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Analysis

Performance of pig slurry on a degraded sandy soil and the yield of irrigated upland rice *(Oryza sativa)* in Owerri, South-East Nigeria

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ABSTRACT

A field experiment was conducted from December, 2017 to April, 2018 dry seasons at the Center for Agricultural Research and Extension, Federal University of Technology, Owerri, to determine the effect of different rates of Pig slurry on a degraded sandy soil and the yield of Upland Rice *(Oryza sativa)*. There were 6 treatments namely T1 (Control), T2 (NPK 20:10:10) at 800 kg.ha^{-1}, T3 (10t/ha of pig slurry), T4 (20t/ha of pig slurry), T5 (30t/ha of pig slurry), T6 (40t/ha of pig slurry) and replicated 3 times. Each plot measured 2 m X 2 m with a 1 m alley between plots. Pre harvest and post harvest soil samples were collected from the sites at 0-30cm depth and used for the determination of selected physical and chemical properties. Grain yield was adjusting to 12 % moisture content and weighed. The experiment was mapped out according to Randomized Complete Block Design. The data generated was subjected to analysis of variance (ANOVA) and significant means were separated using Fishers Least Significant Difference at P = 0.05.The soil properties and grain yield of rice were not significantly affected when T1 (control) was compared with T2 (NPK) treatments. While the application of different rates of Pig Slurry when compared with the control and NPK rates revealed significant effects on soil properties and grain yield of rice. Grain yield increased with increase in rates of pig slurry application. Rice grown on plots treated with 40 t.ha-^{1} pig slurry gave the highest grain yield as it showed 95, 90, 85, 40, and 20% higher yield when compared with rice yield from the control, NPK, 10 t.ha^{-1}, 20 t.ha^{-1} and 30 t.ha^{-1} plots respectively. Pig slurry application rate at 40t.ha^{-1} has proved to be a good rate for rice production with a promise that increasing the rate beyond this level may continue to give economic yield on a degraded sandy soil.

Key Words: Rates of Pig Slurry, Degraded, Irrigated, Sandy Soil, Yield, Upland Rice

1. INTRODUCTION

Changes in soil chemical composition due to application of pig slurry are variable and highly influenced by factors such as soil texture, rate, time and method of application, amount of precipitation, crops grown and time of sampling. Heavy application of manure increased NO_3-N, available P and exchangeable K and Na more than did inorganic fertilizer (Evans *et al*. 1977). King *et al*. (1985) reported accumulation of NO_3-N, Mehlich I extractable P and Na in subsoil from manure effluent application; the level of accumulation increased with increasing rate of manure application. Manures have lower N/P ratios than crop plants, thus when N is supplied through manure to a crop . At high rates of manure application, Ca and Mg may be displaced from exchange sites by competing ions present in the manure, such as Na^+, K^+ and NH_4^+, and may be leached from the top soil with some accumulation in deeper layers. Also, the H^+ produced during conversion of NH_4^+ to NH_3 may compete successfully for Ca and Mg sites on the soil colloids and thus lower the surface soil pH (King *et al*. 1985). Addition of salt or additives to the swine feed can change the swine manure composition and can accumulate in the soil. Similarly, increasing dietary salt levels increased Na levels in manure and the soil (Sutton *et al*. 1984*b*). Bernal & Kirchmann (1992) reported that addition of swine manure in arid and semi-arid areas could cause salinization.

The non-leached part of nitric N is entirely usable by crops. If the application is done in a season when it will soon be absorbed by the crop, losses will be almost negligible. One part of the organic N in slurry will be transformed into mineral N during the first year, or else during the second year, as it is highly affected by temperature and soil moisture.

