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EVALUATION OF DIFFERENT RATES OF POULTRY MANURE ON SOIL PROPERTIES AND GRAIN YIELD OF MAIZE (*ZEA MAYS L.)* IN A TYPIC HAPLUSTULT IN ABAKALIKI, SOUTHEASTERN NIGERIA

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ABSTRACT: *This study was carried out to evaluate different rates of poultry manure on soil properties and grain yield of maize in a typic haplustult at Teaching and Research Farm of Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki. The field was laid out in randomized complete block design with five treatments of poultry manure at 0, 10, 20, 30 and 40t ha^{-1} and replicated four times. Maize variety (Oba Super II) was used as a test crop. The soil properties and maize yield data were analyzed using analysis of variance (ANOVA). Results showed that different rates of poultry manure had significantly (P<0.05) higher total porosity and aggregate stability than control. The plot amended with 40t ha^{-1} of poultry manure had 16% lower bulk density and 14, 20 and 23% higher aggregate stability, total porosity and gravimetric moisture content compared to control. Different rates of poultry manure had significantly (P<0.05) higher organic matter (OM), available P, N and pH when compared to control. Organic matter, available P, N and pH were higher by 32, 21, 42 and 41% in plot amended with 40t ha^{-1} poultry manure compared to control. Furthermore, the plot receiving 40t ha^{-1} of poultry droppings had significantly (P<0.05) higher OM, available N, P, N and pH relative to plots amended with lower rates. Generally, organic matter, available P, N, pH and exchangeable bases of Calcium, magnesium, potassium and Sodium increased in the order of 40>30>20>10>0t ha^{-1} in the different rates of poultry manure. Grain yield of maize was 19, 17, 11 and 7% higher in plot amended with 40t ha^{-1} and plots amended with 10, 20 and 30t ha^{-1} of poultry manure when compared to control. Rates of poultry manure are necessary for improved soil properties but for profitable grain yield of maize, higher rates are recommended.*

KEYWORDS: Evaluation, Grain Yield of Maize, Poultry Droppings, Rates, Soil Properties.

INTRODUCTION

The soils of Abakaliki zone in southeastern Nigeria are mainly Utisols and commonly suffer from inadequate supply of major plant nutrients such as nitrogen, phosphorus and basic cations which are often the causes for poor and unprofitable yields of crops in the area. Essentially, the soils are degraded in physical and chemical properties which are direct consequences of intensive cultivation, slash and burn farming practice, bush burning, overgrazing and other unconventional agricultural use of soil such as lack of crop rotation or shifting cultivation which before now was most prevalent in southeastern Nigeria. Consequently, there has been continued decline in productivity of soil resources in the area to an economical level. The high cost of chemical fertilizers coupled with their attendant problems such as environmental risks and increase in soil acidity as well as cost do not either help matters as these limit their usage by farmers.

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More importantly, organic manure has been shown to improve soil properties (Salam, 1991). Poultry manure improves soil physical properties particularly bulk density, total porosity and moisture retention (Agboola and Fegbenro, 1985). Application of poultry manure is preferred to other animal wastes due to the high concentration of macro-nutrients (Ducan, 2005). According to Agbede *et al.* (2008) poultry droppings when applied to the soil provided N, K, Ca and Mg, which enhanced soil productivity. Although, research on the use of poultry droppings to improve soil properties appears to have been overstretched, yet there is little or no evidence of proper documentation of evaluation of rates of poultry manure on soil properties and grain yield of maize in literature in the study area. Incidentally, most research efforts available in the agroecology are concentrated on evaluation of poultry manure with other animal wastes. Sometimes, research is formulated on integrated nutrient management approach where poultry manure is combined with NPK fertilizer and compared to in organic fertilizer alone. Besides, Mbah *et al.* (2009) reported that higher rates of wood ash and coconut ash used as soil amendments improved soil properties and increased grain yield of maize more than control and plots receiving lower rates of application.

Besides, Clay *et al.* (2002) and Lopez-Masqueral *et al.* (2008) noted that there was a need to assess the potential impacts of poultry manure on soil properties and crop yield with particular attention to critical application levels. It is for this apparent lack of information on rates of poultry manure application at sustainable soil productivity and profitable grain yield of maize as well as to confirm such other similar studies that necessitated this study. The outcome from this experiment could assist farmers and other critical land users in proper planning for soil nutrient optimization and to avoid wastage through over dosage that could cause decline in productivity. The objective of this work was to evaluate rates of poultry manure on soil properties and grain yield of maize in a typic hapslustult in Abakaliki, Southeastern Nigeria.

