International Journal of Agriculture, Food and Biodiversity IJAFAB

Effects of Swine Wastes on Selected Soil Properties, Growth and Yield of *Amaranthus hybridus* in Anambra State, Nigeria

Nwosu, T. V.*, Alexander, C. F., Anene, C. K., Igboka, C. R., Steve-obi, C. E.

Department of Soil Science and Land Resources Management, Nnamdi Azikiwe University, Awka

*Corresponding Author's Email: tv.nwosu@unizik.edu.ng

Abstract

Disposal effect of swine waste into the environment poses a serious environmental threat but channelling it into the soil as an amendment for vegetable production proves to be a vital solution for the challenge. Hence, the "effects of swine wastes on selected soil properties, growth and Yield of *Amaranthus hybridus* in Anambra State" was studied. The study was conducted at the Soil Science and Land Resources Management Research and Teaching Farm, Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Anambra State. The field experiment was laid out in a Randomized Complete Block Design. Auger soil samples were taken from 20 different points at 0-20 cm depth while core soil samples were taken from 10 different points from the experimental plots before and after treatment application which were later taken to the laboratory for analyses. The treatment used was swine wastes and at different rates of 0 kg/plot (zero application), 4.5 kg/plot, 9.0 kg/plot and 13.5 kg/plot. The test crop used was *Amaranthus hybridus*. The results obtained from the laboratory were subjected to statistical analysis and the treatment means were separated using Turkey test at 5% probability level. The results showed that the soil of the studied area was acidic and belonged to sandy loam textural class. Again, obtained results showed there were significant differences in bulk density, total porosity and moisture content however significant differences were not observed in the chemical properties of soil. From this research, it was observed that 13.5 kg/plot of swine wastes applied improved the yield of *Amaranthus hybridus* when compared to other treatment rates as evidenced in the optimum plant height, leaf area index, number of leaves and fresh and dry shoot weight recorded.

Keywords: *Amaranthus hybridus*, amendment, disposal, swine wastes, vegetable, yield

Introduction

Tropical soils are highly susceptible to degradation under continuous cultivation. Amelioration of the soil fertility problem in the tropics through inorganic fertilizer application is faced with much criticism with respect to environmental and health concerns. According to Iren *et al*. (2012), the use of organic manures for the production of leafy vegetable is very effective. Again, the application of organic materials as soil nutrients provides growth-regulating substrates and improves the physical, chemical and microbial properties of the soil (Iren *et al*., 2015). Swine manure can be an asset to a pork producer and to Agriculture when properly managed and utilized in a sustainable food production system however inappropriate disposal of swine waste into the environment often times leads to environmental pollution which could pose a serious environmental pollution hence channelling these wastes into the soil as an amendment for vegetable production remains a solution the disposal challenge. Soil is the dynamic link between the biosphere and the lithosphere and constitutes a practically non-renewable natural resources with the key role for the environment and for agriculture (Moraetis *et al*., 2016). Amaranthus, also called African spinach, Bush green, Green leaf belongs to the family *Amaranthaceae*. It is made up of more than 60 species which includes the cultivated grain amaranth like; *Amaranthus caudatus, Amaranthus hybridus, Amaranthus cruentus* and *Amaranthus hypochondriacus* (Shukla *et al*., 2010). They are the most commonly grown leafy vegetable of the lowland tropics in Asia and Africa. Amaranth leaves have wonderful chemical composition with mild spinach-like taste so it comes beneath an accurate leafy vegetable (Amicarelli and Camaggio, 2012). It may be eaten raw in the form of salad or cooked along with other vegetables especially with potato. Uusikua *et al*. (2010) reported that the plant plays an important role in nutrition due to its chemical composition. This study therefore investigated the influence of swine wastes on selected soil properties, growth and yield of *Amaranthus hybridus* in Anambra State.

MATERIALS AND METHODS

Description of Experimental Site

The research was carried out at Soil Science and Land Resources Management Teaching and Research farm, Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Anambra State. The research farm is located within latitude 6.244175N and 6.250008o N and longitude 7.116615°E and 7.117172o E, with annual rainfall range of about 1800- 2000mm; the rainfall distribution pattern is bimodal with early rain occurring between April and July and late rain between August and October. It has an average relative humidity range of 76 % - 80 % and average minimum and maximum temperatures of 23.5°c and 32.1°c respectively. The experimental site has a gentle slope with well-drained soil. The soils of the experimental area are low in fertility, easily leached and acidic in nature. Weeds such as *Chromolena odorata*, *Aspillia africana*, *Panicum maximum* and *Cyperus* spp dominated the vegetation of the experimental site.

Experimental Design and Layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with four treatments and three replications. The treatment used was swine wastes and at different rates based on plot sizes. The plot for this experiment was not up to one hectare hence the rates were divided to suite the plots and marked as T1- 0kg/plot (Zero Application), T2- 4.5 kg/plot, T3- 9.0 kg/plot, T4- 13.5kg/plot.

