred.

RESULTS AND DISCUSSION

1. The Initial Soil Properties of The Experimental Site

The pre-treated soil was acidic as shown in Table 1 below. It also contained the following exchangeable cations Ca^{2+}, Mg^{2+}, K^+, Na^{2+} at the rates of 1.73 Cmol/kg, 0.47 Cmol/kg, 0.10 Cmol/kg, 0.41 Cmol/kg respectively. The following exchangeable anions were also present; Al^{3+}, H^+ at the rate of 1.98 Cmol/kg and 0.51 Cmol/kg.

Table 1. Some selected physical and chemical properties of the pre-treated soils

Parameters	Values
Sand	61.00
Silt	19.00
Clay	20.00
Textural class	Sandy loam
pH (H_2O)	5.3
Bulk density (mg/m^3)	1.35
Moisture content (%)	14.6
Total porosity (%)	49.4
Organic carbon (g/kg	7.52
Organic matter (g/kg)	15.3
Available Phosphorus (mg/kg)	9.06
Exchangeable acidity (Cmol/kg)	
TEA	1.18
Al^{3+}	1.98
H^+	0.51
Ca^{2+}	1.73
Mg2+	0.47
K^+	0.10
Na^+	0.41

CEC (Cmol/kg)	4.26
BS (%)	68.10

Table 2. Nutrient content of poultry manure used.

SOIL PARAMETERS	VALUES
pH in H_20	7.32
Organic carbon (g/kg)	200
Total nitrogen (g/kg)	14.5
Ca2+ (Cmol/kg)	26.3
Mg2+ (Cmol/kg)	8.6
K+ (Cmol/kg)	32.5
Available Phosphorus (mg/kg)	36.0

Note: Ca^{2+}= Calcium, Mg^{2+}= Magnesium, k^+= Potassium

Table 3 Effect of poultry manure rates on selected physical properties of soil in IfiteOgwari

Treatment	Bulk density (g/cm^3)	Total porosity (%)	Moisture content (%)	Sand (%)	Silt (%)	Clay (%)	Textural class (%)
0t/ha PM	1.45	45.38	14.84	67.28	22.88	9.84	Sandy loam
5t/ha PM	1.25	52.74	18.39	71.68	10.20	18.12	Sandy loam
10t/ha PM	0.98	63.02	21.39	74.52	13.03	12.45	Sandy loam
15t/ha PM	0.74	72.22	23.68	78.15	10.12	11.73	Sandy loam
20t/ha PM	0.64	76.03	26.16	80.58	10.38	9.04	Sandy loam
LSD ($p \leq 0.05$)	0.01	1.25	0.71	1.10	1.45	1.40	

Note: LSD= Least significant difference, PM = Poultry manure.
Note: LSD= Least significant difference, PM = Poultry manure.

Effect of poultry manure rates on physical properties of soil in Ifite-Ogwari.

The effect of the different rates of PM was significant at (P 0.05) on all the physical properties of the post-treated soil. From the table 3 below, 0 tons of PM produced the soil with the highest bulk density of 1.45 mgm-3. 20tons of PM gave the highest total porosity of 76.03 %, while 0 tons gave the lowest total porosity, with a value of 45.38 %. For soil moisture content, 20 tons of PM gave the highest moisture content of 26.16 %, while 0 tons gave the lowest moisture content value of 14.84 %. From the results above higher rate of PM improved the soil physical properties better because PM acts as a binding agent, helping to cement soil particles together, which reduces soil compaction and enhances root penetration. This agrees with the findings of Nguyen *et al*., (2017) that amending the soil with poultry manure improves soil structure Promoting the formation of stable aggregates, reducing compaction, and increasing water-holding capacity.

The result as seen in table 4 showed the pH of the post-treated soil at ($P \leq 0.05$) was not significantly affected by the different PM rates. Moreover, 20 tons of PM produced the soil with highest pH of 6.50 while 0tons had the lowest pH of 5.45. The available phosphorus, total nitrogen, organic carbon and organic matter were significantly affected by the different PM rates at ($P>0.05$). 20 tons of PM gave the highest amount of available phosphorus, having a mean value of 24.93 mg/kg while 0 tons of PM produced the lowest amount of available phosphorus with a mean value of 13.16 mg/kg. For total nitrogen 20 tons of PM produced the soil with the highest value of 2.06 g/kg while 0 tons of PM produced the lowest amount of total nitrogen and with a mean value of 1.04g/kg. For organic carbon, 15 tons of PM produced the soil with the highest amount of organic carbon, with a mean value of 16.48 g/kg while 0 tons of PM produced the lowest amount of organic carbon and with a mean value of 11.63 g/kg.

