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# Assessment of abattoir effluent as a soil amendment for fluted pumpkin (*Telfairia occidentalis,* Hook F.) production in south-eastern Nigeria

*[1]Otobong B. Iren and [2]Aniefiok E. Uko

[1]Department of Soil Science, University of Calabar, Calabar, Cross River State, Nigeria
[2]Department of Crop Science, University of Calabar, Calabar, Cross River State, Nigeria

*Correspondence e-mail: myirenlady@gmail.com

**ABSTRACT:** Misuse of soil amendments can lead to crop damage and cause negative impacts on the receiving soil, air, water or habitat. The effects of different rates of application of abattoir effluent on soil chemical properties, growth and yield of fluted pumpkin were investigated under screen house at the Teaching and Research Farm of the University of Calabar. Six levels of abattoir effluent (0, 40000, 80000, 120000, 160000 and 200000 litres/ha) with the 0 litre/ha serving as control giving corresponding rates of 0,120, 240, 360, 480 and 600 ml/6 kg soil were arranged in a completely randomized design (CRD) and replicated three times. Application of abattoir effluent significantly ($p < 0.05$) enhanced soil organic carbon, total N, available P, exchangeable bases and ECEC while soil texture, pH and base saturation were not however increased significantly($p > 0.05$). Fluted pumpkin numbers of leaves, vine length, number of branches, fresh and dry matter yield were significantly increased. There were corresponding yield increase as the rate of application increased with the highest fresh shoot yield of 12.12 t/ha and dry matter yield of 2 t/ha obtained in soil treated with 600 ml (i.e. 200,000 litres/ha) of abattoir effluent. Relative yield increase of the fresh shoot of fluted pumpkin when compared with control was 79.8, 92.0, 91.5, 101.1 and 114.9 % for plants treated with 120, 240, 360, 480 and 600 ml of abattoir effluent, respectively. Based on these findings, abattoir effluent is a good nutrient source for plant growth and is therefore recommended for use by farmers.

**Keywords:** Abattoir effluent, application rates, fluted pumpkin, soil properties, waste water

**Introduction**

Soil amendments consist of all organic and inorganic substances incorporated into the soil to achieve a better soil condition for crop production. The major function of soil amendments is to provide nutrients for crop growth or to provide materials for soil improvement. Plant nutrients may be added to the soil either through the use of organic or inorganic fertilizers or their combinations. Misuse of soil amendments can lead to crop damage and cause negative impacts on the receiving soil, air, water or habitat (Udoh and Iren, 2016). However, the use of inorganic fertilizers is not presently encouraged due to its negative impact on soil properties, human health and the environment. Studies have also shown that application of inorganic fertilizers supply only nutrients while organic fertilizer not only supply nutrient elements but also help in the improvement of soil physical properties, which enhances growth and development of crops (Olaniyi and Odedere, 2009). Huge amounts of wastes such as fish pond effluents, abattoir effluents, palm oil mill effluent, animal wastes and crop wastes are generated as by-products and are found in most agricultural processing units, posing potential environmental challenge. These may be channeled to effective use in the production of crops (Iren *et al*., 2013, 2014a & b, 2016; Udoh and Iren, 2016; Udoh *et al.*, 2016, Isitekhale and Adamu, 2016). Incorporating the organic wastes into the soil helps to build up the soil organic matter layer needed for steady supply of plant nutrients (Iren *et al*., 2015). Abattoir effluent is the waste water obtained from the slaughter house (abattoir) after washing the animals slaughtered. An abattoir is an approved place where animals like goats, sheep, cattle etc. are killed and processed for their meat and skin. The effluent comprises materials like water, blood, urine, feces, etc. of the slaughtered animals. The animal cellulose fibre, undigested protein, excess nitrogen from digested protein, residues from digested fluids, waste minerals, worn-out cell form, intestinal linings, mucus, bacteria and foreign matter such as dirt consumed by the animal, contains several minerals like calcium (Ca), magnesium (Mg), iron (Fe), phosphorus (P), sodium (Na) (Isitekhale and Adamu, 2016). These elements enhance good fertility of the soil but some of the nutrients may be toxic to the microbial, floral and faunal community of the soil when present in excessive quantity (Rabah *et al.,* 2010; Chukwu and Anuchi, 2016; Ediene *et al*., 2016; Ediene and Iren, 2017).