Pre-nursery and Nursery Operation

The seeds were subjected to viability test and the seeds attained 90 % germination before planting them in the nursery. A nursery bed was made very close to the experimental field for ease of transplant and to reduce transplanting shock of the *Amaranthus* seedlings. The swine wastes was mixed with water to form slurry and was applied on the experimental plots one week before transplanting with enough water applied daily to enhance the curing process. The transplanted *Amaranthus* seedlings had an average height of 0.32 m.

Pre-planting operation

An experimental field size of 14.5 m x 15 m (217.5 sq/m) was mapped out using a measuring tape, rope and pegs. Prior to land clearing, soil samples were collected from the experimental plot in an undisturbed manner using 10 core samplers and used for physical analysis and an auger was used to collect soil samples at 20 different points at the depth of 0-20 cm after which it was bulked and mixed thoroughly from which a representative sample was collected and used for chemical analysis. Land clearing was done using cutlass; the debris were packed in between the furrows which measured 0.5 m x 1 m. Sixteen (16) plots of 3 m x 3 m (9 Sq/m) each was made using a hoe while transplanting spacing used was 0.25m and 0.5m for intra row and inter row respectively.

Post-planting operation

After harvest, soil samples were collected accordingly for physical and chemical analysis; Samples collected were properly labeled, bagged and taken to the laboratory for analysis.

Laboratory Analysis

The following soil physical and chemical parameters analyses were carried out:

i. Particle size Distribution: The hydrometer method as described by Gee and Or (2002) was used to determine the particle size distribution of the samples while the soil textures were determined using the USDA Textural triangle.
ii. Bulk Density: The bulk density was determined by core method as described by Grossman and Reinsch (2002).
iii. Total Porosity: This was calculated from the bulk density as shown in this equation:
Total porosity = 1-Bd/pd×100 (%);
Where Bd=Bulk density, Pd=particle density (2.65g/cm^3).
iv. Soil pH: The soil pH in water was determined using pH Meter in 1:2:5 ratio of soil to water according to Thomas (1996).
v. Saturated Hydraulic conductivity (Ksat): This was determined using Young (2001) method.
vi. Aggregate stability: Soil Aggregate stability was determined using wet sieving method of Kemper and Rosenau (1986).
vii. Gravimetric Moisture Content (GMC): Moisture content of the soil was determined by oven drying at a temperature of 1050C and percentage of moisture in soil calculated mathematically as follows:

$$GMC = \frac{\mathrm{W2} - \mathrm{W3}}{\mathrm{W3} - \mathrm{W1}} \times 100$$

Where W1=Weight of the Can, W2=Weight of wet sample + Can, W3=Weight of oven dried sample + Can

viii. Soil organic carbon (SOC): The wet digestion method (Nelson and Sommers, 1996) was used to determine the organic carbon content of the soil samples. Soil organic matter (SOM) was calculated by multiplying the value of SOC by a factor of 1.724. (Van Bemmelen's correction factor).
ix. Total Nitrogen (TN): This was determined by the Kjeldahl digestion method according to Jackson (1965).
x. Exchangeable Basic cations (calcium, magnesium, potassium and sodium): These were

extracted in 1N, NH_4OAC at pH 7. Calcium and magnesium were determined using Atomic Absorption Spectrophotometer while potassium and sodium were determined using flame photometer.

xi. Exchangeable total acidity: Hydrogen and Aluminum were estimated titrimetrically.

xii. Available phosphorus: Bray II method according to Olsen and Sommer (1982) was used to determine available phosphorus content.

xiii. Base Saturation: This was calculated on a percentage basis by dividing total exchangeable bases (Ca2+, mg+, K+, Na+) by cation exchange capacity multiplied by 100.

xiv. Cation Exchange Capacity (CEC): This was determined by 1N ammonium acetate extraction method (Thomas, 1982).

Swine waste Laboratory Analysis

i. Determination of Nitrogen (N) by the micro-kjeldahl digestion method of Bremmer and Mulvaney (1982).

ii. Determination of phosphorus was colorimetrically determined using Olsen and Sommers (1982).

iii. Organic carbon was determined using Walkley and Black oxidation method. Organic matter was derived by multiplying organic carbon (OC) by 1.724.

Plant Data Collection

Five middle stands from each plot were tagged and used as sample plants for data collection on the following parameters:

i. Average plant height at 3 weeks after transplanting (3WAT): The plant height was measured using a meter rule from soil level to the apex of the leaves at 3 weeks after transplanting.

ii. Leaf area index: The leaf area index (LAI) was computed according to the procedure of Samkeliso et al. (2020) using the formula:

$$LAI = Y \times N \times LA / AP$$

Where Y=Population of plants per plot, N = Average number of leaves, LA = Leaf area AP = Area of plot

iii. Fresh shoot weight: Fresh shoot was harvested and weighed using weighing balance.

iv. Dry shoot weight: The fresh shoot was subjected to drying in an oven at a temperature of 105°c for 72 hours; it was weighed intermittently until a constant weight was achieved.

v. Number of nodes after first and second cut: The nodes were counted after first and second cuts.