There is little to no information available on the effect of pig manure on soil physical properties. However, the effects of swine manure may be similar to those reported for cattle manure. Cattle manure has been reported to improve soil aggregation (Elson 1941; Williams & Cooke 1961; Hafez 1974), to lower bulk density (Hafez 1974; Tiarks *et al*. 1974), and to improve structure and water holding capacity of soils due to increased organic matter (Unger & Stewart 1974; Weil & Kroontje 1979). Also, Sommerfeldt & Chang (1985), working on Chernozemic soil with three different tillage systems, reported increased soil organic matter and decreased bulk density, spring soil temperature, and drawbar draft on tillage implements with increasing rate of pig manure. It was due to this dearth of data that an experiment to investigate the effect of different rates of pig slurry on a degraded irrigated sandy soil and yield of upland rice *(oryza sativa)* in Owerri, South-East Nigeria was carried out.

2. MATERIALS AND METHOD

Description of Study Area

The experiment was carried out at the Center for Agricultural Research and Extension, Federal University of Technology Owerri (FUTO) located at 05°22.87^{1}N 006°59.57^{1}E. The 26.4°C average temperature was recorded with an annual average rainfall of over 2500 mm and a relative humidity of 65 – 80 %. Owerri is sited the humid rain forest and has many agricultural products like yam, corn, rubber, cassava, corn and palm. Reconnaissance visit was made to the site before sampling. Initial soil samples were collected before clearing and plowing and final samples were taken after the rice grain was harvested. Soil samples were collected randomly using a core sampler attached to soil auger at a soil depth of 0-30cm from each of the treated plots. The initial soil samples were bulked, mixed thoroughly and a representative sample collected for analysis. Again the post harvest soil samples from each of the

36 plots were bulked according to treatments and three representative samples were collected from each treatment. These soil samples were analyzed for soil physical and chemical properties according to standard analytical methods.

Treatment Allocation

The organic matter used was pig slutty. There were 6 levels of the treatments namely: Control as T1, NPK 20:10:10 at 800 kg/ha as T2, 10t/ha of pig slurry as T3, 20t/ha of pig slurry as T4, 30t/ha of pig slurry, as T5 and 40t/ha of pig slurry as T6 with three replications.

Land Preparation

The study site was cleared of existing vegetation and irrigated an hour each day for 10 days before plowing was done using spade to prepare flat seed beds. This was done to make the soil loose and also enable seed germination. The site was laid out using pegs, measuring tape, hammer, cutlass and spade. The total land area of the site was 16 m x 24 m with each plot measuring 1 m x 1.5 m and an alley of 0.5 m giving a total of 36 plots.

Treatment Application

The different rates of pig slurry were applied to designated plots by uniformly spreading them on the plots. They were incorporated into the soil by harrowing using hoe to mix the soil thoroughly with the treatment and in the process bring the soil to a fine tilt. This was done 1 week before planting and NPK was applied to designated plots 2 weeks after sprouting to ensure that losses were reduced before the plant was physiologically ready to use the nutrient.

Planting of Test Crop

The test crop upland rice CP 306 (*Oryza sativa*) was planted one week after treatment application. The planting distance was 30 cm between the row and 20 cm along the row with a pinch of seeds per hole. The seedlings were later thinned to 3 seedlings per hole after germination.

Agronomic Practices

Weeding was done twice during the growing period using hand picking and hoe. Irrigation was practiced to supplement the natural rainfall. When irrigated it was for period of one hour each day. Potential bird attack was avoided by netting the entire plot (Fig.1).

