AMERICAN-EURASIAN JOURNAL OF SUSTAINABLE AGRICULTURE
ISSN: 1995-0748, EISSN: 1998-1074
2017, volume(11), issue(5): pages (10-17)
Published Online in http://www.aensiweb.com/AEJSA/

Evaluation Of Different Rates Of Poultry Manure On Soil Properties And Grain Yield Of Maize In A Typic Haplustult In Abakaliki, Southeastern Nigeria

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Received 12 May 2017; Accepted 12 August 2017; Published Online 1 September 2017

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ABSTRACT

Poultry manure is potential source of soil nutrients, it arises thousands of years ago and has continued to be globally used for sustaining soil productivity, enhancing potential of agricultural industry, technology started to be used for nutrient optimization, to be able to predict optional nutrient usage, it therefore becomes necessary the study of different rates of poultry manure. Evaluation and optimization of soil nutrients and grain yield of maize using input data obtained from different rates of poultry manure. The field was laid out in randomized complete block design with five treatments of PM at 0, 10, 20, 30 and 40t ha^{-1} which were 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 PM had 16% lower bulk density and 14, 20 and 23% higher aggregate stability, total porosity and gravimetric moisture content compared to control. Application of PM had 32, 21, 42 and 41% significantly ($p<0.05$) higher organic matter, available P, N and pH in plot amended with 40t ha^{-1} when compared to control and significantly ($p<0.05$) higher in plots receiving higher rates Generally, organic matter, available P, N, pH and exchangeable bases of Calcium, magnesium, potassium and sodium improved in the treatments in the order of 40>30>20>10>0t ha^{-1} in the different rates of PM. 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 PM when compared to control. By using soil amendment allows to evaluate different rates of poultry manure and their potentials, so the scope of the technology which in this case is not limited to a single amendment is increased.

KEY WORDS
evaluation, grain yield of maize, poultry manure, 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 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 [1] 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 [2] and increase in soil acidity do not either help matters as these limit their usage by farmers.

Poultry manure improve soil physical properties particularly bulk density, total porosity and moisture retention as well as chemical properties [3]. Application of poultry manure is preferred to other animal wastes due to high concentration of macro-nutrients in the former [4]. According to [3] poultry manure when applied to the soil provided N, K, Ca and Mg which enhanced soil productivity. Although, research on the use of poultry manure to improve soil properties appears to have been overstretched, yet there is little or no evidence of proper documentation of evaluation of rates of PM 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 PM with other animal wastes. Sometimes, research is formulated on integrated nutrient management approach where PM is combined with NPK fertilizer and compared to inorganic fertilizer alone. Besides, [5] and [6] respectively 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. More importantly, organic manure has been shown to improve soil properties [7]. For instance, [8] noted that there was a need to assess the potential impacts of poultry manure on soil properties [9] 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 PM on soil properties and grain yield of maize in a typic haplustult 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 Latitude 06°4/N and longitude 08°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°C to 31°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 [10]. 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 [11]. 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 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, 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:

Core samples were used for determination of soil physical properties. Bulk density was determined by Blake and Hartge [12] method. Total porosity and gravimetric moisture content were evaluated using [13] procedure. Particle size distribution was determined by [14] method. Aggregate stability determination was as described by [15].

Auger samples were air-dried at 26°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 [16]. Available phosphorus was determined according to [17] method. Organic carbon determination was done as described by [18]. 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 [19]. Calcium and magnesium were determined with atomic absorption spectrophotometer while potassium and sodium were by use of flame photometer. Poultry manure was analyzed for its nutrients composition using the method of [20]. Carbon-nitrogen was evaluated by calculation using values of carbon and nitrogen.

Data Analysis:

Data obtained from yield of maize and soil 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 [21].

Results:

Table 1 shows the result of soil properties at initiation of study. The textural class is sandy loam. 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 and are expected to benefit the soil. It is believed that nutrient composition of PM especially organic carbon (16.0%), N(3.10%) calcium and potassium (6.2 and 3.3 $comlkg^{-1}$) could improve the soil. Effect of different rates of PM 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 10 h^{-1} of poultry manure. Silt fraction increased generally after planting compared to pre-planting values in all treatments. Nevertheless, the texture remained sandy loam in the different rates of PM application. The plots amended with different rates of PM had significantly ($p<0.05$) higher aggregate stability values when compared to control. Plot amended with 40t ha^{-1} of PM had significantly ($P<0.05$) higher aggregate stability value compared to their counterparts amended with 10 and 20t ha^{-1}. These represent 8 and 8% increments in aggregate stability in plot amended with 40t ha^{-1} of PM relative to those amended with 10 and 20t ha^{-1}. Furthermore, the plot amended with 40t ha^{-1} of PM had significantly ($P<0.05$) higher total porosity when compared to values obtained in other rates of PM amended plots and control. These were 20, 14, 14 and 4% higher in total porosity in plot amended with 40t ha^{-1} of PM compared to control and plots receiving 10, 20, and 30t ha^{-1} of poultry manure, respectively. Even though, there were no significant treatment effect on bulk density and gravimetric moisture content (GMC), nevertheless, the plots receiving different rates of PM 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 PM when compared to its counterpart in plot amended with 40t ha^{-1}. Similarly, the plot receiving 40t ha^{-1} of PM 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 PM. 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 PM had significantly ($P<0.05$) higher organic matter, available phosphorus, nitrogen and pH when respectively compared to control. Furthermore, the plot amended with 40t ha^{-1} of PM had significantly ($P<0.05$) higher organic matter, available phosphorus, nitrogen and pH than other plots receiving lower rates. These soil parameters were higher by 32, 42, 21 and 41% in plot amended with $40th^{-1}$ of PM compared to their corresponding value in control. The result further showed that there were no significant ($P<0.05$) treatments effect on calcium, magnesium, potassium and sodium among the different rates of poultry manure. Yet the plot amended with 40t ha^{-1} of had higher 24, 35, 48 and 22% calcium, magnesium, potassium and sodium than value obtained in control. Plots amended with lower rates had also corresponding values of exchangeable bases than plot amended with 40t h^{-1} of PM. Table 5 and Figure 1 show that there were no significant treatments ($P<0.05$) effect of different rates of PM on grain yield of maize, although the plot amended with 40t ha^{-1} of PM 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 yield of maize in plot amended with 40t ha^{-1} of PM when compared to values obtained in control and plots treated with 10, 20 and 30t ha^{-1}, respectively.

Discussion:

The pH was strongly acidic according to [22]. The organic matter and available phosphorus were of moderate values according to benchmark of [23] 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 [24]. This could be attributed to continuous cultivation, low input of amendment and generally poor management practices. The soils of Abakaliki area are highly kaolinitic and have low activity clays. The value of organic carbon, total nitrogen and organic matter ranged from high to very high values while available phosphorus was low in poultry manure. Calcium dominated other exchangeable bases. Carbon nitrogen ratio was moderate [25]. [26] noted that nutrients composition of PM varied and indicated reflection of nutrients in the diet of poultry. Nutrients compositions of PM were far higher than those in soil before initiation of study and is believed it could support good crop performance in a degraded or low productive soil when applied as amendment [24]. Low phosphorus content in poultry PM 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. Results further indicated that even though cultural practices such as cultivation could cause variations and redistribution in particle sizes of soil but could not change texture. This is supported by the report of [13] 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 [1]. 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 caused eluviations of finer particles leaving higher concentration of sand rather than rates of PM amendment [27]. Organic matter (Table 4) released by different rates of PM during decomposition and mineralization was enough to cause soil aggregation and stabilization [2]. [28] noted that organic matter contributed about 70% of aggregate stability of soils. [5] and [6] 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 PM compared to their counterparts in other amended plots could be attributed to higher significant organic matter content released by PM in the soil (Table 4). Higher total porosities recorded in plots amended with different rates of PM relative to control could be due to effect of organic materials from the added PM 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 PM probably because of higher effect of PM compared to other plots amended with lower rates. On the other hand, differences observed in total porosities among plots receiving different rates of PM could be attributed to combined effect of cultivation and PM 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 PM amendment as they are not limiting to soil productivity. The non-significant treatment effect of different rates of PM amendment on bulk density and gravimetric moisture content is attributable to low rates of PM which could not elicit good and positive response on these soil properties. It suggests that the rates of PM used are low and not appropriate to significantly reduce soil bulk density and increase GMC to productive and profitable production of maize crop. Nevertheless, bulk density and GMC were improved due to positive influence of organic matter in different rates of PM application on soil (Table 4). [29] and [30] reported that total porosity followed the trend of decrease of bulk density. Lowest bulk density and its corresponding highest GMC in plot amended with 40t ha^{-1} of PM imply that higher rate of PM 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 [31]. The significant increments recorded in organic matter, available phosphorus, nitrogen and pH in plots amended with PM are attributable to sequestration of these soil chemical properties in soil by the amendment. These findings are supported by the report of [3] that nitrogen and organic matter significantly increased following PM application on soil. This result is further confirmed by the observation of [24] that PM amendment contained and released macronutrients such as available phosphorus and nitrogen in soil compared to control. Though different rates of PM increased soil pH, it was still very strongly acidic [22]. This could be attributed to on one hand low rates of PM application and on the other carbon iv oxide released during decomposition of amendment material. [32] 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 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 PM 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 clue to soil acidity (Table 4). [33] reported that low soil acidity mobilized soil bases which resulted in formation of complexes and reduced their