It has been reported that up to 60- 85% of total N in farm diary effluent is in organic form, which is not immediately available for plant uptake (Hawke and summers, 2006). This high percentage of organic fraction of effluent qualifies it as an organic amendment. The inorganic forms of nutrients in effluents will be immediately available to plants and the organic form takes time to be available giving most effluents its residual characteristics that make them beneficial manure (Isitekhale and Adamu, 2016).

Fluted pumpkin (*Telfairia occidentalis,* Hook F.) is one of the most important vegetables grown predominantly in the south-eastern Nigeria. It is generally regarded as leaf and seed vegetable. They have been several studies on the response of fluted pumpkin to organic amendments but few if any on its response to abattoir effluent application. This study, therefore, evaluates the response of fluted pumpkin to different levels of abattoir effluent application in south-eastern Nigeria.

**Materials and methods**

A pot experiment was conducted at the screen house of the Teaching and Research Farm of the University of Calabar, Calabar ($5^o$32' and $4^o$ 27' N and $7^o$15' and $9^o$ 28' E). Calabar is a tropical rainforest region with total rainfall ranging from 2000 to 3500 mm annually while the mean temperature ranges from 23 to 33 $^oC$. The mean relative humidity is 60 to 90%.

Top soil (0 to 15 cm) used for the experiment was collected from the Teaching and Research Farm of the University of Calabar, using a spade. The soil samples were air-dried and sieved with 4 mm mesh before measuring 6 kg of soil into perforated plastic buckets (5 Litres capacity). Six treatments, including the control were laid down in a completely randomized design (CRD) and replicated three times. The treatments comprised of six levels of abattoir effluent (0, 40000, 80000, 120000, 160000 and 200000 litres/ha) with the 0 litre/ha serving as control. These gave corresponding rates of 0,120, 240, 360, 480 and 600 ml per 6 kg soil per pot. To each pot containing 6 kg of soil, the various levels of abattoir effluent were applied, thoroughly mixed with the soil except the control pots, watered to field capacity for a period of two weeks before planting. Two fluted pumpkin seeds were planted in each pot and were later thinned down to one plant per pot after two weeks of planting. One composite soil sample was taken before experiment and at the end of the experiment; soil in each pot was sampled for analysis. The soil samples were air dried, ground and sieved with 2 mm size sieve.

Data collection commenced after three weeks of planting and then at a weekly interval. The growth parameters measured were the vine length, number of branches and number of leaves while the fresh yield was taken at the end of the experiment. The freshly harvested vines from each pot were oven dried at $68^0$C for 48 hours and the dry weight determined using the sensitive weighing balance. The abattoir effluent and soil samples were analyzed using standard procedures as described by Udo *et al.* (2009). Particle size analysis was carried out by the Bouyoucos hydrometer method. Soil pH was determined in a 1:2.5 soil⁄water suspension using a glass electrode pH meter. Organic carbon was determined by the Walkley and Black wet oxidation method. Total nitrogen (N) was determined by the modified macro-Kjeldahl method. Available phosphorus (P) was extracted by the Bray 1 extraction method, and the content of P was determined calorimetrically using a Technicon AAII auto analyzer (Technicon, Oakland, Calif.). Determination of exchangeable bases was by neutral ammonium acetate extraction and read with an atomic absorption spectrophotometer (AAS). Exchangeable acidity ($H^+$ + $Al^{3+}$) was determined by titration method. Effective action exchange capacity (ECEC) was taken as the sum of the exchangeable acidity and exchangeable bases. Base saturation was determined by dividing the total exchangeable bases (Ca, Mg, K, Na) by the ECEC and multiplied by 100.

Data collected were subjected to analysis of variance and significant means compared by Fishers least significant difference (FLSD) at the 5% level of probability.

## Results and Discussion

### Properties of the soil and the abattoir effluent used for the experiment

The soil used for the experiment was strongly acidic [pH ($H_2O$) 5.23] and sandy loam in texture (Table 1). The soil was low in organic carbon, total nitrogen, exchangeable Mg, K and Na but moderate in exchangeable Ca and high in available phosphorus and base saturation. The low levels of nutrients obtained in the experimental soil indicate low fertility status which necessitates the need for additional nutrient supply.