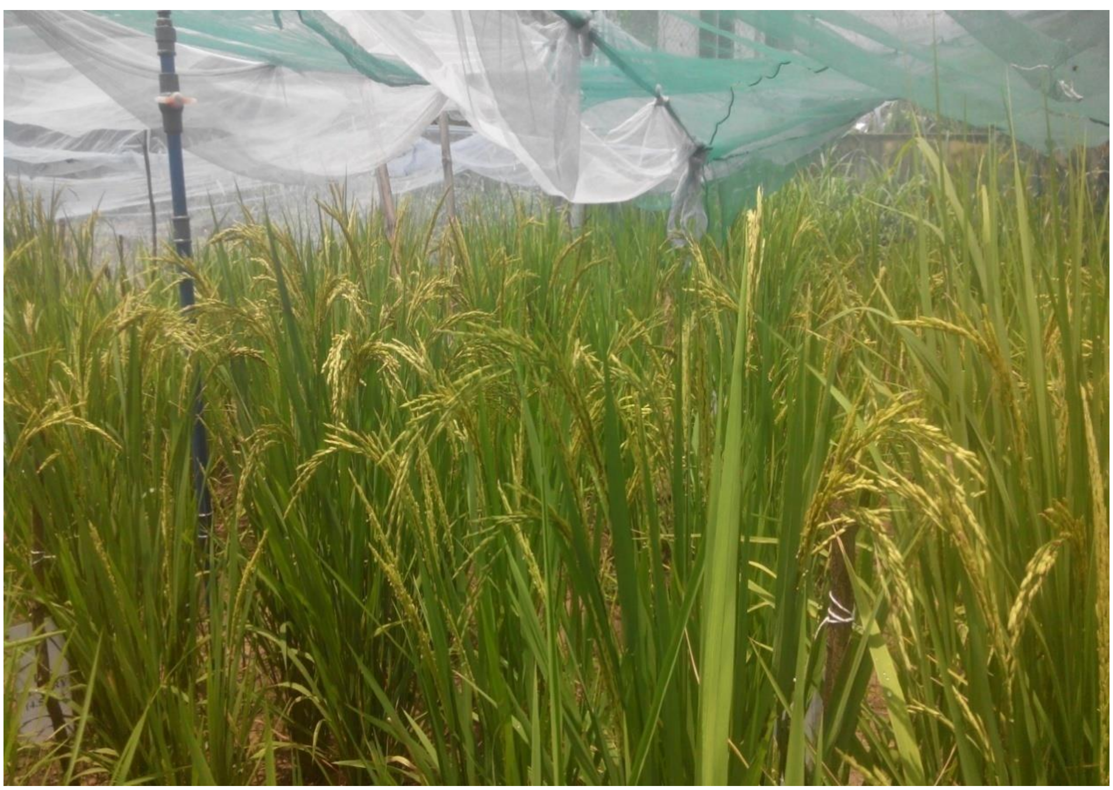

Fig. 1: Netted Experimental Site to check Birds and rodents on the Rice Farm

Grain Yield

Harvesting of ripe grain was done by cutting rice panicle at about 10 - 15 cm above ground level. The panicles were thrashed and the grains removed. Grain yield was recorded after adjusted the grains to 12 % moisture content. The yield was reported in tones per hectare.

Laboratory Analysis of Soil Samples

The sand, silt and clay content of the soil sample were determined by Hydrometer method using Sodium Hexametaphosphate as a dispersing agent (Gee and Or, 2002). Bulk density was determined following the method described by Grossman and Reinsch (2002). The bulk density was calculated using equation 1;

$$\mathbf{BD} = \frac{\mathbf{Ms}}{\mathbf{Vt}} ------------------ equ.1$$

Where BD= Bulk Density

Ms= Mass of oven dried soil

Vt= Volume of soil (taken as volume of cylinder)

Moisture content was determined using the Gravimetric method and calculated using equation 2.

$$MC = \frac{W2-W3}{W3-W1} X\ 100 --------------- equ.2$$

W1= Weight of can with lid

W2= Weight of can + wet soil

W3= Weight of can + dry soil

Total porosity was calculated from the values gotten from Bulk density thus.

$$TP = \left(1 - \frac{BD}{PD}\right) \times 100 -------------------- equ.3$$

TP= Total porosity

BD= Bulk density

PD= Particle density (2.65g/cm^3)

Saturated hydraulic conductivity was determined using constant head method (Landon, 1986).

$$Ksat = \frac{Q}{A \times t} \times \frac{L}{\Delta H} -------------------- equ.4$$

Where Q = Steady Reading

L = Length of the core

t = Time

A = Area of core

ΔH = Height of steady water supply

Soil Chemical Properties

Soil pH was determined in soil water ratio of 1:2.5 using a glass electrode pH meter according to Tookey Kerridge, (1925). Organic carbon was determined following the method described by Walkley and Black (1934) method. Total nitrogen was determined using Kjeldahl digestion method (Juo, 1979). Available phosphorus was determined using Bray and Kurts (1945) method. Exchangeable bases such as Ca, Mg, K, Na were extracted in a pH 7 level of 1N NH_4OAC. Potassium and sodium were determined with flame photometer while Calcium and Magnesium by ETDA titration method (Black *et al*, 1965). Exchangeable acidity was determined by titration method using 1NKCL extract (Mclean, 1965). Effective Cation Exchange Capacity was determined by the summation of exchangeable bases and exchangeable acids. Percentage base saturation was calculated by dividing the total exchangeable bases by the effective cation exchange capacity of the same soil sample.