MATERIALS AND METHODS

Experimental Site

The study was carried out at the Teaching and Research Farm of Faulty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki. The area is located by Latitude06^{o}4$^{/}$N and longitude 08^{o}65$^{/}$E. The area lies within the derived savannah zone of Nigeria. The rainfall distribution ranges from 1700 to 2000 mm with a mean annual rainfall of 1800 mm for two peak periods of March to July and September to early November. There is a break in August referred to as “August break”. The temperature ranges from 27^{o}C to 31^{o}C for minimum and maximum periods in the year. Relative humidity is often very high reaching 80% during rainy season but declines to 65% in dry season (ODNRI, 1989). The soil of the area is derived from sedimentary deposits from cretaceous and tertiary periods. Geologically, the area has shale residuum and the soil is unconsolidated up to 1 m depth. The texture of the surface soil is sandy loam and belongs to the broad category of the order Ultisol, classified as Typic Haplustult (FDALR, 1985).The site for the experiment has been under cultivation for the past three years. Crops grown were maize, yam and cassava.

Field Methods

A land area of 0.03t ha^{-1} was cleared, debris removed without burning and used for the experiment. The field was laid out using randomized complete block design (RCBD). A hybrid

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variety of maize (Oba Super II) was used as a test crop. The plots measured 3 m x 3 m with 0.5 m spaces among them. Poultry manure was sourced from the poultry farm from Animal Science Department of Ebonyi State University, Abakaliki. The poultry manure was applied on the beds at five rates of 0, 10, 20 30 and 40t ha^{-1} and replicated four times giving a total of twenty experimental plots. The treatments were incorporated into the soil using rake. The replications were separated by 1m alley. The maize variety was sourced from Ebonyi State Agricultural Development Programme (EBADEP), Onuebonyi Izzi, Abakaliki. The maize seeds were sown two per hole at a planting distance of 25 cm x 75 cm after two weeks of treatment incorporation. Two weeks after emergence of maize seedlings, (WAE) they were thinned down to one per hole while weak ones were uprooted and maize seeds replanted to replace the lost ones. These gave plant population of approximately 53, 333 in the field. Weeds were removed at three-weekly intervals until harvest.

Soil Sampling

A composite soil sample was randomly collected with auger at 0-20 cm depth from the site before cultivation and treatment application for pre-planting analysis. Soil samples were further collected with auger and cores from each plot for post harvest determinations.

Agronomic Data

Cobs were harvested when husks were dry. The cobs were dehusked, shelled and grains of maize further dried to constant weight. Grain yield was determined at 14% moisture content.

Laboratory Methods

Core samples were used for determination of soil physical properties. Bulk density was determined by Blake and Hartge (1986) method. Total porosity and gravimetric moisture content were evaluated using Obi (2000) procedure. Particles size distribution was determined by Gee and Or (2002) method. Aggregate stability determination was as described by Kemper and Rosenau (1986).

Auger samples were air-dried at 26^{o}C, ground and sieved with 2 mm sieve and used to determine chemical properties of the soil. Soil pH was determined in soil/water solution ratio of 1:2.5 and values read off using glass electrode pH meter. Total nitrogen determination was done using the method described by Bremner and Mulvaney (1982). Available phosphorus was determined according to Page *et al.* (1982) method. Organic carbon determination was done as described by Nelson and Sommers (1982). The value of organic matter was calculated using Van Bemmeler factor of 1.724. Exchangeable bases were extracted using 0.1NH_4OAC solution according to Mba (2004). Calcium and magnesium were determined with atomic absorption spectrophotometer (AAS) while potassium and sodium were by use of flame photometer. Poultry manure was analyzed for its nutrients composition using the method of Juo (1982). Carbon-nitrogen ratio was evaluated by calculation using values of carbon and nitrogen.

Data Analysis

Grain yield of maize and soil data were analyzed using analysis of variance (ANOVA). Treatment means that were significant were separated using Fisher's Least Significant Difference (F-LSD) as recommended by Steel and Torrie (1980).