availability in soil. [34] 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. The authors however, attributed this finding to time of application rather than effect of rates of amendment. The non-significant treatment effect of different rates of PM 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 [35] and [36] that PM rates between 10 and 30t ha^{-1} did not have significant effect on yield of maize. Earlier, [37] in their studies had noted that different rates of PM failed to significantly increase grain yield of maize. This finding was further corroborated by [34] which noted that PM 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 PM amended plots compared to control are attributable to effect of amendment material. Poultry 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 PM treatment 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 PM compared to control and other rates of amendment. These findings are corroborated by [5] that higher rate of treatment produced superior soil properties and gave higher grain yield of maize.

Conclusion:

This study had shown that different rates of PM could significantly improve soil properties but not grain yields of maize. Different rates of PM significantly 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 PM did not give significant grain yields of maize. The general trend of different rates of PM in improvement of soil physicochemical properties and grain yield of maize is 40>30>20>10>0t ha^{-1}, respectively. Although, PM is important for improvement of soil properties, higher rates are necessary for sustainable and profitable grain yield of maize in Abakaliki agro-agro ecology. Practically, the different rates of PM produced the same effect on grain yield of maize and probably higher rates could be recommended for profitable maize production. Higher rates of PM could be assessed on soil pollution, phytotoxic effect and its suppression on grain yield of maize. Generally, by using different rates of PM as soil amendment, which allows for evaluation of their potentials, and in this case although not limited, application at 40t ha^{-1} improved physicochemical properties and grain yield of maize more than lower rates.

Table 1: Soil properties at initiation of 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 P phosphorus	$mgkg^{-1}$	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

Table 2: Nutrients composition of poultry manure

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

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

	← gkg–1 →							
Treatment	Sand	Silt	Clay	Texture	BD ($Mgm^{-3)}$	(%)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	260	100	SL	1.35	68.7	49	36.2
FLSD (P<0.05)					NS	2.0	10.0	NS

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

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

					← Comlkg^{-1} →			
Treatment	OM(%)	($Pmgkg^{-1)}$	N(%)	pH (kcl)	Ca	Mg	K	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, poultry manure at 0, 10, 20, 30, and 40t ha^{-1} respectively. Ns- Not significant, FLSD-Fisher's Least Significant Difference

Table 5: Effect of different rates of poultry manure 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 are rates of poultry manure.

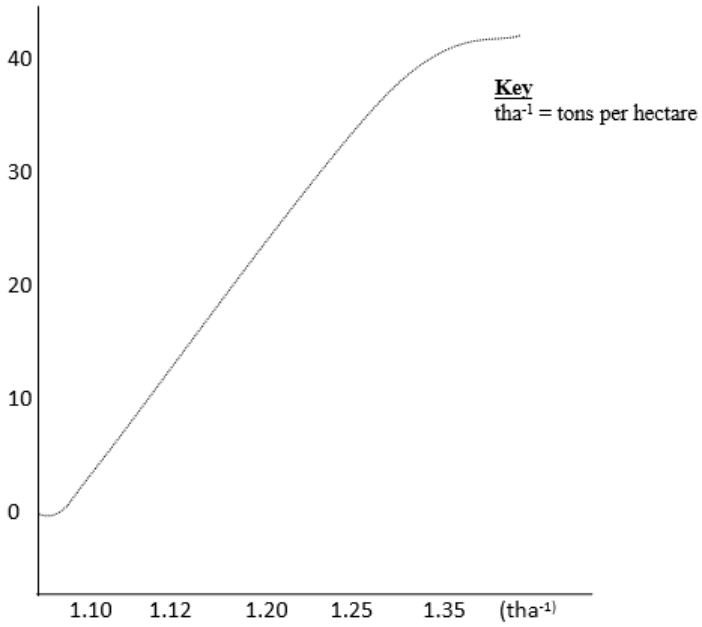

Fig. 1: Effect of different rates of poultry manure on Grain Yield of Maize

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