Experimental Design and Statistical Analysis

The experimental was laid out in a randomized complete block design (RCBD). Data collected were subjected to ANOVA ie analysis of variance. Mean difference was separated using Fishers Least Significant Difference at P = 0.05 according to Gomez and Gomez, 1984.

3. RESULTS AND DISCUSSION

Nutrient Composition of the Pig Slurry Used

The nutrient composition of pig slurry is presented in Table 1.

Table 1: Nutrient composition of Pig Slurry

Nutrient Element	Value
pH	7.8
OC (g/kg)	21.6
OM (g/kg)	37.2
TN (g/kg)	18
Avail. P (cmol/kg)	1.8
Ca (cmol/kg)	2.0
Mg (cmol/kg)	2.2
K (cmol/kg)	4.0
Na (cmol/kg)	1.4
Al (cmol/kg)	1.7
H (cmol/kg)	3.9
C:N	12

The result of the analysis of the pig slurry before application showed that there were 4.3 % solid with a pH value of 7.8 indicating that it was alkaline in nature. The organic carbon and organic matter values of 21.6 and 37.2 respectively. These values of organic carbon and organic matter were rated high. The Available Phosphorus was high, the exchangeable bases (Ca, Mg, Na, and K) and ECEC were equally high indicating that pig slurry hold a promise of improving soil fertility. Pig Slurry can be an excellent source of plant nutrients including Nitrogen (N), Phosphorus (P) and Potassium (K). It can be used to replace much of the chemical fertilizers required to fertilize grassland and crops (Marschner, 1995; Tisdale *et al*., 1993).

Treatment Effects on Physical Properties of the Soil

The effect of treatment on Soil Physical Properties is presented in Table 2

Bulk density:

The results showed that there was no significant difference when T1 (Control) was compared with other treatments and when the other treatments were compared with one another. Generally, the bulk density of the plots treated with pig slurry was reduced. This was confirmed by Hafez (1974) and Tiarks *et al*. (1974) who reported that pig slurry application on soil lowered bulk density of such soils.

Total Porosity:

The result showed that there was no significant difference in the total porosity of the soil from the plots treated with different rates of pig slurry when compared with control and NPK treatments. But there were mean differences which ranged from 0.50% to 1.50%. Plots with high treatment application (T4, T5, T6) had higher porosity values when compared with plots treated with T1, T2, and T3. This is because the higher the organic matter the lower the bulk density (Chikezie *et al*., 2010).

Table 2: Effect of Treatment on Soil Physical Properties.

TRT	BD (g/cm^3)	TP (%)	Ksat (cm/hr)	MC	SAND →	SILT	CLAY g/kg
T1	1.0	62.5	7.8	63.4	884.1	36.2	79.7
T2	1.0	62.5	7.7	70.6	897.8	33	69.2
T3	1.0	62.5	7.6	78.6	889.3	37.6	73.1
T4	0.9	63.0	7.6	83.8	889.9	20.9	89.2
T5	0.9	63.0	7.4	131.4	880.2	32.1	87.7
T6	0.8	64.0	7.2	134	852.1	31.4	116.5
LSD P=0.05	**NS**	**NS**	**NS**	**24.9**	**10.6**	**NS**	**12.3**

Legend

TRT=Treatment, T1=Control, T2=NPK 20:10:10 at 120g per plot, T3=10t/ha, T4=20t/ha, T5=30t/ha, T6=40t/ha, BD=Bulk Density, TP=Total Porosity, MC=Moisture Content NS=Not Significant Statistically at P=0.05

Saturated Hydraulic conductivity:

The result showed that there was no significant difference when plots treated with T1 and T2 were compared with the pig slurry treatments and when the different rates of application of pig slurry was compared with one another. Nevertheless, the rate of water movement into the soil was slower with T5 and T6 treatments, while T, and T2 revealed faster rate of water movement through the saturated water column.

