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PRODUCTION OF ORGANIC FERTILIZER USING BIODEGRADABLE WASTE

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ABSTRACT

The increasing cost of chemical fertilizers coupled with the growing awareness on the possible hazards of chemical fertilizer on the environment, motivates the interest to study the production of organic fertilizer from biodegradable waste for a sustainable and environmentally friendly agricultural practices. This study focuses on the production of organic fertilizer from fruit wastes and cow dung and determined the yield, characterization of the produced organic fertilizer and comparative investigation of the produced fertilizer with chemical fertilizer. Organic fertilizer with competitive nutrient for sustainable and environmentally friendly agricultural practices was successfully produced from fruit waste (65%) and cow dung (35%) with a high yield of 62.19%. The characteristics of the produced organic fertilizer such as electrical conductivity (1.72 dS/m), pH (6.8), organic carbon (17.52), C:N ratio (11.526) and NPK values are well within acceptable and recommended standards. The comparative analysis of the produced organic fertilizer compared favorably with the commercially available organic and chemical fertilizer and it utilization will enhance sustainable agricultural practice among rural farmers in Nigeria, as well as mitigate the rising rate of organic waste generation in most part of the country.

Keywords: Organic fertilizer, decomposition, biodegradable waste

1. INTRODUCTION

Human existence and advancement owe gratitude to local agricultural industries. Agriculture was the key development that led to the rise of human civilization, with the plants and husbandry of domesticated animals and has created food surpluses that enable the development from small settlement to densely populated and stratified society. However, agriculture has undergone series of advancement since the 12th century and is being practiced extensively throughout the world today and, it was recorded that one-third of the world's workers were employed in the area of agriculture (Itelima *et al.*, 2018). Despite the series of advancement in agricultural activities, farmers in rural areas have been facing the challenge of declining agricultural productivity.

One of the reasons for this is decrease in soil fertility because for optimum plant growth, nutrients must be available in sufficient and balanced quantities (Mohammadi and Sohrabi, 2012). The most important constraint limiting crop yield in developing nations worldwide, like Nigeria, and especially among resource-poor farmers, is soil infertility. Unless the fertility is restored in these areas, farmers will gain little benefit from the use of improved varieties and more productive cultural practices. Soil fertility can be restored effectively through adopting the concept of integrated soil fertility management (ISFM) encompassing a strategy for nutrient management-based on natural resource conservation, biological nitrogen fixation (BNF) and increased efficiency of the inputs.

According to Khosro and Yousef (2012), the most important constraint limiting crop yield in developing nations worldwide and especially among resource poor farmers, is soil infertility. Therefore, maintaining soil quality can reduce the problems of land degradation, decreasing soil fertility, and rapidly declining production levels in large parts of the world that needed the basic principles of good farming- practice.

(Mfilinge *et al.* 2014), opined that low crop productivity is a general problem facing most farming systems in Sub Saharan Africa (SSA). These low yields are pronounced in legumes and are often associated with declining soil fertility and reduced nitrogen fixation due to biological and environmental factors. Biological nitrogen fixation (BNF), a key source of nitrogen for farmers using little fertilizer, constitutes one of the potential solutions and plays a key role in sustainable production of legumes and even non legumes.

The continuous cultivation of the same piece of land year in year out due to increased population has resulted to a decline in soil fertility such that even with the application of chemical inorganic fertilizer, little is obtained in return. Conventional agriculture plays an important role in meeting the food needs of a growing human population, which has led to an increasing dependence on the use of chemical fertilizers and pesticides for increased productivity (Itelima *et al*., 2018). Chemical fertilizers are industrially made substances which are composed of known quantities of nitrogen, phosphorus and potassium (Eroa, 2015).

Using chemical fertilizers to improved farming outputs over the years have been found to cause air and ground water pollution as a result of eutrophication of water bodies, though the practice of using chemical fertilizers and pesticides accelerates soil acidification, it also poses the risk of contaminating ground water and the atmosphere (Chun-Li *et al.*, 2017). Also, it weakens the roots of plants and makes them susceptible to unwanted diseases that often affect growth and yield. For this reasons, there have been attempts in recent times in the direction of the production of nutrient rich and high quality fertilizer to ensure bio-safety through organic agricultural practice. The increasing cost of chemical fertilizers coupled with the growing awareness on the possible hazard of synthetic chemicals on health and the environment, and the issue on sustainable development has brought wide interest on organic agriculture (Matias *et al.*, 2017).