The mineral composition of the abattoir effluent used for the experiment is as presented in Table 2. The effluent had alkaline pH and was found to contain considerable amounts of macro and micro nutrients such as nitrogen, phosphorus, potassium, calcium, magnesium, copper, zinc etc. thus having the potential of being regarded as a soil amendment. The heavy metals (cadmium, lead) contained in the abattoir effluent was within the permissible limits given by Nangia (1991), Alloway and Alloway (1995) and Kabata- Pendias and Pendias (2000) and therefore may not pose any threat to human life and the environment.

Table 1: Properties of the soil used for the experiment

| Soil property | Value |
|---|---|
| Sand (%) | 73.50 |
| Silt (%) | 15.67 |
| Clay (%) | 10.83 |
| Textural class | Sandy loam |
| pH ($H_20$) | 5.23 |
| Organic carbon (%) | 1.24 |
| Total nitrogen (%) | 0.10 |
| Available phosphorus ($mgkg^{-1}$) | 20.62 |
| Exch. Ca ($cmolkg^{-1}$) | 2.60 |
| Exch. Mg ($cmolkg^{-1}$) | 1.67 |
| Exch. K ($cmolkg^{-1}$) | 0.10 |
| Exch. Na ($cmolkg^{-1}$) | 0.06 |
| $Al^{3+}$ ($cmolkg^{-1}$) | 0.00 |
| $H^+$ ($cmolkg^{-1}$) | 1.29 |
| ECEC ($cmolkg^{-1}$) | 5.72 |
| BS (%) | 77.45 |

Table 2: Mineral composition of the abattoir effluent

| Parameter ($mgL^{-1}$) | Value |
|---|---|
| pH | 7.6 |
| Nitrogen (N) | 8.27 |
| Phosphorus (P) | 3.41 |
| Potassium (K) | 2.51 |
| Sodium (Na) | 7.81 |
| Calcium (Ca) | 6.60 |
| Magnesium (Mg) | 2.14 |
| Copper (Cu) | 0.12 |
| Cadmium (Cd) | 0.02 |
| Zinc (Zn) | 0.21 |
| Lead (Pb) | 0.01 |
| Iron (Fe) | 1.22 |

**Effects of abattoir effluent on soil properties**

Table 3 shows the effects of different rates of application of abattoir effluent on soil properties. There was no significant ($p > 0.05$) difference in the texture of the soil as a result of the effluent addition. There was also no significant increase in the pH values of the treated soils when compared with the control. However, the soil pH increased from 5.20 in the control soil to values that ranged from 5.21 to 5.43 with the values increasing as the rate of application of the effluent increased. A similar observation of gradual but not significant increase in soil pH in effluents treated soils have been reported by Isitekhale and Adamu (2016) in Ekpoma, Nigeria. Osibanjo and Adie (2007) found that fish pond effluent increased the pH of the soil from 4.1 to 5.81 and 5.95 after first and second cropping season relatively with 100% effluent application. Increase was attributed to high suspended solids, dissolved solids and alkaline nature of the effluent. Organic carbon content of the soil was significantly ($p < 0.05$) increased in effluent treated soil with the values increasing as the effluent concentration increased. Soil organic carbon increased from 1.24% in control soil to a range of 1.50 to 1.89% in treated soils. This finding conforms to that of Neboh (2013) and Isitekhale and Adamu (2016) who obtained high percentage organic carbon values on effluent treated soils than on untreated soil. This could be due to the fact that wastes from abattoir typically contain compounds that are characterized by high organic level ((Hawke and summers, 2006). Total nitrogen (N) content in the soil was significantly ($p < 0.05$) increased in treated soils except the soil that received 120 ml of effluent relative to the untreated soil with the values increasing as the effluent concentration increased. Total N increased from 0.09% in control to values ranging from 0.10 to 0.21% in treated soils. This is contrary to the findings of Isitekhale and Adamu (2016) that had no significant increase in soil total nitrogen content when abattoir effluent was used in the cultivation of maize in Ekpoma, Nigeria. Osemwota (2010) also obtained a non-significant increase in soil total N from the application of abattoir effluent. The possible reason for this disparity could be as a result of variability in the composition of effluent or it may be due to site specific changes (Hawke and summers, 2006).