Statistical Analysis

Data collected were subjected to Welch's one way Analysis of variance (ANOVA) using SAS Statistical package version 9.4. Separation of treatment means was done using Turkey test at 5% probability level.

RESULTS AND DISCUSSION

Pre-treatment Soil Properties

The results of soil physical and chemical properties of the experimental site before the application of treatment are shown in table 1. From the results obtained, the study area had a mean sand, silt and clay contents of 704 g/kg, 216 g/kg and 80 g/kg respectively, having a textural class of sandy loam. The soils of the area had a mean bulk density of 1.54 g/ cm3, total porosity of 41.77 %, soil moisture content of 9.67 %, hydraulic conductivity of 0.18 cm/hr and aggregate stability of 0.45%. An average soil pH value of 5.33 was obtained and can be classified as strongly acidic soils. The average soil organic matter and soil organic carbon contents of the area were 1.95 % and 1.13 % respectively. Again, the average exchangeable acidity, cation exchange capacity, total nitrogen, available phosphorus and base saturation of the area were 1.10 cmol/kg, 5.69 cmol/kg, 0.09 %, 5.26 mg/kg and 80.00 % respectively.

Nutrient Composition of the swine wastes

Prior to the treatment application, the swine wastes was subjected to laboratory analysis to determine the nutrient composition. The result is shown in Table 2.

Post-treatment Soil Properties

Soil Physical Properties

From the results obtained (Table 3), the plot with zero application had an average sand, silt and clay contents of 729 g/kg, 206 g/kg and 65 g/kg respectively, the plot treated with 4.5 kg/plot of swine waste had an average sand, silt and clay contents of 719 g/kg, 201 g/kg and 80 g/kg respectively. the plot treated with 9.0 kg/plot of swine waste had an average sand, silt and clay contents of 719 g/kg, 200 g/kg and 81 g/kg respectively while the plot that was treated with 13.5 kg/plot of swine waste had an average sand, silt and clay contents of 749 g/kg, 175 g/kg and 76 g/kg respectively. The result showed that there was no treatment effect on the texture of the soil; however the sandiness of the studied area could be attributed to the nature of the parent material from which the soils were derived. Soils of the experimental area belongs to textural class of sandy loam. Higher sand contents obtained in soils of the area could suggest low CEC, leaching of nutrients and can encourage soil erodibility on exposure to high rainfall intensity (Nwosu *et al.*, 2023).

Table 1: Initial soil properties of the experimental site

Soil Parameter	Values
Sand (g/kg)	704
Silt (g/kg)	216
Clay (g/kg)	80
Textural class	Sandy loam
Bulk density (g/ cm^3)	1.54
Porosity (%)	41.77
Aggregate stability (%)	0.45
Moisture content (%)	9.67
Hydraulic conductivity (cm/hr)	0.18
pH	5.33
Organic carbon (%)	1.13
Organic matter (%)	1.95
Total exchangeable acidity (cmol/kg)	1.10
Al^{3+} (cmol/kg)	0.9
H^+ (cmol/kg)	0.2
Ca^{2+} (cmol/kg)	2.60
Mg^{2+} (cmol/kg)	1.60
K^+ (cmol/kg)	0.24
Na^{2+} (cmol/kg)	0.15
C.E.C. (cmol/kg)	5.69
Total nitrogen (%)	0.09
Available phosphorus (mg/kg)	5.26
Base saturation (%)	80.00

Table 2: Nutrient composition of the swine waste

Properties	Values
Organic matter (%)	3.71
Total Nitrogen (%)	3.21
Available Phosphorus (mg/kg)	1.68