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RESULTS AND DISCUSSION

Table 1 shows result of soil properties at initiation of study. The textural class is sandy loam. The pH was strongly acidic according to Schoenerberger *et al.* (2002). The organic matter and available phosphorus were of moderate values according to benchmark of FMARD (2002) rating for tropical soils while total nitrogen was low. Exchangeable calcium and magnesium dominated the exchange complex of soil. The soil could be said to be degraded and of poor fertility before initiation of study. This could be attributed to continuous cultivation, low input of amendment and generally poor management practices. The soils of abakaliki are highly kaolinitic and have low activity clays.

Table 1. Soil properties at initiation of the field study

Soil properties	Unit	Value
Sand	gkg^{-1}	600
Silt	gkg^{-1}	250
Clay	gkg^{-1}	150
Textural class		Sandy loam
pH	KCL	4.6
Organic matter	%	2.98
Available phosphorus	gkg^{-1}	34.50
Total nitrogen	%	0.15
Calcium	cmol kg^{-1}	5.20
Magnesium	cmol kg^{-1}	3.20
Potassium	cmol kg^{-1}	0.26
Sodium	cmol kg^{-1}	0.52

Nutrients Composition of Poultry Manure

The results of Table 2 show the nutrients composition of poultry manure which are higher compared to their corresponding values in soil before initiation of study. The value of organic carbon, total nitrogen and organic matter ranged from high to very high values while available phosphorus was low (Landon, 1991). Calcium dominated other exchangeable bases. Carbon nitrogen ratio was moderate (Biswas and Murkherjee, 2008). The nutrients composition in the poultry manure is a reflection of nutrients in the diet of the birds. These findings agree with the observation of Mbah (2004) that nutrients composition of poultry manure varied and indicated nutrients in the diet of poultry. Nutrients compositions of poultry manure were far higher than those in soil before initiation of study and is believed to benefit the soil when applied as amendment. Low phosphorus content in poultry manure could be due to eutrophication process, leaching losses and possibly entering into complex with calcium since it was stored for one month before application on soil.

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Table 2. Nutrients composition of poultry droppings

Nutrient	Unit	Value
Organic carbon	%	16.0
Nitrogen	%	3.10
Organic mater	%	28.8
Phosphorus	mg kg^{-1}	2.20
Calcium	$cmolkg^{-1}$	6.2
Magnesium	$cmolkg^{-1}$	2.0
Potassium	$cmolkg^{-1}$	3.3
Sodium	$cmolkg^{-1}$	0.7
Carbon: Nitrogen	%	8.0

Physical Properties of Soil

Effect of different rates of poultry manure on physical properties of soil is shown in Table 3. The particle size distribution (PSD) varied among treatments. Generally, sand faction was dominant in all the treatments compared to other fractions and slightly higher than pre-planting values, except plot amended with 10t ha^{-1} of poultry manure. Silt fraction increased generally after planting compared to pre-planting values in all the treatments. Nevertheless, the texture remained sandy loam in the different rates of poultry manure application. The plots amended with different rates of poultry manure had significantly ($P<0.05$) higher aggregate stability values when compared to control. Plot amended with 40t ha^{-1} of poultry manure had significantly ($P<0.05$) higher aggregate stability value compared to their counterparts with 10 and 20t ha^{-1}. These represent 8 and 8% increments in aggregate stability in plot amended with 40t ha^{-1} of poultry manure relative to those amended with 10 and 20t ha^{-1}. Furthermore, the plot amended with 40t ha^{-1} of poultry manure had significantly ($P<0.05$) higher total porosity when compared to values obtained in other rates of poultry manure amended plots and control. These are 20, 14, 14 and 4% higher in total porosity in plot amended with 40t ha^{-1} of poultry manure compared to control and plots receiving 10, 20 and 30t ha^{-1} of poultry manure, respectively. There were no significant treatment effect on bulk density and gravimetric moisture content (GMC). However, the plots receiving different rates of poultry manure had respectively lower bulk densities and higher GMC when compared to their respective values obtained in control. Bulk densities were higher by 49, 14, 7 and 4% in control and plots amended with 10, 20 and 30t ha^{-1} of poultry manure compared to its counterpart in plot amended with 40t ha^{-1}. Similarly, the plot receiving 40t ha^{-1} of poultry manure had 23, 20, 16 and 16% higher GMC when respectively compared to values recorded in control and plots amended with 10, 20 and 30t ha^{-1} of poultry manure. The general trend in improvements of studied physical properties of soil by different rates of poultry manure application followed the trend of 40>34>20>10>0t ha^{-1}.