Moisture content

There were no significant differences when the soil moisture content from the T1 plot was compared with T2 and T3 treated plots but there were significant differences when the moisture content of T1 treated plot was compared with the values from the plots treated with T4, T5 and T6 treatments. The plots treated with 20, 30 and 40 t.ha^{-1} recorded 61.80 g.kg^{-1}, 59.15 g.kg^{-1}, and 8.80g/kg higher soil moisture content when compared with the control plot. Treatment six recorded the highest moisture content of 134.0 g.k^{-1} followed by T5 131.4 g.kg^{-1} while the lowest moisture content was recorded from the control plot with a value 63.4 g.kg^{-1}. This low moisture content in T1, T2 and T3 can be attributed to low organic matter resulting from the degraded nature of the sandy soil while the high water content of T5 and T6 can be as a result of the effect of the increased organic matter from the treatments. This was also reported that pig manure improved soil aggregation, lowered bulk density, and improved structure and water holding capacity of soils due to increased organic matter (Unger & Stewart, 1974; Weil & Kroontje, 1979; Zane E.E, 2006; Elson, 1941; Williams & Cooke, 1961; Hafez, 1974; Tiarks *et al*., 1974).

Particle size distribution:

Sand fractions dominated the particle size distribution of the study area. There was significant difference in the particle size distribution when T1 was compared with T6 but there was no significant difference when T1 treated plot was compared with plots treated with T2, T3, T4 and T5. The same trend was the case with the clay fraction. Also there was no significant difference in silt content of the soil when T1 was compared with other treatments and when the other treatments were compared with one another. These results conform with the results obtained by Onweremadu (2007) and Onwudike (2015) on textural characteristics of coastal plain soils in Owerri, Southeast Nigeria.

Effect of Treatment on Soil chemical Properties

The effect of treatment on soil chemical properties is presented in Tables 3 and 4.

pH

The result showed that the soil pH was low in both water and KCl with T2 having the highest mean value of 5.5 in water and 4.4 in KCl while T4 had the lowest pH mean value of 5.2 in water and 4.3 in KCl. There was no significant difference when T1 was compared with other treatment and when the other treatments were compared with one another. This low pH is attributed to the high rainfall and coarse texture of the soil that influenced high rate of leaching of cation (Nnaji *et al*, 2002).

Table 3: The effect of treatments on soil chemical properties

TRT	pH H2O	pH (Kcl)	OC	TN	C:N	Avail.P Cmol/kg
T1	5.4[a]	4.3 [a]	12.0 [a]	10.1a	11.6 [a]	1.2
T2	5.5 [a]	4.4 [a]	17.0[b]	18.3[b]	11.6 [a]	1.6
T3	5.3 [a]	4.3 [a]	19.5[c]	16.7[c]	11.6 [a]	2.0
T4	5.2 [a]	4.3 [a]	21.0[d]	18.0[d]	11.6 [a]	2.6
T5	5.4 [a]	4.3 [a]	25.0[e]	21.5[e]	11.6 [a]	2.3
T6	5.4 [a]	4.3 [a]	27.0[f]	23.2[f]	11.6 [a]	2.5
FLSD(P=0.05)	**NS**	**NS**	**1.3**	**1.0**	**NS**	**0.1**

LEGEND: OC=Organic Carbon, TN=Total Nitrogen, OM=Organic Matter, C:N=Carbon: Nitrogen Ratio, TRT=Treatment, T1=Control, T2=NPK 20:10:10 (800kg.ha^{-1}) , T3=10 t.ha^{-1}, T4=20 t.ha^{-1}, T5=30 t.ha^{-1}, T6=40 t.ha^{-1}, NS=Not Significant .Note: Figure with same superscript are no statistically significant.