The use of organic fertilizer has been identified as an alternative to chemical fertilizer to increase soil fertility and crop production in sustainable farming. These potential biological fertilizers would play the key role in productivity and sustainability of soil and also protect the environment as eco-friendly and cost effective inputs for the farmers (Khosro and Yousef, 2012). Organic farming is one of such strategies that not only ensures food safety but also adds to biodiversity of soil. The application of organic fertilizer to the soil increases the biodiversity which constitutes all kinds of useful bacteria and fungi including the arbuscular mycorrhiza fungi (AMF) called plant growth promoting rhizobacteria (PGPR) and nitrogen fixers and considerable number of these microorganisms possess a functional relationship and constitute a holistic system with plants with beneficial effects on plant growth (Itelima *et al*., 2018). Application of beneficial organic fertilizer in agricultural practices started about several years back and it is now evident that this beneficial substance can enhance plant resistance to adverse environmental stresses e. g., water and nutrient deficiency and heavy metal contamination.

Organic fertilizers keep the soil environment rich in all kinds of macro and micro nutrients via nitrogen fixation, phosphate and potassium solubilisation or mineralization, release of plant growth regulating substances, production of antibiotics and enhance biodegradation matter in the soil. In general, 60 – 90%

of the total applied fertilizer in soil is lost and the remaining 10 – 40% is taken up by plants (Itelima *et al.*, 2018). Hence organic fertilizers can be important component of cheaper and integrated nutrient management systems to sustain agricultural productivity and a healthy environment. It is against this background that this study seeks to investigate the production and application of organic fertilizer for sustainable agricultural practice.

The call for diversification to agriculture which use to be the Nigeria's source of income before the discovery of crude oil and the high cost of chemical fertilizer, as well as the environmental implication of chemical fertilizer application calls for the need for a sustainable and environmentally friendly agricultural practices in Nigeria. Also, the rising rate of organic waste generation in most part of the country which, over time have constituted environmental challenges could serve to mitigate the challenges of chemical fertilizer by substitution with organic fertilizer produced using the large quantity of organic waste generated in most part of the country for sustainable and environmentally friendly agricultural practice.

This has led to a growing interested in the application of organic of bio fertilizer for a sustainable and environmentally friendly agricultural practice. Several studies have investigated the use of agricultural waste for organic and bio fertilizer production. Organic fertilizer enhancing soil fertility and crop productivity have been investigated by Khosro and Yousef (2012); Mohammadi and Sohrabi (2012); Mfilinge *et al.* (2014) and Itelima *et al.* (2018). Also, Eroa (2015) have examine the production of organic fertilizer from Jatrophacurcas, and organic fertilizer from agricultural wastes (Matias *et al.*, 2017). However, there is little or no documented study done on the production of organic fertilizer from fruits waste in Nigeria. To fill this gap, this study was intended to assess the production of organic fertilizer from biodegradable waste for sustainable agricultural purposes. The objectives are production of organic fertilizer from fruit wastes and cow dung and determined the yield, characterization of the produced organic fertilizer and comparative investigation of the produced fertilizer with chemical fertilizer.

2. MATERIALS AND METHODS

2.1 Materials

Fruits and vegetable waste were obtained from Sabo Marked, Kaduna State while cow dung was obtained from a farm in Gonin Gora area of Kaduna South, Kaduna State. All chemicals used were of analytical grade. The samples were sorted, washed and then reduced in size to smaller sizes. The prepared samples were further washed in order to separate unwanted material such as clay, coarse sand and any other impurities from the waste fruit sample and kept for further analysis

2.2 Organic Fertilizer Production

The composition of the organic materials on % weight basis, that will be used in the production of organic fertilizer are as follows; biomass material (65%) and cow dung (35%). In this study, biomass materials refer to the biodegradable materials which are fruit waste products. 5.6 kg of fruit waste was measured (65%) and 3kg of cow dung (35%) and thoroughly mixed together in container. The mixture of the waste was then mixed with water up to a maximum of 80% moisture level before covering the mixture for to enhance decomposition of the waste into organic product in the absence of the atmospheric oxygen. The mixture was turned after 2 – 3 days until all organic materials are fully decomposed and to maintain 28 – 35°C. Complete decomposition was reached in 4 weeks when all the substrates are no longer recognizable and the compost is turn dark brown to black. The decomposed materials (organic fertilizer) was allowed to cure/sweeten for 2 – 3 days. Curing/sweetening was done by completely removing the cover and continuously turning the decomposed materials every day to further lower the temperature and reduce the moisture content. The decomposed materials were sun dried to reduce the moisture content to barest minimum. The produced decomposed material was stored for further analysis (Matias *et al.*, 2017). The yield of the produced organic fertilizer, was determined using Equation 1.