The results of bulk density as shown in table 3 indicated that value for control, 4.5kg/plot, 9kg/plot and 13.5kg/plot were 1.97 g/cm^3 , 1.86 g/cm^3 , 1.75 g/cm^3 and 1.89 g/cm^3 respectively. There was a significant difference at (P< 0.05) in the soil bulk densities as evidenced in the plot treated with 4.5 kg and 9.0 kg of swine wastes. The bulk density of soil is usually reduced with the application of animal manures; this is because organic matter has a lower particle density than the mineral particles and its increase results in reduction of the soil particulate density as a whole. Again, increase in soil organic matter increases the degree of soil aggregation, increasing the volume of pores and reducing the density of the soil. The higher soil bulk density observed in this study could suggest a compacted soil owing to machinery compression in the course of road construction close to the experimental site. According to Celik *et al.*, 2004; Barzegar *et al.*, 2002, and Bulluck *et al.*, 2002, reduction in soil bulk density occurs both with the application of manures alone and in association with mineral fertilizers (Hati *et al.*, 2008; Bandyopadhyay *et al.*, 2010). Research has equally proved that the application of pig slurry does not alter bulk density (Arruda *et al.*, 2010) especially when a low percentage is added to the soil which could be another reason for high bulk density in this study. The plot with zero treatment (control) and 4.5 kg/plot of swine wastes had an average total porosities of 25.72 % and 28.91 % respectively, while the plot treated with 9.0 kg/plot and 13.5 kg/plot of swine wastes had a mean total porosities of 23.59 % and 29.59 % respectively. The plot with 13.5 kg/plot had the highest total porosity of 29.79 % while 9.0 kg/plot had the least total porosity of 23.59 %. There was a significant difference at (p<0 05) in total porosities of soil treated with 4.5kg and 9.0kg of swine wastes in the experimental area. The results obtained in several studies with application of manure presented divergent results regarding their effects on the total porosity and the classes of pores. Increase in total porosity as often observed is due to the increase of pores with larger diameter (macropores) which is associated with better soil structure (Celik *et al.*, 2004; Rós *et al.*, 2013). Marinari *et al.*, (2000) observed that the increase of macropores in the soil treated with organic fertilizer was mainly due to an increase in the elongated pores which are considered very important for both soil-water plant relationships and maintenance of good soil structure.

For aggregate stability, the results showed that the plot with zero treatment had an aggregate stability of 0.3 %, the plot with 4.5 kg/plot had 0.44 % while the plot treated at the rate of 9.0 kg/plot and 13.5 kg/plot had 0.40 % and 0.37 % respectively. The plot with 4.5 kg/plot of swine wastes had the highest with 0.44 % mean value while control and 13.5 kg/plot had 0.3% and 0.37 % mean values respectively with the control being the least. Soil aggregate stability is one of the properties most influenced by increase in manure application. Low soil aggregate stability was observed in this study and could be as a result of the sandy nature of the experimental area as reported by Nwosu *et al.*, (2021*)*. According to Kay *et al.,(*1999) , a level of soil organic carbon of 2.0 to 2.5% is considered necessary to maintain good aggregate stability which is considered to deteriorate rapidly when SOC falls below 1.2% to 1.5% as it was in the case of this study falling below the critical limit.

From the results obtained for soil hydraulic conductivity (Ksat), the plot with zero treatment (control) had a mean Ksat value of 0.02 cm/hr, the plot treated with 4.5 kg/plot had 0.01 cm/hr, the plot with 9.0 kg/plot had 0.03 cm/hr while the plot with 13.5 kg/plot had 0.05 cm/hr. The plot with 13.5 kg/plot had the highest Ksat while the plot with 4.5 kg/plot had the least. There was a significant difference at (P<0.05) in Ksat when plot treated with 13.5kg of swine wastes was compared with the control. Researchers have reported seepage reduction due to sealing of soils by animal manure and by other organic liquids. Organic manure is known to improve soil physical properties (Aluko and Oyeleke, 2005).

Soil Chemical Properties

Soil pH ranged from 5.26-5.39 indicating the acidic nature of soils of the experimental area (Table 4). The plot treated with 0kg/plot and 4.5kg/plot of swine waste had an average pH value of 5.39 and 5.39 respectively while the plot treated with 9.0kg/plot and 13.5kg/plot of swine had average pH values of 5.26 and 5.37, respectively.

Table 3: Effect of swine wastes on selected soil physical properties

Treatments	BD (g/cm^3)	TP (%)	MC (%)	Agg. Stab (%)	Ksat (cm/hr)	Sand (g/kg)	Silt (g/kg)	Clay (g/kg)	Textural class
0 kg/plot	1.97^{ab}	25.72^{b}	1.95^{c}	0.37^{a}	0.02^{a}	729	206	65	SL
4.5 kg/plot	1.86^{ab}	28.91^{ab}	2.26^{bc}	0.44^{a}	0.01^{a}	719	201	81	SL
9.0 kg/plot	1.75^{b}	23.59^{a}	3.2^{a}	0.40^{a}	0.03^{a}	719	200	81	SL
13.5 kg/plot	1.89^{ab}	29.59^{ab}	2.97^{ab}	0.37^{a}	0.05^{ab}	749	175	76	SL

Note: Letters with same alphabets are not statistically significant while different alphabets are significant**; BD =** Bulk Density**; TP =** Total Porosity**; M.C =** Moisture Content**; Agg. Stab. =** Aggregate Stability; Ksat = Hydraulic Conductivity

As revealed by Ronen (2007), the range of acidity of soils of the studied area may have promoted good crop growth and development as vegetables generally thrive well on acidic soils ensuring high bioavailability of most nutrients. Less than this range or above this range may pose severe danger for the crop development. Total Exchangeable Acidity of the studied area ranged from 1.10 cmol/kg -1.42 cmol/kg; the plot with zero treatment and 4.5kg/plot of swine waste had mean TEA values of 1.12cmol/kg and 1.10 cmol/kg while the plots treated with 9.0kg/plot and 13kg/plot had TEA mean values of 1.42cmol/kg and 1.30cmol/kg respectively. As revealed by other researchers, swine waste and other types of animal manure have been linked with reduction of soil acidity apart from soil nutrient enrichment (Olatunji and Oboh, 2012; Sunassee, 2001) which was not the case in this study.