Organic carbon

The result of the effect of treatment on soil organic carbon showed that there were significant differences when the OC from the control was compared with that from T2 and the rest of the treatments and when the other treatments were compared with one another. Treatment 2 recorded the lowest mean value of 17.0 g.kg^{-1} of OC while T6 recorded the highest mean value of 27.0 g.kg^{-1}. There was consistent reducing organic matter in the plots treated with 40t.ha^{-1} pig slurry when compared with the rest of the treatments. Take for example there was 15.0, 10.0, 7.5, 6.0 and 2.0 g.kg^{-1} more organic matter when T6 was compared with T1, T2, T3, T4 and T5 respectively. The low values for organic carbon in the control plot and the plot treated with NPK could be attributed to the fact that the soil was naturally low in organic matter having lost its top soil to excavation for construction work, and erosion losses (Lekwu and Oparaugo, 1984). The environment of Eastern Nigeria is characterized by high temperature and high relative humidity conditions that favour rapid decomposition and mineralization of organic matter. This could explain the low levels of organic carbon in the non pig slurry treated plots (Chikezie *et al*., (2010). The high organic matter from the plots that received pig slurry treatment could come from the fact that pigs are monogastric animals that feed on roughage. With its single chamber stomach, the digestion of this roughage is incomplete in the animal and therefore supplies large quantity of organic matter when the excreta are used as manure.

Total Nitrogen

The result of the total soil nitrogen showed that there were significant differences when T1 (control) were compared with T2 and the rest of the treatments and when the other treatments were compared with one another except when the total nitrogen from the NPK 20:10:10 was compared with that recorded from the plot treated with 20 t.ha^{-1}. The high total nitrogen relatively recorded from the T2 can be attributed to the use of NPK 20:10:10 at that 800 kg.ha^{-1} .The low nitrogen content of the soil under the control plot may be due to the nature of the parent material and the fact that soils of this area are inherently poor coupled with the degradation resulting from de-surfacing caused by civil engineering activities (Onweremadu et al., 2013). Again the higher level of pig slurry application of 40t.ha^{-1} showed another steady increase in enriching the soil with nitrogen. This was evident when the result recorded 13.10, 4.9, 4.8, 1.70 g.ha^{-1} more total nitrogen when compared with T1, T2, T3 and T5 respectively. Here there was a deviation from the normal decreasing relative trend of soil enrichment when T6 was compared with T4. The result revealed a much higher mean difference of 5.2 g.kg^{-1}. The applied treatment was found to supply nitrogen to the soil as reported by Marschner, (1995) and Tisdale *et al*., (1993). Evans *et al*., (1977) reported that high application of pig slurry increased nitrogen content, Available P and Exchangeable Potassium and Sodium more than inorganic fertilizers. The improvement in total nitrogen from the plots that received the pig slurry treatment may have resulted from the fact that pigs excrete partially digested food that are still rich in nutrients such as nitrogen. Pig Slurry has proven to be an excellent source of nitrogen to plant.

Available Phosphorus:

There were significant differences when the available phosphorus concentration of the soil from T1 (control) was compared with T2 (NPK), T4 (20t/ha), T5 (30t/ha), and T6 (40t/ha). Also there were significant differences when the result from T2 was compared with, T3, T4, and T6. Again there were significant differences when T4 was compared with T2 and T3. Generally, the applied treatment improved the concentration of availability Phosphorus in the soil as pig slurry has been found to be an excellent source of plant nutrients including Nitrogen (N), Phosphorus (P) and Potassium (K) (Marschner, 1995; Tisdale *et al*., 1993). There was no particular trend in the release of phosphorus to the soil by the treatments. However there was a decreasing release of phosphorus to the soil as the application rate of pig slurry increased relative to the increasing rate of application. For instance there was 0.2g.kg^{-1} more available phosphorus when T6 was compared with T5 but the value increased to 0.5, 0.9 and 1.30 g.kg^{-1} when T6 was compared with T3, T4 and T5 respectively. Worthy of mention here is the higher concentration of available phosphorus recorded from the plots treated with 30 t.ha^{-1} of pig slurry. These available phosphorus concentrations are by fertility indices according to Landon, (1990) is low. The low Phosphorus content of the native soil can be attributed to high solubility of the substance which makes it easily leachable as explained by King *et al*. (1985). The inefficient digestive system of the pig system makes them ideal for the production of manure rich in plant nutrient.