$$\text{yield} = \frac{\text{weight of organic fertilizer produced}}{\text{Initial weight of substrate mixture}} x100 \qquad \text{Eq. c1}$$

2.3 Characterization of Produced Fertilizer

To establish quality of the produced organic fertilizer, the product was analysis to determine the pH, conductivity, phosphorous, potassium, nitrogen, organic carbon, C:N ratio and plant growth.

To determine the NPK content of the produced organic fertilizer, triacid extract was first prepared as described subsequently. 5g of the sample was weighed in a 250 ml conical flask and 15 ml triacid mixture was added and the flask was covered with funnel. The contents were digested over a sand bath at 180 – 200˚C until dense white fumes of H_2SO_4 and $HClO_4$ were evolved. A brown greenish scum of MnO_2 may appear with $HClO_4$ but it re-dissolves in the concentrated H_2SO_4, at the end of the digestion, a clear solution was obtained and later diluted with distilled water and filtered through whattman filter paper while the filtrate was collected in a 250 ml volumetric flask. The conical flask was washed with small amounts of hot water and the washings of filter paper were also added. The residue on the filter paper was washed and the washings were continued till the filtrate runs free of chloride (test with silver nitrate solution). The volumetric flask was cooled under tap water and the volume was made up to 100 ml with distilled water to give triacid extract. The triacid extract was kept and used for the analysis of nutrients in the given organic samples (Gnanaprakasam *et al.*, 2013).

Phosphorous: 5ml of the prepared triacid extract was pipetted out into a 25ml volumetric flask. 5ml of the triacid was added and the volume was made up with distilled water while allowing the development of yellow colour for 30 min and the intensity of colour was measured using blue filter after adjusting the transmittance of the meter to 100 with a blank. The colour was stable for 24 hours. The concentration of Phosphorous in the organic fertilizer was then read from a calibration curve (Figure 1a) developed for Phosphorous using a UV spectrophotometer (Gnanaprakasam *et al.*, 2013).

Potassium: 5 ml of the triacid extract was pipetted out into 25 ml volumetric flask and the acid was neutralized with ammonium hydroxide (the piece of red litmus put into the flask turns to blue). The volume was made up with distilled water. The solution was mixed well to make it homogeneous. The concentration of potassium (K) in the solution was measured by using flame photometer. The concentration of K in the organic fertilizer was deduced from the standard curve (Figure 1b) established using UV spectrophotometer and the percentage of potassium in the manure can be calculated (Gnanaprakasam *et al.*, 2013).

Nitrogen: About 0.25 g of the produced organic fertilizer sample was weighed and transferred into a dry kjeldahl flask and 30 ml of concentrated H_2SO_4 was added containing 1 g of salicylic acid. The contents were mixed well and allowed to stand for at least half an hour with frequent shaking. 5 g of crystalline sodium thiosulphate ($Na_2S_2O_3.H_2O$) was added and shake well. It was digested over a low flame until frothing ceases. Then 10 g of K_2SO_4 and 1 g of $CuSO_4.5H_2O$ was added and heated strongly until the liquid in the flask turns green (Gnanaprakasam *et al.*, 2013). The concentration of Nitrogen in the organic fertilizer was then read from a calibration curve developed for nitrate using a UV spectrophotometer.

Calibration Curve: Stock solution of phosphate, potassium and nitrate were prepared in the range of 1 -5g/L in separate beakers. The UV spectrophotometer was then switched on and blanking was carried out using distilled water. Samples of each prepared solution of nitrate, potassium and phosphate was the analyzed to determine the corresponding absorbance of the solution after the UV spectrophotometer has been set to the wavelength of 840 nm for phosphate, 766.5 nm potassium and 540 nm for nitrate.

