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# Evaluation of the agronomic potentials of swine waste as a soil amendment

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**The objective of this experiment was to evaluate the agronomic potentials of different rates of swine waste on soil properties, maize growth and yield. Four rates of swine waste namely 0, 7, 13 and 27 t ha$^{-1}$ were laid out in a randomized complete block design (RCBD) and replicated three times at the Teaching and Research Farm of the Faculty of Agriculture and Natural Resources, Enugu State University of Science and Technology, Enugu, South East Nigeria. Oba super 11 hybrid maize was planted to a depth of 5 cm in the prepared beds at a spacing of 25 cm by 75 cm (inter and intra row spacing, respectively). Soil samples were collected from the top soil at a depth of 0 to 15 cm before and 2 weeks after the application of the swine waste. The obtained results showed that the application of different rates of swine waste significantly altered the chemical properties of the soil. The concentration of the exchangeable bases (calcium, magnesium, potassium and sodium) was increased, while exchangeable acidity and cation exchange capacity significantly decreased at a rising rate of swine waste application. There was a significant difference ($p < 0.05$) in soil pH, cation exchange capacity, organic matter content, total nitrogen, organic carbon, available phosphorus, base saturation, bulk density and moisture content among the treatments. The mean plant height at harvest and maize grain yield increased relative to the control treatment. Generally, swine waste was found to be an effective soil amendment in improving the soil properties, growth and yield of maize.**

**Key words:** Swine waste, agronomic potential, soil amendment, maize grain yield.

## INTRODUCTION

One of the inherent defects of the soils in the tropics is its low level of fertility status which is a major drawback in the agricultural usefulness of the soil (Schlecht et al., 2007). According to Srivastara (2007), fertile soil is defined as the quality that enables a soil to provide plant nutrients in adequate amounts and in proper balance for growth of specified plants when light, moisture, temperature, tilt and other growth factors are

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favorable. Mafongoya et al. (2007) reported that maintenance of high crop yield under intensive cultivation is possible through the use of fertilizers. Fertilizer can be in form of organic or inorganic. The use of inorganic fertilizers has not been helpful as it is associated with increased soil acidity, leaching and nutrient imbalances (Schlecht et al., 2007). According to Ayoola and Makinde (2006), inorganic fertilizers are usually not available and are always rather expensive for the low income small-scale farmers. Organic manure such as cow-dung, poultry manure, swine waste and crop residues can be used as an alternative for inorganic fertilizers. The use of swine waste which is readily available in the tropics can compensate for the expensive and unreliable supply of inorganic fertilizers for low income small-scale farmers in the tropics.

The main objective of this study was to evaluate the agronomic potentials of swine waste rates as a soil amendment. This will be achieved through evaluating its effect on the soil physical properties, soil chemical properties, growth and yield of maize.

## MATERIALS AND METHODS

This experiment was carried out at the Teaching and Research Farm of the Faculty of Agriculture and Natural Resources, Enugu State University of Sciences and Technology, Enugu, South East Nigeria. The site is situated at latitude 06°52' North, longitude 07°15' East and 450 m above sea level. The range of rainfall amount is within 1700 to 2000 mm and it has a bimodal pattern of occurrence. Within April and October it is wet, November and December it is dry. The soil type is Ultisol of sandy-clayey-loam textual class and classified as Tropaquent or Eutric leptosol (Anikwe*,* 2006). The experiment consisted of four rates of swine waste namely 0 t $ha^{-1}$ (0 kg/plot), 7 t $ha^{-1}$ (6 kg/plot), 13 t $ha^{-1}$ (12 kg/plot) and 27 t $ha^{-1}$ (24 kg/plot) laid out in a randomized complete block design (RCBD) and replicated three times. The swine waste was slurry from pig abattoir that had been air-dried for 40 days. The land was cleared of existing grasses, ploughed and made into beds of 3 by 3 m (9 $m^2$). A total of 12 beds were made. Each of the bed separated from one another by a spacing of 1 and 1 m pathway between replications. Swine waste was incorporated into the soil to a depth of 0 to 15 cm using the hand hoe. Oba super 11 hybrid maize was planted to a depth of 5 cm in the prepared beds at a spacing of 25 by 75 cm (inter and intra row spacing, respectively) given a total of 48 plants per plot. Planting was done two seeds per hole and thinned to one plant at 2 weeks after planting. The plants at the two centre rows were randomly sampled during data collection. Weeding was done manually whenever necessary throughout the experimental period. Soil samples were collected from the top soil at a depth of 0 to 15 cm before and 2 weeks after the application of the swine waste. Three representative soil samples were collected per plot and bulked to form a composite soil sample for each plot. A total of 12 composite soil samples were collected. Samples were air-dried, grounded and passed through a 2-mm standard mesh. The soil pH was determined with a pH meter using 1:2.5 soils to water ratio according to Page et al. (1982). Organic carbon was determined using the Walkley and Black wet digestion method (Bremmer and Mulvaney, 1982); soil organic matter content was obtained by multiplying the value of organic carbon by 1.724 (Van Bemmeler factor), total nitrogen determined by macro-kjeldahl procedure (Page et al., 1982). Available phosphorus was extracted with Bray II extractant as described by Bray and Kurz (1945) and colorimeterically using ascorbic acid method (Murphy and Riley, 1962). Exchangeable potassium and sodium were extracted using 1N ammonium acetate ($NH_4OAC$) solution and determined by the flame emission spectroscopy as outlined by Anderson and Ingram (1993). Aluminum and hydrogen content (exchangeable acidity) were determined by the titrimetric method after extraction with 1.0 N KCL (McLean, 1982). The cation exchange capacity was determined by the $NH_4OAC$ displacement method (Rhoades, 1982). Calcium and magnesium was determined by the complexiometeric titration method as described by Chapman (1982). Particle size distribution analysis was done by the hydrometer method (Gee and Bauder, 2002) and the corresponding textural class determined from the United States Department of Agriculture Soil Textural Triangle. Bulk density was determined using the core method as described by Blake and Hartage (1986), total porosity by the method outlined by Anderson and Ingram (1993) and moisture content was obtained by the method stated by Klute and Dirkson (1986). Samples of air-dried swine waste were collected and chemical analysis was done to determine pH, organic carbon, total nitrogen, available phosphorus, potassium, magnesium, calcium, sodium and organic carbon. Data were collected on mean plant height at harvest and maize grain yield after harvest. The data collected were subjected to analysis of variance (ANOVA) as outlined by Gomez and Gomez (1984). Significant means were separated using Fishers least significant difference (F-LSD) at 5% probability level. Statistical analysis was executed using GENSTAT Release 7.2DE Discovery Edition 3 (GENSTAT, 2007) statistical software.