Exchangeable Acidity (Al, H):

There were no significant differences when the Al concentration of T1 (control) was compared with T2 NPK, T3 10t/ha, T5 30t/ha and T6 40t/ha and when the treatments were compared with one another. Nevertheless in the hydrogen ion concentration the result showed that there were significant differences when T1 was compared the treatments except T4 and when the treatments were compared with one another except when T3 was compared with T5. The highest mean difference was recorded when the control was compared with T2 and T6. The result revealed 9.6, and 8.10 g.kg^{-1} more hydrogen ion concentration in T2 and T6 respectively. Among the treatments the comparison of T2 with T4 and T4 and T6 equally revealed significantly higher mean difference of 8.7 and 7.2 g.kg^{-1} respectively. Hydrogen ion concentration in soils determines the pH value of such soils. This increase in hydrogen ion in the treated soil may be attributed to the application of pig slurry and the NPK 20:10:10 in the soil.

Exchangeable Bases (Ca, Mg, K, Na)

There were no significant differences in potassium and sodium concentrations of the soil when T1 was compared with T2 and the rest of the treatments and when the treatments were compared with one another.

The result of the calcium concentration showed that T1 differed significantly when compared with the other treatments except T2, T4 and T6. Also there were significantly higher concentration of calcium in T2 when compared with T3 and T4 and when T3 was compared with T4, T5, and T6. There were 0.5 g.kg^{-1} more calcium in the plots treated with 20 t.ha-1 pig slurry when compared with those treated with 10 t.ha^{-1}.

Again the result showed that there was significantly high magnesium concentration in the plots treated with T2, T3, T5 when compared with the control. Here there were 2.2, 2.6 and 0.7 g.kg^{-1} more magnesium in T2, T3 and T5 plots respectively when compared with the control. There was no significant difference when T1 was compared with T 4, and T 6, and when T 2 was compared with T 3 and T5 and when T4 was compared with T6. Furthermore there were significant differences when T2 was compared with T4 and T6 and when T3 was compared with T4, T5 and T6. The result also recorded significantly 0.8 g.kg^{-1} more magnesium in the plots treated with 40t.ha $^{-1}$ than the plots that received 30 t.ha^{-1} pig slurry treatment. The Exchangeable bases (Ca, Mg, Na, and K) of treated plots were improved indicating that pig manure has basic cations to enhance plant growth as reported by (Tisdale *et al*., 1993).

Effective Cation Exchange Capacity (ECEC)

Result showed that there were significant differences when T1 was compared with T3, T4, T5 and T6. The soil ECEC increased by 8.1, 9.4, and 18.0 respectively when T1 was compared with T3, T4, T5 and T6. But there were no significant differences in the soil ECEC only when T1 was compared with T2, and when T3 was compared with T4, but showed no significant difference when compared with T4. Treatment 2 showed significant difference when compared with other treatments with their mean difference values ranging from 24.4cmol/kg to 6.48cmol/kg. Treatment 4 showed significant difference when compared with other treatments except with T1. The low effective cation exchange capacity content of the soil reaffirmed that the adsorption capacity of soil was humus dependent (Okalebo *et al.,* 1993). Generally, the applied treatment improved the ECEC of the plots treated with higher rates.

Percent Bases Saturation (%BS):

There were significant differences when the soil percent base saturation from the control plot was compared with those from T2, T3, T5 and T6 plots. The base saturation values from the various plots ranged from 53.31% to 59.70% with consistent decreasing mean difference when values from 40 t.ha^{-1} were compared with one another. The mean differences were 59.70, 53.30, 43.30, 31.0 and 14.10 % when T6 was compared with T1, T2, T3, T4, and T5 respectively. Also there was significant reducing mean value when T2 mean value was compared with T3, T4, T5 and T6. The trend was true when T3 was compared with T4, T5 and T6. The percent base saturation increased as pig slurry application increased. The best rate of application for improved base saturation was found to the 40 t.ha^{-1}.