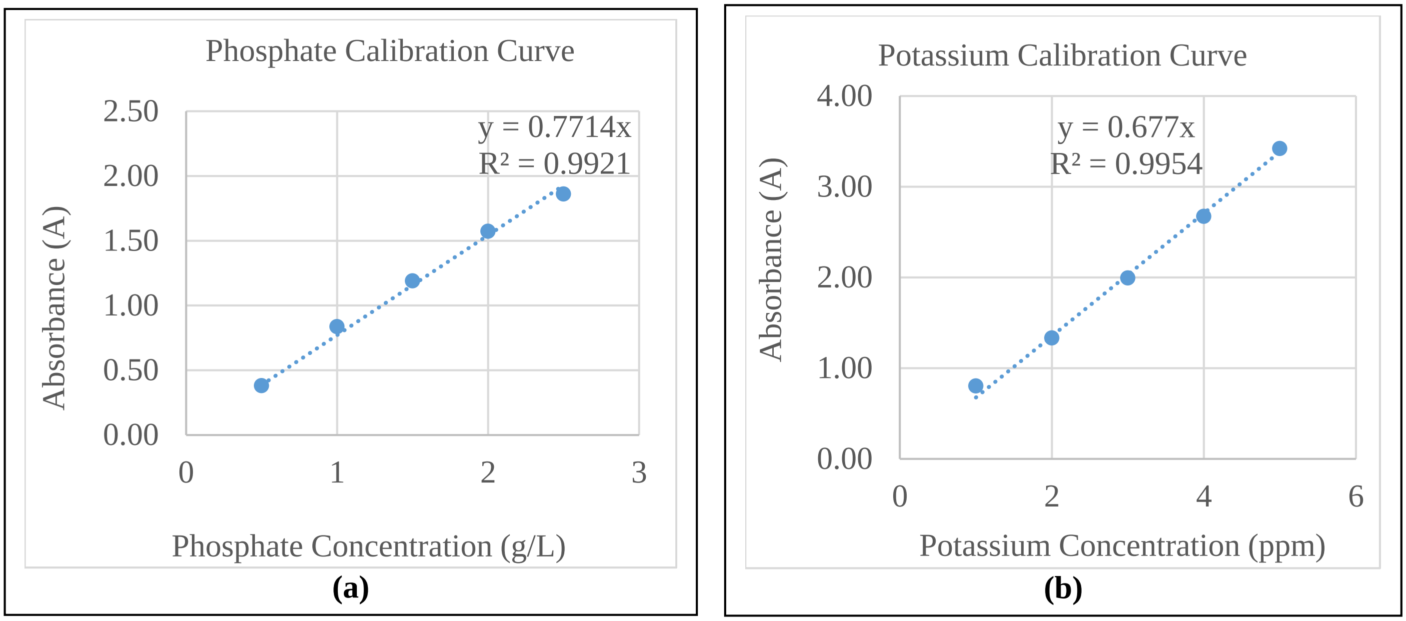

Figure 1: Calibration curves (a) for potassium and (b) for phosphate

3. RESULTS AND DISCUSSION

The result obtained from the production of organic fertilizer and quality assessment of the produced fertilizer are presented in Table 1.

Table 1: Physiochemical Properties of the Produced Organic Fertilizer

Parameter	Value
Organic Fertilizer Yield (%)	62.19
pH of Substrate	6.3
pH of Organic Fertilizer	6.8
Electrical Conductivity (dS/m)	1.72
Organic Carbon (%)	17.52
Nitrogen (N), %	1.52
Phosphorous (P), %	0.84
Potassium (K), %	1.72
C:N	11.526

Organic fertilizer was produced from a mixture of fruit waste (65% w/w) and cow dung (35% w/w) and allowed to decompose for 4 weeks. At the end of 4 week of decomposition period of the raw materials, the organic fertilizer yield was determined as well as the physiochemical analysis of the produced organic fertilizer. Table 1 present the physiochemical evaluation of the produced fertilizer. From Table 1, it was observed that the mixture of 65% fruit waste and 35% cow dung gives a yield of 62.19%. This obtained yield compared favorably with 47.9 – 68.9% reported by Matias *et al.* (2017) for various mixtures of biomass material (chicken dung, carbonized rice hull, rice straw, sawdust and goat manure). The loss of about 37.81% of weigh after complete decomposition could be attributed to volatile matter removal during decomposition. The organic fertilizer produced is dark brown in colour.