Results indicated that even though cultural practices such as cultivation could cause variations and redistribution in particle sizes of soil but texture would not be affected. This is supported by the report of Obi (2000) that texture of soil is a permanent property of soil and could not be modified by temporary cultural practices such as cultivation. Texture of soil is associated with water retention, nutrient retention and supply and aeration propensity. The differences observed in particle size distribution between pre-planting and post harvest analysis could be attributed to re-distribution of particle sizes due to effect of pedoturbation arising from cultivation which

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caused eluviations of finer particles leaving higher concentration of sand rather than rates of poultry manure amendment.

The results further showed that different rates of poultry manure significantly increased aggregate stability compared to control. This implies that organic matter (Table 4) released by different rates of poultry manure during decomposition and mineralization was enough to cause soil aggregation and stabilization. Several researchers such as Mbagwu and Ekwealor (1991) and Lal and Kang (1982) had earlier reported that organic matter released during decomposition of organic materials added to soil increased soil aggregate stability. Akamigbo (1984) noted that organic matter contributed about 70% of aggregate stability of soils. Mbah *et al.* (2009) corroborated earlier reports of former researchers where they reported that organic carbon released during organic wastes decomposition and mineralization increased aggregate stability and stabilization of soil. The higher aggregate stability obtained in plot receiving 40t ha-^{1} of poultry manure compared to their counterparts in other amended plots could be attributed to higher significant organic matter content released by poultry manure in the soil (Table 4). Higher total porosities recorded in plots amended with different rates of poultry manure relative to control could be due to effect of organic materials from the added amendment during decomposition and subsequent mineralization. These organic materials loosened the soil and increased total pore volume of soil. Total porosity was highest in plot amended with 40t ha^{-1} of poultry manure probably because of higher effect of poultry manure compared to other plots amended with lower rates. On the other hand, differences observed in total porosities among plots receiving different rates of poultry manure could be attributed to combined effect of cultivation and poultry manure amendment. Implements could create both micro and macro pores depending on intensity of cultivation which could increase total porosity. In this case tillage implement reduced total porosity but not beyond the salvation of poultry manure amendment as they are not limiting to soil productivity. The non-significant treatment effect of different rates of poultry manure amendment on bulk density and gravimetric moisture content is attributable to low rates of poultry manure which could not elicit good and positive response on these soil properties. It suggests that the rates of poultry manure used are low and not appropriate to significantly reduce soil bulk density and increase gravimetric moisture content to productive and profitable production of maize crop. However, the improvements obtained in bulk density and gravimetric moisture content could be due to positive influence of organic matter in different rates of poultry manure application on soil (Table 4). Anikwe *et al.* (2007) and Anikwe *et al.* (2003) reported that total porosity followed the trend of decrease of bulk density. This increase in pore volume increased water storage in soil as pointed out by Obi and Asiegbu (1985). Lowest bulk density and its corresponding highest GMC in plot amended with 40 t ha^{-1} of poultry manure imply that higher rate of poultry manure was more effective than lower rates in loosening soil compaction and increasing water storage and supply in soil. Low bulk density and high moisture content are soil productivity indicators.

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Table 3. Effect of different rates of poultry manure on soil physical properties

Treatment	Sand	Silt	Clay	Texture	BD Mg m^{-1}	As (%)	TP (%)	GMC (%)
0	610	280	110	SL	1.60	59.2	39	28.0
10	580	320	100	SL	1.54	63.2	42	29.0
20	630	270	100	SL	1.45	63.2	42	30.3
30	630	270	100	SL	1.40	67.2	47	30.4
40	640	290	70	SL	1.35	68.7	49	36.2
FLSD (P<0.05)						2.0	10.0	NS

0-Control, - Poultry manure at 10t ha^{-1}, Poultry manure at 20 t ha^{-1}, Poultry manure at 30 t ha^{-1}, poultry manure at 40 t ha^{-1}, SL-sandy loam, BD-Bulk density, TP-Total Porosity, AS-Aggregate stability, GMC-Gravimetric Moisture Content, Ns- Not significant at P<0.05-significance accepted at 5% probability- FLSD- Fisher's Least significant difference