Table 4: Continuation of the effect of treatments on soil chemical properties

TRT	Al^+	H^+	Ca	Mg Cmol /kg	TEA	TEB	ECEC	BS (%)
T1	Trace	0.9	1.6	0.5	0.9	2.3	3.2	10.4
T2	12.6	10.5	1.6	2.7	23.1	4.5	4.4	16.8
T3	5.0	3.0	1.2	3.1	8.0	4.5	11.3	26.3
T4	Trace	1.8	1.7	0.7	1.8	2.6	12.6	39.0
T5	5.0	3.4	1.6	1.2	8.4	2.9	21.2	56.0
T6	10	9.0	1.6	0.4	19.0	2.2	27.7	70.1
FLSD(P=0.05)	**NS**	**1.0**	**0.1**	**0.6**	**1.9**	**0.5**	**1.7**	**5.6**

LEGEND: Al=Aluminum, H=Hydrogen. Ca=Calcium, Mg=Magnesium, TEA=Total Exchangeable Acidity, TEB=Total Exchangeable Bases, ECEC=Effective Cation Exchange Capacity, BS= Base Saturation

Grain Yield:

The effect of treatment on grain yield is presented in Table 5.

Table 5: Effect of Treatment on Yield of Rice.

TRT	GRYD* t.ha^{-1}
T1	1.30^{a}
T2	1.76^{a}
T3	2.58^{b}
T4	3.27^{c}
T5	4.15^{d}
T6	4.91^{e}
FLSD (P=0.05)	**1.2**

GRYD= Grain Yield

Note: figures with the same superscript are not statistically significant.

There were significant differences in the rice grain yield when T1 (control) was compared with T3, T4, T5 and T6. The result further recorded grain yield increase of 0.48, 1.28. 1.97, 2.85 and 3.61 t.ha^{-1} form T2, T3, T4, T5 and T6 treated plots respectively when compared with the grain yield from the control plot. Nevertheless there was no significant difference when the grain yield from the control plot was compared with the plots treated with 800 kg.ha^{-l} of NPK, 20:10:10. It was observed that there was a trend of increasing rice grain yield as the rate of the pig slurry application increased. This scenario indicated that pig slurry improved the yield of rice at an increasing rate of application leaving room for application of higher rate than 40 t.ha^{-1}. This finding is in agreement with the findings of Sutton *et al*. (1978); Xie & MacKenzie (1986), Chase *et al*. (1991), Vıˆjialaˇ *et al*. (1991); Petrˇı´kova, (1992) who reported that increasing rate of applied pig slurry increased crop yields.

4. CONCLUSION

Results obtained from the research showed that the application of pig slurry had positive impact on the soil physical and chemical properties and yield of rice. Plots treated with 30 and 40 t.ha^{-1} of the treatments showed higher growth and yield of the test crop (Rice) than the other treatments. Using pig slurry at a rate of 40 t.ha^{-1} to cultivate rice in a degraded sandy soil is suggested. The increasing improvement in rice grain yield recorded means that the highest rate used in this research can be increased until a steady yield is reached. At a point when an increase in application of the pig slurry will not lead to economic increase in grain yield of the test crop.

RECOMMENDATIONS

Based on the findings of this research, it is recommended that;

1. Farmers should be encouraged to adopt the use of pig slurry as manure on a degraded sandy soil for the cultivation of upland rice in Owerri and similar ecologies,
2. The rate of application of 40 $t.ha^{-1}$ should be adopted for rice production for now on a degraded sandy soil of Imo State Nigeria for upland rice production.
3. Since the researchers recorded increasing positive response with increasing rate of application of pig slurry, it is our opinion that higher rates should be tried until a constant or decreasing response is recorded.

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The authors declare that there are no conflicts of interests.

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Data and materials availability:

All data associated with this study are present in the paper.

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