CEC mean values of 5.09 cmol/kg, 6.14 cmol/kg, 5.44 cmol/kg, 5.33 cmol/kg were obtained in the plots with zero treatment of swine waste, 4.5kg/plot, 9.0kg/plot, and 13.5kg/plot respectively (Table 4). The plot with 4.5kg/plot swine waste application had the highest CEC (6.14cmol/kg) while the plot with zero application had the least CEC (5.09cmol/kg). Dauda *et al.,* (2005) noted that organic materials such as swine manure are known to modify soil properties and boost the soil nutrient content; It equally enhances cation exchange capacity of the soil and acts as a buffering agent against undesirable soil pH fluctuations (Ngeze, 1998). At different rates of treatment application; the organic carbon content of the soil ranged from 1.30%-1.42% however highest organic carbon of 1.42% was respectively obtained in the plots treated with 4.5kg/plot and 9.0kg/plot of swine wastes. With regards to Landon (1991) ratings, the organic carbon obtained in this study was moderate. Total Nitrogen content of the studied area was < 1% and had equal values (0.11%) across the treatment levels. TN content of the studied area was low and could be seen as a common occurrence in southeast Nigeria as a result of high nitrogen losses sustained through the leaching of nitrates (Madueke *et al.,*2021*)* as well as the predominantly sandy texture of the soil; an indication of nutrient loss at the epipedon (Nwosu *et al.,* 2020).

Base saturation of the studied area ranged from 75.82% - 81.72%; the result showed that the plot with 4.5kg/plot of swine waste application had the highest BS (81.72%) while the plot treated with 13.5kg/plot swine waste had the lowest (75.82%). Ikenganyia *et al.,* (2014) observed a significant changes in soil base saturation which is in contrast with the observations made in this study and could be due to short term duration of the study. Calcium, magnesium, potassium and sodium contents ranged from 2.20cmol/kg-2.82cmol/kg, 1.40-1.80 cmol/kg, 0.14-0.22 cmol/kg, 0.12-0.17 cmol/kg, respectively at different rates of swine waste application. The average available phosphorus content in the soil treated with 0kg/plot,4.5kg/plot,9.0kg/plot, 13.5kg/plot swine waste were 9.56mg/kg, 8.98mg/kg, 8.98mg/kg, and 7.21mg/kg respectively; the plot with zero swine waste application had the highest content while the plot with 13.5kg swine waste application had the lowest content. The study observed that 13.5kg swine wastes application rate did not affect/increase the available phosphorus content of the soil. Generally, the values obtained for chemical properties of soil varied but were statistically similar at different rates of treatment application.

Plant Parameters

Some plant parameters such as plant height, leaf area index and number of leaves, fresh shoot weight, dry shoot weight, number of nodes at first and second cuts were taken to determine the effect of swine wastes on the Amaranthus plant (Table 5).

Plant Height

From the results obtained, the plots with 0 kg/plot, 4.5 kg/plot, 9.0 kg/plot, and 13.5 kg/plot rates of swine wastes application had plant heights of 37.25 cm, 39.65 cm, 44.90 cm, and 49.95 cm respectively; highest plant height was observed in the plot treated with 13.5 kg while the lowest height was observed in the zero treatment plot. This showed that plant height increased with increasing rate of treatment application which is in accordance with findings by Dlamini *et al*. (2020) who reported an increase in plant height of amaranth due to fertilizer application. Giacomini and Aita (2008) further revealed that animal waste such as deep litter in poultry and liquid pig slurry applied as a source of N for corn increased the availability of this nutrient in the soil throughout the crop cycle compared to the control.

Leaf area index and number of leaves

The plots with zero treatment recorded a mean leaf area index of 37.60 cm and 43.15 cm with respect to the number of leaves, the plot treated with 4.5 kg/plot recorded a mean leaf area index of 46.50 cm and 60.90 cm for number of leaves respectively, the plot treated with 9.0 kg/plot recorded a mean leaf area index of 43.47 cm and 73.00 cm for number of leaves while the plot treated with 13.5 kg/plot had a mean leaf area index of 70.80 cm and 73.90 cm for number of leaves respectively. The enhancement in the number of leaves among the treatment application could suggest high concentration of phosphorus in the amended soil compared to the control (Rus *et al*., 2023). The plot with 13.5kg treatment had a significantly higher leaf area index compared to other treatments. This showed that the higher the treatment rate the more increase in the leaf area index. High LAI values suggest higher leaf production levels, leaf expansion as well as leaf length and can indicate a limited amount of light blocking the plant. LAI of any plant is a measure of the capacity of the photosynthetic transmission system which according to Mathowa *et al*. (2014) has marked effect on growth and yield of the plant.