Table 4 Effect of poultry manure rates on some selected chemical properties of soil in Ifite-Ogwari.

Treatment	pH	Av. P (mg/kg)	TN (g/kg)	OC (g/kg)	OM (g/kg)	CEC	TEA	BS(%)
0t/ha PM	5.45	13.16	1.04	11.63	21.15	5.02	1.34	71.42
5t/ha PM	5.82	19.09	1.14	15.30	29.38	4.28	1.27	73.20
10t/ha PM	6.28	20.91	1.09	16.07	28.82	6.35	1.38	77.64
15t/ha PM	6.39	24.20	1.13	16.48	30.29	7.23	1.64	78.94
20t/ha PM	6.50	24.93	2.06	14.73	31.23	6.96	1.61	80.66
LSD ($p \leq 0.05$)	NS	0.84	0.09	0.63	0.95	0.20	0.05	1.303

Note LSD= Least significant difference, PM = Poultry manure, Av. P= Available Phosphorus, TN= Total Nitrogen, OC= Organic carbon, OM= Organic matter, NS = Not significant

For organic manure 20 tons of PM producing the soil with the highest amount of organic matter, with a mean value of 31.23 g/kg while 0 tons of PM produced the lowest amount of organic matter and with a mean value of 21.15 g/kg. CEC, TEA and Base saturation were significantly affected by the different PM rates at ($P \leq 0.05$), with 15 tons of PM producing the soil with the highest CEC, and with a mean value of 7.23 Cmol/kg while 5 tons of PM produced the lowest CEC and with a mean value of 4.28 Cmol/kg. For TEA, 15 tons of PM gave the highest amount of TEA, with a mean value of 1.64 Cmol/kg while 5 tons of PM gave the lowest amount of TEA and with a mean value of 1.27 Cmol/kg. For base saturation, 20 tons of PM gave the highest amount of base saturation, and with a mean value of 80.66 % while 0 tons of PM produced the soil with the lowest amount of base saturation and with a mean value of 71.42 %. Addition of PM at the rate of 20 tons/ha improved soil chemical properties better compared to the other rates and the control this is because PM application can influence soil pH and buffer soil acidity or alkalinity. This agrees with Nuruzzaman *et al*., (2016) that poultry manure contains alkaline components, such as calcium carbonate (CaCO3), which can help neutralize acidic soils. Udo *et al*., (2009) showed that the application of poultry manure resulted in notable improvements in soil physicochemical properties, this study further pointed out that the significant increase in soil pH with increasing poultry manure rates suggests a shift towards a more favorable soil environment for plant growth. Akinremi*et al*., (2017) found out that poultry manure increased SOM which in turn enhanced soil water-holding capacity, nutrient cycling, and microbial activity, promoting soil health and fertility as well as soil nutrient uptake(Onunwa*et al*., 2021).

Effect of poultry manure rates on morphological characteristics (number of leaves and vine length) of cucumber at 2, 4 and 6 WAP.