However, most researchers have shown that effluent irrigation increases total soil N (Cameron *et al*., 2002; Hawke and summers, 2006; Ediene *et al*., 2016). Available P was increased from 21.6 $mgkg^{-1}$ in control soil to a range of 35.5 to 41.9 $mgkg^{-1}$ in treated soils. Exchangeable bases in the soil were significantly improved and the increases were highest in soils treated with higher concentration of effluent. These increases agree with the findings of Isitekhale and Adamu (2016). A similar trend was observed for ECEC content of the treated soils with all the treated soils recording significant increases relative to the untreated soil.

Table 3: Effects of abattoir effluent on soil physical and chemical properties

| Effluent rates (ml/6 kg soil) | Particle size: Sand | Silt | Clay | pH ($H_2O$) | OC | TN | AV. P ($mgkg^{-1}$) | Exchangeable cations: Ca | Mg | K | Na | Exch. Acidity: $Al^{3+}$ | $H^+$ | ECEC | BS (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | → % ← | | | | → % ← | | | → $cmolkg^{-1}$ ← | | | | | | | |
| Control | 73.00 | 15.67 | 10.83 | 5.20 | 1.24 | 0.09 | 21.6 | 2.37 | 0.67 | 0.10 | 0.05 | 0.00 | 1.29 | 4.48 | 71.21 |
| 120 | 75.67 | 17.00 | 8.00 | 5.21 | 1.50 | 0.10 | 35.5 | 4.20 | 1.93 | 0.10 | 0.06 | 0.00 | 0.87 | 7.16 | 87.85 |
| 240 | 76.67 | 12.33 | 11.0 | 5.27 | 1.78 | 0.15 | 35.8 | 3.93 | 2.33 | 0.17 | 0.06 | 0.00 | 0.88 | 7.37 | 88.06 |
| 360 | 76.67 | 13.67 | 10.33 | 5.30 | 1.72 | 0.15 | 40.6 | 4.33 | 2.07 | 0.19 | 0.07 | 0.00 | 0.74 | 7.40 | 90.00 |
| 480 | 74.33 | 14.67 | 9.33 | 5.43 | 1.79 | 0.17 | 41.9 | 4.60 | 2.37 | 0.19 | 0.07 | 0.00 | 0.62 | 7.85 | 92.10 |
| 600 | 76.00 | 15.33 | 9.00 | 5.43 | 1.89 | 0.21 | 41.7 | 4.60 | 2.40 | 0.19 | 0.08 | 0.05 | 0.61 | 7.93 | 91.68 |
| LSD (0.05) | NS | NS | NS | NS | 0.08 | 0.05 | 12.8 | 0.38 | 0.82 | 0.02 | 0.02 | NS | NS | 2.16 | NS |

ND: NS = not significant

**Effects of abattoir effluent on growth parameters of fluted pumpkin**

Significant ($p < 0.05$) increases in the number of leaves per plant of fluted pumpkin were observed across all the growth stages measured (Table 4). All the treated soils recorded values that were significantly higher when compared with the control at 4, 5, 6, 7 and 8 weeks after planting (WAP) with the 600 ml treated plants recording more number of leaves.

The vine length of fluted pumpkin was significantly ($p < 0.05$) affected by the application of the abattoir effluent across all the growth stages measured. Longer vines were obtained in treated soils than the untreated soils with the length increasing as the rate of application increases (Table 4). There was no significant ($p > 0.05$) difference in number of branches of fluted pumpkin at 4 and 5 WAP in abattoir effluent treated soils when compared with the control but significant increase was observed at 6, 7and 8 WAP. The positive response of fluted pumpkin in abattoir effluent treated soils indicates the potential of the effluent to be used as an amendment.