Table 4: Effect of swine waste on selected soil chemical properties

	%					cmol/kg					
Treatments	pH	OC	TN	OM.	BS	Al^{3+}	H^{+}	T.E.A	Ca^{2+}	Mg^{2+}	K^{+}
0 kg/plot	5.39^{ns}	1.31^{ns}	0.11^{ns}	2.27^{ns}	78.22^{ns}	0.75^{ns}	0.37^{ns}	1.12^{ns}	2.30^{ns}	1.40^{ns}	0.14^{ns}
4.5 kg/plot	5.39^{ns}	1.42^{ns}	0.11^{ns}	2.46^{ns}	81.72^{ns}	0.70^{ns}	0.40^{ns}	1.10^{ns}	2.82^{ns}	1.80^{ns}	0.22^{ns}
9.0 kg/plot	5.26^{ns}	1.42^{ns}	0.11^{ns}	2.45^{ns}	77.87^{ns}	0.72^{ns}	0.47^{ns}	1.42^{ns}	2.52^{ns}	1.40^{ns}	0.20^{ns}
13.5 kg/plot	5.37^{ns}	1.30^{ns}	0.11^{ns}	2.23^{ns}	75.82^{ns}	0.82^{ns}	0.42^{ns}	1.30^{ns}	2.20^{ns}	1.56^{ns}	0.17^{ns}

Note: ns = not significant, OC = organic carbon, TN = Total nitrogen, OM = organic matter, BS = Base saturation, Al^{3+} = Aluminium ion, H^{+} = Hydrogen ion, TEA = Total exchangeable acidity, Ca^{2+} = Calcium ion, Mg^{2+} = Magnesium ion, Potassium ion, Na^{+} = Sodium ion, CEC = Cation exchange capacity, AP = Available phosphorus

Table 5: Effect of swine waste on some plant parameters

Treatments	PH	LAI	NL	FSW (kg)	DSW (kg)	Nodes (1st cut)	Nodes (2ndst cut)
0 kg/plot	37.25^{a}	37.60^{a}	43.15^{a}	0.51^{a}	0.15^{a}	13.85^{b}	4.80^{a}
4.5 kg/plot	39.65^{ab}	46.50^{a}	60.90^{ab}	0.32^{a}	0.15^{ab}	14.75^{b}	5.85^{a}
9.0 kg/plot	44.90^{b}	43.40^{a}	73.00^{b}	0.47^{a}	0.12^{b}	14.50^{b}	4.75^{b}
13.5 kg/plot	49.95^{bc}	70.80^{b}	73.90^{b}	0.51^{a}	0.17^{c}	13.10^{a}	4.75^{b}

Note: Letters with the same alphabets are not statistically significant while different alphabets are significant, FSW = Fresh shoot weight, DSW = Dry shoot weight; PH = Plant Height; LAI = Leave Area Index; NL = Number of leaves

Fresh shoot weight, Dry shoot weight, Number of nodes at first and second cut

The plot treated with 13.5 kg/plot of swine waste gave the highest dry shoot weight (0.17kg), while the plot treated with 9.0 kg/plot of swine waste had the lowest weight (0.12kg). Nodes were more at the first cut than in the second cut at the various application rates however there was a significant difference in the nodes at the first cut when plots with 4.5 kg/plot, 9.0 kg/plot and 13.5 kg/plot were compared with zero application. Generally, it was observed that plant height, leaf area index, number of leaves, fresh shoot and dry shoot weight increased with increasing treatment application rates. This could be attributed to high content of Total N, P and K in the pig manure however Adebayo *et al.* (2011) in their study found that organic amendment increased both vegetative and dry matter yield of *Moringa oleifera.*

Conclusion

The research observed a significant effect of the applied swine wastes on some soil physical properties studied unlike in soil chemical properties. Findings from this research has proved that the higher the rate of swine wastes application the more and better the growth and yield of Amaranthus as was evidenced in the following parameters: plant height, leaf area index, number of leaves, fresh and dry shoot weight.

Recommendation

Repetitions and more trials should be carried out annually to see if there will be any effect of the swine wastes on soil chemical properties considering the short duration associated with this study.