Chemical Properties of Soil

Table 4 shows effect of different rates of poultry manure on chemical properties of soil. The result indicated that the plots amended with different rates of poultry manure had significantly (P<0.05) higher organic matter, available phosphorus, nitrogen and pH when respectively compared to control. Similarly, the plot amended with 40t ha^{-1} of poultry manure had significantly (P<0.05) higher organic matter, available phosphorus and pH than other plots receiving lower rates. Furthermore, plot amended with 40t ha^{-1} had significantly higher nitrogen when compared to their counterparts in plots amended with 10 and 20t ha^{-1} of poultry manure. The organic matter content, nitrogen, available phosphorus and pH of poultry manure amended plot at 40t ha^{-1} were higher by 32, 42, 21 and 41% when compared to their corresponding value in control. The organic matter, available phosphorus, nitrogen and pH increased in a trend of 40>30>20>10>0t ha^{-1} in the different rates of poultry manure application. The result further showed that there were no significant (P<0.05) treatment effect an exchangeable calcium, magnesium, potassium and sodium among the different rates of poultry manure. The plot amended with 40t ha^{-1} of poultry manure had higher calcium, magnesium, potassium and sodium when compared to values obtained in control and plots amended with lower rates. The plot amended with 40t ha^{-1} of poultry manure had Ca, Mg, K, Na which were respectively higher by 24, 35, 48 and 22% than control.

The significant increments recorded in organic matter, available phosphorus, nitrogen and pH in plots amended with poultry manure are attributable to sequestration of these soil chemical properties in soil by the amendment. These findings are supported by the report of Agbede *et al.* (2008) that nitrogen and organic matter significantly increased following poultry manure application on soil. This result is further confirmed by the observation of Ducan (2005) that poultry manure amendment contained and released macronutrients such as available phosphorus and nitrogen in soil compared to control. Though different rates of poultry manure increased soil pH, it was still very strongly acidic (Schoenergerberger *et al.,* 2002). This could be attributed to on one hand low rates of poultry manure application and on the other carbon iv oxide released during decomposition of amendment material. Nnabude and Mbagwu (2001) noted that carbon iv oxide released during organic waste decomposition reduced pH of soil. The significant increments obtained in organic matter, available phosphorus, nitrogen and pH in plots amended with 40t ha^{-1} compared to those receiving lower rates imply that it could be

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the optimum rate for improvement of chemical properties of soil. The rate contained higher contents of these soil nutrients than other rates which were released into soil (Table 4).

The non significant treatment effect of different rates of poultry manure on exchangeable bases could be due to comparable release of these bases by different rates in soil. It implies that these rates are low and cannot affect significant increase in exchangeable bases in soil. It is possible that exchangeable bases could have suffered immobilization or entered into complexes with aluminum hydroxide due to soil acidity (Table 4) Agbogidi *et al.* (2007) and Mbah *et al.* (2009) reported that low soil acidity mobilized soil bases which resulted in formation of complexes and reduced their availability in soil. Onwuka *et al.* (2011) in their studies in Abia State of Nigeria reported non significant increases in exchangeable bases of calcium, magnesium, potassium and sodium in plots amended with poultry manure. They however, attributed this finding to time of application rather than effect of rates of amendment.

Table 4. Effect of different rates of poultry manure on chemical properties of soil

Treatment	OM (%)	P mg/kg	N (%)	pH (Kcl)	Ca	Mg	K Cmolkg^{-1}	Na
0	2.3	32.3	0.11	4.7	8.7	1.7	0.13	0.39
10	3.0	35.1	0.15	4.8	9.8	1.9	0.14	0.39
20	3.1	36.0	0.17	4.8	10.4	2.0	0.16	0.39
30	3.2	36.8	0.18	4.8	10.5	2.3	0.23	0.49
40	3.4	40.9	0.19	4.9	11.5	2.6	0.25	0.50
FLSD (P<0.05)	0.2	0.2	0.02	0.1	NS	NS	NS	NS

OM- Organic matter, 0, 10, 20, 30, and 40t ha^{-1}, are rates of poultry manure amendment, Ns- Not significant, FLSD-Fisher's Least Significant Difference

Grain Yield of Maize

Table 5 and Figure 1 show that there were no significant (P<0.05) treatment effect of different rates of poultry manure on grain yield of maize. The plot amended with 40t ha^{-1} of poultry manure had higher grain yield of maize compared to control and corresponding values obtained in plots receiving lower rates. This translated to 19, 17, 11 and 7% higher grain yields of maize in plot amended with 40t ha^{-2} of poultry manure when compared to values obtained in control and plots treated with 10, 20 and 30t ha^{-1}, respectively.