The pH of the substrate mixture before decomposition started and that of the produced organic fertilizer was also determined. From Table 1, the pH of substrate before decomposition started and the pH of the produced organic fertilizer are 6.3 and 6.8 respectively. The pH of an organic fertilizer is a very crucial property of fertilizer that must be determined, because it alters the pH of the soil to which it is applied (Santillan *et al.*, 2014). Also, the soil root zone, especially the rhizosphere, is the active zone of microbial and root activity and the pH of the rhizosphere zone is critical in deciding microbial activity, which in turn regulates the innumerable chemical reactions involved in nutrient transformations and uptake by plant roots (Sudharmaidevi *et al.*, 2016). For this reason, the best pH range for active growth and development of plants and microbes is 6.5 –7.5. From Table 1, it can be seen that the pH of the produced organic fertilizer is within the standard and best acceptable range for active growth and development of plants and microbes. The pH value of 6.8 obtained for organic fertilizer in this study is slightly lower that 7.1 – 7.4 reported by Vidhya and Harriet-Sumathy (2018) for fruit waste organic fertilizer.

Electrical conductivity (EC) which is a measure of the amount of salts that is contained in soil is an important indicator of soil health as it affects crop yields, crop suitability, plant nutrient availability, and activity of soil microorganisms which influence key soil processes including the emission of greenhouse gases such as nitrogen oxides, methane, and carbon dioxide (Adviento-Borbe *et al.*, 2006). Also, EC is a measure of soluble salts. A high salt content is not desirable, because very high concentrations of soluble salts damage plants through specific ion effects and plasmolysis (Chauhan *et al.*, 2016). Electrical conductivity of the produced organic fertilizer was determined as 1.72 dS/m (Table 1). The EC determined in this study is considered safe for use as organic fertilizers as the standard recommended value is, EC < 4 dS/m (Sudharmaidevi *et al.*, 2016). So a value of 1.72 dS/m is considered safe for soil application.

Organic carbon (TOC) is an important parameter with respect to the maturity of the compost and or manure, because a decrease in TOC is desired to attain the optimum carbon to nitrogen ratio (C:N) for soil application. The main aim of decomposition is to reduce the organic carbon content to achieve a C:N ratio of 10 – 25, which is the standard for beneficial microorganisms (Sudharmaidevi *et al.*, 2016). From Table 1, the organic carbon and nitrogen content in the produced organic fertilizer are 17.52% and 1.52% respectively. The organic carbon and nitrogen content in the produced organic fertilizer gives a C:N ratio of 11.526. The C:N ratio for the produced fertilizer is within the standard acceptable range of 10 – 25 C:N ratio for organic fertilizer. According to Nada (2015), approximately 36 – 56% of the initial organic carbon is lost at the end of decomposition.

Organic fertilizers are used to improve soil quality and tilth, and to provide nutrients for plant growth. These nutrient majorly are nitrogen, phosphorus, and potassium, as well as other minor elements essential for plant development and overall good health of soil for healthy planting. This necessitate evaluation of the major nutrient in the produced fertilizer. From Table 1, nitrogen, phosphorus, and potassium content of the produced fertilizer are 1.52%, 0.84% and 1.72% respectively. Applying the organic fertilizer to soil will enhance the amount of NPK present in the soil. The obtained N (1.52%), P (0.84%) and K (1.72%) for the produced fertilizer compared favorably with 1 – 4.44% N, 0.18 – 2.09% P and 0.48 – 2.08% K reported by Eroa (2015) for organic fertilizer from various agro waste. Also, the NPK value obtained in this study is higher 1.18% N, 1.07%P and 1.35% K reported by Matias *et al.* (2017). The produced organic fertilizer shows relatively high and competitive content of major nutrient (NPK) required for improved plant growth.

4. CONCLUSION

The increasing cost of chemical fertilizers together with the growing awareness on the possible hazard of chemical fertilizer on the environment, and the issue on sustainable development motivate the interest to study the production of organic fertilizer from biodegradable waste for a sustainable and environmentally friendly agricultural practices in Nigeria. From the study carried out, it was concluded that, organic fertilizer with competitive nutrient for sustainable and environmentally friendly agricultural practices was successfully produced from fruit waste (65%) and cow dung (35%) with a high yield of 62.19%. Also, the characteristics of the produced organic fertilizer such as electrical conductivity (EC), pH, organic carbon, C:N ratio and NPK values are well within acceptable and recommended standards. The comparative analysis of the produced organic fertilizer compared favorably with the commercially available organic and chemical fertilizer and it utilization will enhance sustainable agricultural practice among rural farmers in Nigeria and beyond, as well as mitigate the rising rate of organic waste generation in most part of the country.

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