REFERENCES

Adebayo A.G., Akintoye H.A., Olufolaji A.O., Aina O.O., Olatunji M.T. and Shokalu, A.O. (2011). Assessment of organic ammendments on vegetative development and nutrient uptake of Moringa oleifera Lam. in nursery. *Asian Journal of Plant Science*. **10:**74-79

Aluko O.B., Oyeleke D.J., (2005). Influence of organic wastes incorporation on changes in selected soil physical properties during drying of a Nigerian alfisol. Journal of applied sciences

Amicarelli, V. and Camaggio, G., (2012). “Amaranths: A Crop to rediscover”. *Forum Ware International*. **2**: 4-11

Arruda, C.A.O., Alves, M.V., Mafra, A.L., Cassol, P.C., Albuquerque, J.A., Santos, J.C.P (2010). Aplicação de dejeto suíno e estrutura de um Latossolo Vermelho sob semeadura direta. *Ciência e Agrotecnologia* 34, 804-809

Bandyopadhyay, K.K., Misra, A.K., Ghosh, P.K., Hati, K.M (2010). Effect of integrated use of farmyard manure and chemical fertilizers on soil physical properties and productivity of soybean. *Soil Tillage Research* 110,115-125

Barzegar, A.R., Yousefi, A., Daryashenas, A. (2002). The effect of addition of different amounts and types of organic materials on soil physical properties and yield of wheat. Plant Soil 247, 295-301

Bulluck I.I.I., L.R., Barker, K.R. and Ristaino, J.B. (2002) Influences of Organic and Synthetic Soil Fertility Amendments on Nematode Trophic Groups and Community Dynamics under Tomatoes. Applied Soil Ecology, 21, 233-250.

Celik, I., Ortas, I., Kilic, S. (2004) Effects of Compost, Mycorrhiza, Manure and Fertilizer on some Physical Properties of a Chromoxerert Soil. *Soil Tillage Research* 78, 59-67.

Dauda, S.N., Aliya, L. and Chiezey, U.F. (2005). Effect of Variety, Seedling Age and Poultry Manure on Growth and Yield of Garden Egg (*Solamun gilo L.).* Nigerian Academic Forum, 9, 88-95.

Dlamini, S. N., Masarirambi, M. T., Wahome, P. K., and Oseni, T. O. (2020). The Effects of organic fertilizers on the growth and yield of Amaranthus (Amaranthus hybridus L.) grown in a lath house. Asian Journal of Advances in Agricultural Research, 12(1), 1-10.

Gee, G.W., Bauder, D. (2002). Particle Size Analysis. In: Dane, J.H. and Topp, G.C. (eds). *Methods of Soil Analysis. Part 4, Physical methods, Soil Sci. Soc. Am.* **5**: 255-293

Giacomini, S.J., Aita, C.,(2008). Emissão de diõxide de carbono após aplicacacão de dejetos líquiidos e cama sobreposta de suinos.pesqui Agropecu Bras.43(1):107-114

Grossman R.B and Reinsch T.G (2002).SSSA book series.5methods of soil analysis.ch2 Ed.Dane J.H,Clarke,Topp G.Soil science society of America,Inc.madison,Wisconsin,USA

Hati, K.M., Swarup, A., Mishra, B., Manna, M.C., Wanjari, R.H., Mandal, K.G., Misra, A.K (2008). Impact of Long-term Application of Fertilizer, Manure and Lime under Intensive cropping on Physical Properties and Organic Carbon Content of an Alfisol. *Geoderma* 148,173-179

Ikenganyia, E. E., Onyeonagu, C. C., Mbah, C. N., Azuka, C. V. and Aneke, I. (2014). Evaluation of the agronomic potentials of swine waste as a soil amendment. Africa Journal of Agricultural Research. Vol. 9 (51), pp. 3761-3765.

Iren, O. B., Asawalam, D. O., Osodeke, V. E. and John, N.M. (2012).Comparative effects of animal manures and urea fertilizer on soil properties in a Rainforest Ultisol. *Journal of Agricultural Research and Policies*, **6**(2): 51-56

Iren, O.B., Akpan, J.F., Ediene, V.F. and Asanga, E.E. (2015). Influence of Cassava Peels and Poultry Manure-based Compost on Soil Properties, Growth Yield of waterleaf (*Talinum triangulare jacq)* in the ultisol of South-eastern Nigeria. *Journal of Soil Science and Environmental Management*, **6**(7): 187-194.

Jackson, G.B. (1993).Applied water and spent water chemistry. Van Noostrand Reinhad New York pp 54-158

Kay, B.D., Angers, D.A., (1999). Soil Structure In “Handbook of Soil Science”. (Ed ME Summer). Pp. A229-A276. (CRC press: Boca Raton USA)

Landon, J. R. (1991). Booker tropical soil manual: A handbook for soil survey and agricultural land evaluation in the tropics and sub tropics. Essex: Addison Wesley Longman Limited, pp 472.

Marinari S., Masciandaro G., Ceccanti B., Grego S. (2000): Influence of organic and mineral fertilizers on soil biological and physical properties. Bio resource Technology, 72: 9–17.