The results in table 5 showed that the number of leaves of the cucumber plants was significantly affected by the different PM rates at 2, 4 and 6 WAP at ($P \leq 0.05$). At 2 WAP, 20 tons of PM produced the highest number of leaves and with a mean value 9.50, while 0 tons of PM produced the lowest number of leaves, with a mean value of 4.25. At 4 WAP, 20 tons of PM gave the highest number of leaves, with a mean value of 33.75 while 0 tons of PM produced the lowest number of leaves and with a mean value of 8.50. At 6 WAP, 20 tons of PM showed the highest number of leaves, with a mean value of 41.25 while 0 tons of PM produced the lowest number of leaves and with a mean value of 11.75.Vine length was also significantly affected by the different PM rates at 2, 4 and 6 WAP ($P \leq 0.05$), At 2 WAP, 20 tons of PM gave the highest vine length of 44.18 cm, while 0 tons of PM produced the smallest vine length of 8.26 cm. At 4 WAP, 20 tons of PM produced the highest vine length of 207.6 cm, while 0 tons of PM produced smallest vine length of 39.7 cm. At 6 WAP, 20 tons of PM produced the highest vine length of 266.1 cm, while 0 tons of PM produced smallest vine length of 47.9 cm. The observed increase in cucumber growth parameters with higher poultry manure application rates underscores the positive influence of organic fertilization on crop performance as was reported by Nwosu *et al.* (2023). The higher number of leaves and longer vine length observed in treatments with greater poultry manure rates can be attributed to improved nutrient availability, root development, and overall plant vigor. Singh *et al*., (2011) stated that poultry manure increases soil organic matter, which improves water holding capacity, aeration, and beneficial microbial activity. This improved soil environment fosters better root growth and nutrients uptake by plants, leading to potentially higher plant growth and development

Table 5: Effect of poultry manure rates on morphological characteristics (number of leaves and vine length) of cucumber at 2, 4 and 6 WAP.

Treatment	Number of leaves (2WAP)	Vine length (2WAP) (cm)	Number of leaves (4WAP)	Vine length (4WAP) (cm)	Number of leaves (6WAP)	Vine length (6WAP) (cm)
0t/ha PM	4.25	8.26	8.50	39.7	11.75	47.9
5t/ha PM	6.00	17.02	15.50	104.8	20.50	143.5
10t/ha PM	6.00	16.61	18.25	118.1	23.75	160.7
15t/ha PM	7.50	24.62	22.25	165.1	27.75	207.6
20t/ha PM	9.50	44.18	33.75	207.6	41.25	266.1
LSD ($p \leq 0.05$)	1.60	4.03	4.59	22.54	4.35	22.85

NOTE: WAP= Weeks after planting, PM = Poultry manure.

Effect of poultry manure rates on yield and yield related characteristics of Cucumber at 6 WAP.

The number of fruits, fruit length, fruit circumference and fruit weight after harvest were all significantly affected by the PM rates at (P 0.05)(Table 6). For the number of fruits, 20 tons of PM gave the highest number of fruits, with a mean value of 16.25 while 0 tons of PM produced the lowest number of fruits and with a mean value of 4.00. For fruit length, 20 tons of PM produced the highest fruit length of 29.20 cm, while 0 tons of PM produced smallest fruit length of 12.38 cm. For fruit circumference, 20 tons of PM showed the highest fruit circumference, with a mean value of 24.80 while 0 tons of PM produced the lowest fruit circumference with a mean value of 11.45. For weight of fruit, 20 tons of PM produced the highest fruit weight of 726 g, while 0 tons of PM produced smallest fruit weight of 76 g. The significant improvement in crop yield-related characteristics, particularly the number of fruits and fruit weight, with increasing PM application rates underscores its positive impact on overall crop productivity. Singh *et al*., 2018 observed that the higher nutrient content and balanced soil fertility resulting from PM application promote optimal plant growth, flowering, and fruit set, leading to increased yield potential. Kumar *et al*., (2019) confirmed that there is increase in fruit size and number with higher rate of poultry and further highlights the importance of organic fertilization in maximizing crop yield and economic returns for farmers.

Table 6: Effect of poultry manure rates on yield of Cucumber at 6 WAP.

Treatment	Number of fruits at harvest	Fruit length at harvest (cm)	Fruit circumference at harvest (cm)	Weight of fruit at harvest (g)
0t/ha PM	4.00	12.38	11.45	76
5t/ha PM	9.00	23.88	18.53	302
10t/ha PM	9.50	23.20	19.88	432
15t/ha PM	12.50	25.50	21.00	519
20t/ha PM	16.25	29.20	24.80	726
LSD ($p \leq 0.05$)	1.96	2.40	3.10	75.7

NOTE: PM = Poultry manure.

CONCLUSION

The study showed that poultry manure application improved the soil fertility properties and the improvements were proportional to the rate of amendment. The improvement on soil fertility properties due to poultry manure addition led to corresponding increases in cucumber growth and yield parameters. Treatment unit that had 20 tons/ha of poultry manure emerges as the most effective in increasing soil fertility, promoting robust crop growth, and maximizing yield potential.

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