The non-significant treatment effect of different rates of poultry manure on grain yield of maize could be attributed to the fact that these rates are not optimal for sustainable and profitable production of maize. This finding is supported by the reports of Chukwu (2003) and Nwadialo (1991) that poultry manure rates between 10 and 30t ha^{-1} did not have significant effect on yield of maize. Earlier, Olayinka and Adebayo (1983) in their studies had noted that different rates of poultry failed to significantly increase grain yield of maize. This finding was further corroborated by Onunka *et al.* (2011) which noted that poultry manure amendment and time of application produced high sweet potato yield although not at significant level.

Poor maize yield could further be linked to birds devastation and weevils infestation in field as there was occasional drought. Higher maize yields obtained in different rates of poultry manure amended plots compared to control are attributable to effect of amendment material. Poultry

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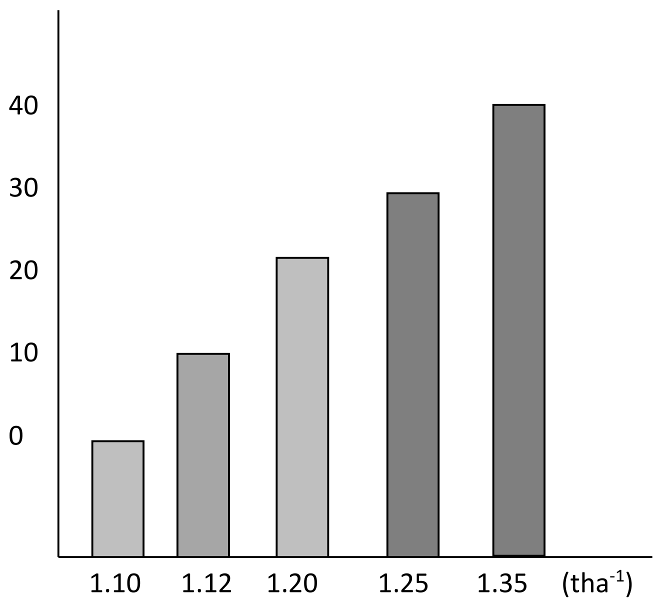
manure released valuable nutrients that improved soil physicochemical properties which gave rise to superior grain yields of maize (Table 3-4) than control. The highest grain yield of maize recorded in plot amended with 40t ha^{-1} of poultry manure suggests that the rate could be near optimum level for profitable grain yield of maize in Abakaliki. It could also be due to superior physicochemical properties of soil obtained in the plot receiving 40t ha^{-1} of poultry manure compared to control and other rates of amendment. These findings are corroborated by Mbah *et al.* (2009) that higher rate of treatment produced superior soil properties and gave higher grain yield of maize. Practically, the different rates of poultry manure produced the same effect on grain yield of maize and probably higher rates could be recommended for profitable maize production.

Table 5. Effect of Different rates of Poultry droppings on grain yield of maize

Treatments	Maize grain yield tha^{-1}
0	1.10
10	1.12
20	1.20
30	1.25
40	1.35
FLSD(P<0.05)	NS

Ns= Not significantly, FLSD = Fisher's Least Significance Difference accepted at 5% probability, 0, 10, 20, 30, 40 are rate of poultry manure amendment.



Key

Ns = Not significant

t ha^{-1} = tons per hectare

Figure 1. Effect of different rates of poultry manure on Grain Yield of Maize

CONCLUSION

This study had shown that different rates of poultry manure could significantly improve soil properties but not grain yields of maize. Different rates of poultry manure significantly

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enhanced total porosity and soil aggregation as well as organic matter, available phosphorus, nitrogen and pH. All the rates used failed to increase soil pH beyond limiting level for higher and sustainable soil productivity. Similarly, different rates of poultry manure did not give significant grain yields of maize compared to control. Although, poultry manure are important for improvement of soil properties, higher rates are recommended for sustainable and profitable grain yields of maize in Abakaliki ecology. Further trial of the experiment is recommended to assess higher rates of poultry manure application on soil pollution, phytotoxic effect and its suppression on maize yield.

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