## RESULTS

Table 1 shows the chemical properties of the soil before the study. The soil was sandy-clayey-loam texture with pH of 4.60. The soil organic carbon, organic matter content, total nitrogen and base saturation were 7.93, 0.17, 0.03 and 58%, respectively. The exchangeable bases (calcium, magnesium, potassium and sodium) were 0.98, 0.68, 0.09 and 0.11 meq/100 g, respectively, while the available phosphorus was 1.20 ppm.

The impact of swine waste rates on the soil chemical properties of the soil (Table 2) indicates that the soil total nitrogen, available phosphorus, organic carbon, organic matter contents, pH, base saturation, calcium, magnesium, potassium and sodium were significantly ($p < 0.05$) increased with increasing rate of swine application. On the contrary, a decrease in exchangeable acidity and cation exchange capacity were recorded at an ascending swine waste application.

The results shown in Table 3 reveals that the application of swine waste significantly ($p < 0.05$) increased the total porosity and moisture content and decreased the bulk density. The highest effects on these physical parameters were observed in plots amended with 27 t $ha^{-1}$ swine waste.

Furthermore, Table 4 shows that the mean plant height at harvest and maize grain yield after harvest were significantly ($p < 0.05$) influenced by the swine waste addition to the soil. The highest plant height (480.00 cm) was recorded at the plots amended with 27 t $ha^{-1}$ and the least (90.00 cm) was observed in the control treatment (0 t $ha^{-1}$). The dry grain weight increased by about 128.43,

**Table 1.** Initial soil characteristics and the chemical composition of swine waste.

| Properties | Level | Swine waste |
|---|---|---|
| **Particle size distribution (%)** | | **-** |
| Sand | 79.00 | - |
| Slit | 16.00 | - |
| Clay | 5.00 | - |
| Textural class | Sandy-clayey-loam | - |
| pH (water) | 4.60 | 6.56 |
| Organic matter (%) | 0.17 | 21.46 |
| Organic carbon (%) | 7.93 | 12.45 |
| Available phosphorus (ppm) | 1.20 | 1.64 |
| Total nitrogen (%) | 0.03 | 2.41 |
| | | |
| **Exchangeable bases (meq/100 g)** | | - |
| Calcium | 0.98 | 5.27 |
| Magnesium | 0.68 | 0.30 |
| Potassium | 0.09 | 1.52 |
| Sodium | 0.11 | 0.38 |
| Exchangeable acidity (meq/100 g) | 1.53 | - |
| Cation exchange capacity ( meq/100 g) | 3.51 | - |
| Base saturation (%) | 51.00 | - |

**Table 2.** The effects of swine waste application on the chemical properties of the soil.

| Rates | pH | OM | OC | TN | AP (ppm) | Ca | Mg | K | Na | EA | CEC | BS (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (%) | | | | | meq/100 g | | | | | | |
| 0 t ha$^{-1}$ | 5.00 | 0.64 | 0.37 | 0.06 | 1.58 | 1.12 | 0.83 | 0.12 | 0.14 | 1.59 | 5.80 | 52.00 |
| 7 t ha$^{-1}$ | 5.16 | 1.93 | 1.12 | 0.09 | 2.91 | 2.10 | 1.00 | 0.19 | 0.18 | 1.36 | 6.00 | 62.00 |
| 13 t ha$^{-1}$ | 5.26 | 2.05 | 1.19 | 0.13 | 3.03 | 2.92 | 1.02 | 0.20 | 0.20 | 1.20 | 6.30 | 62.00 |
| 27 t ha$^{-1}$ | 5.43 | 2.66 | 1.54 | 0.13 | 3.35 | 3.01 | 1.09 | 0.22 | 0.28 | 1.00 | 6.80 | 62.00 |
| F-LSD (0.05) | 0.50 | 0.03 | 0.02 | 0.04 | 0.01 | 0.02 | 0.02 | 0.34 | 0.04 | NS | NS | 1.91 |