Table 4: Effects of abattoir effluent on growth parameters of fluted pumpkin

| Effluent rates (ml/6 kg soil) | **Number of leaves** | | | | |
|---|---|---|---|---|---|
| | 4WAP | 5WAP | 6WAP | 7WAP | 8 WAP |
| Control | 24.3 | 31.3 | 39.0 | 45.0 | 48.3 |
| 120 | 34.7 | 44.7 | 56.7 | 60.7 | 78.7 |
| 240 | 33.7 | 46.3 | 58.0 | 68.0 | 80.7 |
| 360 | 39.7 | 48.7 | 62.0 | 71.0 | 82.0 |
| 480 | 39.7 | 50.3 | 66.7 | 72.7 | 84.7 |
| 600 | 42.7 | 50.8 | 67.0 | 79.7 | 97.3 |
| **LSD (0.05)** | 4.34 | 3.87 | 5.22 | 5.51 | 4.35 |
| Effluent rates (ml/6 kg soil) | **Vine length (cm)** | | | | |
| Control | 43.3 | 51.7 | 66.0 | 78.7 | 83.0 |
| 120 ml | 94.3 | 103.0 | 100.0 | 111.3 | 114.3 |
| 240 ml | 84.3 | 117.7 | 122.7 | 134.7 | 138.7 |
| 360 ml | 86.0 | 113.7 | 124.7 | 139.7 | 143.7 |
| 480 ml | 99.0 | 117.3 | 128.3 | 138.0 | 152.3 |
| 600 ml | 101.0 | 122.3 | 133.3 | 148.7 | 160.7 |
| **LSD (0.05)** | 13.22 | 20.10 | 19.45 | 12.62 | 10.03 |
| Effluent rates (ml/6 kg soil) | **Number of branches** | | | | |
| Control | 1.33 | 1.67 | 1.67 | 2.33 | 2.33 |
| 120 ml | 1.67 | 2.67 | 2.67 | 3.33 | 3.67 |
| 240 ml | 1.33 | 2.33 | 3.00 | 3.00 | 3.00 |
| 360 ml | 1.67 | 2.33 | 2.67 | 3.00 | 3.33 |
| 480 ml | 1.70 | 2.00 | 2.33 | 3.00 | 3.33 |
| 600 ml | 2.00 | 3.33 | 4.00 | 4.00 | 4.00 |
| **LSD (0.05)** | NS | NS | 1.02 | 1.06 | 1.00 |

**Effect of abattoir effluent on fresh and dry matter yield of fluted pumpkin**

Significant ($p < 0.05$) increase in fresh and dry matter yield of fluted pumpkin was observed in plants treated with different levels of abattoir effluent relative to the control (Table 5). There were corresponding yield increase as the rate of application increased with the highest fresh shoot yield of 12.12 t/ha and dry matter yield of 2 t/ha obtained in soil treated with 600 ml (i.e. 200,000 litres/ha) of abattoir effluent. Relative yield increase of the fresh shoot of fluted pumpkin when compared with control was 79.8, 92.0, 91.5, 101.1 and 114.9 % for plants treated with 120, 240, 360, 480 and 600 ml of abattoir effluent, respectively. Significant increases in fluted pumpkin yield as a result of amendments applied have been documented in many studies (Olaniyi and Odedere, 2009; Ndor and Dauda, 2013; Iren *et al.*, 2013, 2014a, 2015 & 2016).

Table 5: Mean fresh and dry matter yield of fluted pumpkin as affected by abattoir effluent

| Effluent rates (ml/6 kg soil) | Fresh shoot and leaves weight (t/ha) | Dry weight (t/ha) |
|---|---|---|
| Control | 5.64 | 0.87 |
| 120 ml | 10.14 | 1.66 |
| 240 ml | 10.82 | 1.77 |
| 360 ml | 10.80 | 1.89 |
| 480 ml | 11.34 | 1.91 |
| 600 ml | 12.12 | 2.00 |
| **LSD (0.05)** | 2.0 | 0.09 |

**Conclusion**

The increase in almost all the parameters assessed in this study showed the ability of abattoir effluent to serve as a soil amendment. The increase was proportional to the rate of application as an increase in the concentration of the effluent resulted to a corresponding increase in soil properties, growth and yield of fluted pumpkin. Based on these findings, abattoir effluent is a good nutrient source for plant growth and is therefore recommended for use by farmers.

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