Mathowa T.,Madisa M.E., Moshoeshoe C.M., Mojeremane W., Mpofu C.,(2014). Effect of different growing media on the growth and yield of jute mallow (*Corchorus olitorius L.)*.

International Journal of Research Studies in Bioscience.**2**(11):153-163.

Madueke, C .O, Okore I. K, Maduekeh E.C, Onunwa A.O, Okafor M.J, Nnabuihe,E.C, Nwosu T.V ,Nwaiwu C.I ,Nwosu ,B. (2021). Characterisation and Land Evaluation of three Tropical rainforest Soils derived from coastal plain sands of southeastern Nigeria.Journal of Tropical Agriculture, Food, Environment and Extension-Agro-Science Vol 20.No 2.2021 PP 25-36.

Moraetis, D., Lydakis-simantiris, N., Pentari, D., Manoutsoglou, E., Apostolaki, C., Perdikatsis, V., (2016). Chemical and Physical Characteristics in Uncultivated Soils with different Lithology in Semi-arid Mediterranean Clima. Appl. Environ. Soil. 3590548. 13p.

Nelson D.W and Sommers L.E (1996).Total carbon, organic carbon and organic matter. In: Methods of soil analysis part 3.chemical methods. Soil science society of America. Book series.

Ngeze, P.B. (1998). Learn how to make use of compost manure in farming. Friend of the Book Foundation, Nairobi-Kenya. 45-46.

Nwosu T.V. Nnabuihe E.C, Okafor M.J, Ekpe I.I. (2020). Chemical properties of a watershed prone to erosion along Nworie river banks in Owerri-Imo State, Southeast Nigeria. Proceeedings of the 44th conference of soil science society of Nigeria on climate smart management/soil health/quality and land management: synergies for sustainable ecosystems. https://doi.org/10.36265/colsssn.2020.4433

Nwosu T.V. Nnabuihe E.C, Okafor M.J, Madueke C.O (2021). Assessment of some physical properties of soil along an erosion prone watershed, Owerri Imo State Nigeria. Journal of CleanWAS (JCleanWAS) 5(1) (2021).06-12 http://doi.org/10.26480/jcleanwas.01.2021.10.16

Nwosu, T.V, Orji, O. J, Nnabuihe, E. C, Igboka, C. R, Nwaiwu, C.J. (2023). Impact of Different Land Uses on Soil Erodibility Assessed using selected Indices in Awka, Southeastern Nigeria. Proceedings of the 1st Faculty of Agriculture International Conference, Nnamdi Azikiwe University, Awka, Nigeria

Olatunji O. and Oboh V.U. (2012). Growth and yield of okra and tomato as affected by pig dung and other manures, issue for economoic consideration in Benue State. *Nigerian journal of Soil Science.* Vol **1**:103-107.

Olsen R.SS and Sommer L.E (1982).Phosphorus in methods of soil analysis part 2.America society of Agronomy Madison, Wisconsin pp 15-72

Olsen, S.R. and Sommers, I.E. (1982). "Soil available phosphorus". In: Methods of soil analysis, part 2. Argon, Mono. ASA and SSSA Madison. USA.

Rós A.B., Hirata A.C.S., Narita N. (2013): Cassava roots yield and soil chemical and physical properties according to chicken manure fertilization. Pesquisa Agropecuaria Tropical, 43: 247–254.

Rus, R. C., Salisu, M. A., and Usaizan, N. (2023). Influence of Composition of Soilless Substrates Monitored with IoT Sensor Nodes on the Growth, Nutrient and Fruit Quality of Rockmelons (Cucumis melo Var. Cantalupensis). Indian Journal of Agricultural Research, 1, 7.

Samkeliso N. Dlamini, Michael T. Masarirambi, Pual K. Wahome and Tajudeen O. Oseni (2020). The Effect of Organic Fertilizers on the Growth and Yield of Amaranthus (*Amaranthus hybridus L.*) Grown in a Lath House. Department of Horticulture, Faculty of Agriculture, University of Eswatini, P.O Luyengo M205 Lugengo, Eswatini. Page 4.

Shukla, S., Bhargava, A., Chatterjee, A., A.J. Pandey, A.C. Mishra, B.K. (2010). Diversity in Phenotypic and Nutritional Traits in vegetable amaranthus (*Amaranth tricolor): A* nutritionally underutilized crop. *Journal of Science, Food and Agriculture*. **90**:139-144.

Sunassee S. (2001). Use of litter for vegetable production. AMAS 2001.Food and Agricultural Research Council, Reduit, Mauritius, pp. 259 –263.

Thomas G.W. (1996). Soil pH and Soil acidity.In:Methods of soil analysis part 3-chemical methods L.D.Sparks(ed)SSSA Book series No 5.

Uusikua, N.P. (2010). "Nutritional Value of leafy vegetables of sub-saharan Africa and their potential contribution to human health. A review" *Journal of Food Composition and Analysis*. **23**: 499-509.