OM, Organic matter content; OC, organic carbon; TN, total nitrogen; AP, available phosphorus; Ca, calcium; Mg, magnesium; K, potassium; Na, sodium; EA, exchangeable acidity; CEC, cation exchange capacity; BS, base saturation; F-LSD (0.05), significant at 0.05 probability level; NS, non significant.

68.84 and 35.29% for rate of 27, 13 and 7 t ha$^{-1}$, respectively over the control treatment.

## DISCUSSION

### Effects of swine waste application on soil physical and chemical properties

The changes in the chemical properties of the soil after swine waste application is related to the chemical composition of the added swine waste. Smiciklas (2007) noted that the swine waste application improved the chemical properties of the soil due to the addition of organic matter. The rise in soil pH was due to decrease in exchangeable acidity and increase in exchangeable bases. The status of available phosphorus and total nitrogen were significantly ($p < 0.05$) increased from 1.58 to 3.35 ppm for phosphorus and 0.06 to 0.13% for total nitrogen, respectively. This result is due to the nitrification of ammonium nitrogen in the swine waste. This observation corroborated the assertions of Chong-Ho et al. (2005) that livestock manure such as swine waste contains ammonium nitrogen. The reduction in bulk density and increase in total porosity and moisture content was as a result of swine waste application which caused a homogenous distribution of manure constituents between soil particle and breakdown of swine waste by micro-organisms which produced essential cementing materials that links soil particles and form soil aggregates. This is in harmony with what Mafongoya et al. (2007) noted that organic manure

**Table 3.** The effects of swine waste application on the physical properties of the soil.

| Rates | Bulk density (g $cm^{-3}$) | Total porosity (%) | Moisture content (%) |
|---|---|---|---|
| 0 t $ha^{-1}$ | 1.51 | 43.00 | 30.00 |
| 7 t $ha^{-1}$ | 1.46 | 45.00 | 40.00 |
| 13 t $ha^{-1}$ | 1.43 | 46.00 | 44.10 |
| 27 t $ha^{-1}$ | 1.41 | 46.70 | 46.00 |
| F-LSD (0.05) | 0.15 | 4.84 | 6.60 |

F-LSD (0.05), Significant at 0.05 probability level.

**Table 4.** The effects of swine waste application on the mean plant height (cm) of maize at harvest and the maize grain yield (t $ha^{-1}$) after harvest.

| Rates | Plant height | Maize grain yield | *Increase over control (%) |
|---|---|---|---|
| 0 t $ha^{-1}$ | 90.00 | 1.02 | 0.00 |
| 7 t $ha^{-1}$ | 140.00 | 1.38 | 35.29 |
| 13 t $ha^{-1}$ | 300.00 | 1.67 | 68.84 |
| 27 t $ha^{-1}$ | 480.00 | 2.33 | 128.43 |
| F-LSD (0.05) | 4.35 | 1.08 | |

*** =** Maize grain yield increase over control, F-LSD (0.05) - significant at 0.05 probability level.

improves the tilt of surface soil for crop production.

## Effects of swine waste application on plant height and maize grain yield

The significant increase in mean plant height and maize grain yield over the control were due to the effect of swine waste application in improving soil aggregates, increasing moisture content and pore space distribution between the soil particles. Another explanation is that organic manure act as complexing agents which minimizes the loss of soil nutrient by leaching from the root zone and thereby increases nutrient availability and supply potentials for plant uptake (Dahdoh and El-Hassanin, 1993). Many studies proves that the use of organic manure such as farm yard manure, sewage sludge, cow dung, goat pellets, etc. as a soil amendment promotes plant growth more than when commercial fertilizers were added. The obtained results from this study tallied with those observed by Elsokkary et al. (1989) that sewage sludge application increased the dry weight and grain yield of alfalfa, wheat, faba bean and soybean. Christodoulakis and Margaris (1996) showed that plant height increased in maize by 77% in sludge amended treatment compared to 25% in the commercial fertilizer amendment.

## Conclusion

The results of this study showed that there was a significant difference ($p < 0.05$) among the treatments on the soil properties. The maize plant height and maize grain yield varied over the control treatment. The highest application rate (27 t $ha^{-1}$) gave the highest grain yield and the impact on soil properties was most pronounced at this rate. This placed 27 t $ha^{-1}$ as a satisfactory rate of swine waste application for maize production. Though, little above this rate could be recommended to combat losses of nutrients by volatilization into the atmosphere and leaching into rivers and streams. Furthermore, continuous use of swine waste application should be discourage as it increases the level of residual toxic effects of some micro nutrients in the soils such as zinc and lead which are harmful to man

## Conflict of Interest

The author(s) have not declared any conflict of interest.

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