



**Assessment of Physicochemical Potentials of Compost of
Calopogonium mucunoides Desv. and *Chromolaena odorata*
(L.) R.M. King & H. Rob. for Sustainable Agriculture in
Bayelsa State.**

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ABSTRACT

*The study evaluated the physico-chemical properties of composts produced from *Calopogonium mucunoides* Desv. and *Chromolaena odorata* for sustainable agriculture in Bayelsa State, Nigeria. Fresh plant materials were collected from secondary forests and composted for 12 weeks under controlled conditions. Composts were analyzed for physical parameters including moisture content, bulk density, water-holding capacity, and porosity, as well as chemical properties such as pH, electrical conductivity, nitrogen, phosphorus, organic carbon, organic matter, carbon-to-nitrogen ratio, potassium, and calcium. Results showed that *Calopogonium mucunoides* compost had significantly ($p < 0.05$) higher moisture content (40.20%), bulk density (340.19 kg/m³), water-holding capacity (3.72 g water/g sample), and porosity (78.60%) compared to *Chromolaena odorata*. *Calopogonium mucunoides* also recorded higher pH (5.60), electrical conductivity (1.71 dS), nitrogen (6.90%), phosphorus (2.26%), organic carbon (10.36%), organic matter (20.71%), and calcium (3.35%). In contrast, *Chromolaena odorata* compost had higher potassium content (2.04%) and carbon-to-nitrogen ratio (4.53). The findings showed that both composts have potential as organic soil amendments. However, *Calopogonium mucunoides* compost demonstrated superior nutrient quality and better physical properties, making it more suitable for improving soil fertility. Hence, the utilization of these plant biomasses provides a sustainable and cost-effective alternative to inorganic fertilizers in Bayelsa State and Nigeria at large.*

Keywords: *Calopogonium mucunoides*, *Chromolaena odorata*, Compost, Physicochemical Potentials, Sustainable agriculture, Soil fertility, Organic amendment.

INTRODUCTION

Sustainable agriculture depends largely on the maintenance of soil fertility through environmentally friendly practices that enhance soil productivity while minimizing ecological degradation. In many tropical regions, especially in sub-Saharan Africa, declining soil fertility caused by continuous cultivation, nutrient depletion, and over-dependence on inorganic fertilizers has become a major limitation to agricultural productivity. In response to these challenges, organic amendments such as compost have gained increasing recognition as a viable and environmentally sustainable alternative for improving soil quality, enhancing nutrient availability, and sustaining crop yield (Adeleye *et al.*, 2023; Yusuf *et al.*, 2024). Compost is a biologically stabilized organic material produced through the controlled decomposition of plant residues, animal wastes, and other biodegradable materials under aerobic conditions. During composting, microorganisms transform unstable organic matter into humus-like substances rich in plant nutrients and beneficial microbial metabolites (Musa & Ibrahim, 2023). The application of compost to agricultural soils improves physical properties such as soil structure, porosity, moisture retention, and bulk density while supplying essential nutrients including nitrogen (N), phosphorus (P), potassium (K), and calcium (Ca), all of which are necessary for optimum crop growth (Okeke *et al.*, 2024). Studies have also shown that compost enhances microbial diversity, increases cation exchange capacity, and improves nutrient retention in degraded tropical soils (Ahmed *et al.*, 2025). The essence of organic amendments in sustainable agriculture extends beyond nutrient supply. Organic compost improves soil resilience by enhancing aggregate stability, reducing erosion, and buffering soil pH, especially in fragile tropical ecosystems (Ojo *et al.*, 2023). In addition, composting offers an environmentally safe method for recycling plant biomass into valuable soil amendments, reducing waste accumulation and greenhouse gas emissions associated with poor

organic waste disposal practices (Nnaji & Eze, 2024). The integration of organic compost into crop production systems contributes significantly to sustainable nutrient cycling and reduced dependency on mineral fertilizers, thereby lowering production costs for smallholder farmers (Bassey *et al.*, 2026).

Calopogonium mucunoides, commonly known as Clopo, is a perennial tropical legume widely used as a cover crop due to its vigorous growth, nitrogen-fixing ability and capacity to improve soil fertility. As a leguminous plant, it accumulates substantial amounts of nitrogen in its tissues through symbiotic nitrogen fixation, making it an excellent substrate for nutrient-rich compost production (Nwankwo *et al.*, 2023). Adebayo *et al.* (2024) showed that compost derived from leguminous biomass improved soil nitrogen status and enhanced crop growth significantly compared to non-leguminous organic amendments. Plant materials with high nitrogen content and low lignin concentration, such as *Calopogonium mucunoides* residues, decompose relatively quickly due to their favorable carbon-to-nitrogen ratio, which promotes rapid nutrient mineralization and enhances compost maturity (Ibrahim *et al.*, 2025). Similarly, *Chromolaena odorata*, popularly known as Awolowo belongs to the family Asteraceae. It is a rapidly growing invasive shrub commonly found in tropical regions. The plant produces large quantities of biomass and contains appreciable levels of potassium, calcium, and organic matter, making it useful for compost production (Eze *et al.*, 2025). Nwachukwu and Bello (2024) reported that *Chromolaena odorata* compost improved soil potassium availability and increased crop tolerance to environmental stress. The utilization of *Chromolaena odorata* for composting also presents an environmentally beneficial strategy for managing its invasive spread while converting it into a useful agricultural resource. Declining soil fertility remains a major limitation to sustainable agricultural production in Bayelsa State, located in the humid Niger Delta region of Southern Nigeria. The soils of the region are predominantly acidic, sandy, and poorly structured, with low nutrient retention capacity due to heavy rainfall and intense leaching (Ikechukwu & Friday, 2023). These conditions reduce the availability of important nutrients and negatively affect crop performance. Organic amendments are therefore critical for improving soil organic matter content, nutrient retention, and overall soil productivity in the region (Umar *et al.*, 2025).

Bayelsa State is endowed with abundant natural vegetation, including *Calopogonium mucunoides* and *Chromolaena odorata*, which are readily available in secondary forests and fallow lands. Despite the abundance of these plant species or biomass resources in Bayelsa State, there is limited information on the comparative physico-chemical qualities of compost derived from these plant species and their suitability for improving soil fertility. Assessing the composting potential of these locally available plant materials is essential for identifying cost-effective and sustainable alternatives to inorganic fertilizers. Hence, this study evaluated the physico-chemical properties of composts prepared from *Calopogonium mucunoides* and *Chromolaena odorata* with a view to determining their suitability as organic amendments for sustainable agriculture in Bayelsa State.

MATERIALS AND METHODS

The following equipment and apparatus were used: Soxhlet apparatus, heating mantle, autoclave, Bunsen burner, incubator, automatic weighing balance, refrigerator, water bath, and spectrophotometer. Glassware used includes: test tubes, beakers, conical flasks, bijou bottles, and glass rods. Reagents used include: distilled water, hydrogen peroxide, absolute ethanol, 45% ethanol, sulphuric acid, sodium hydroxide, anhydrous sodium sulphate, ferrous sulphate, ferrous chloride, aluminum chloride, and ammonia solution. Other materials include: Whatman No. 2 filter paper, aluminum foil, spatula, latex gloves, plant samples of *Calopogonium mucunoides* and *Chromolaena odorata*, polythene bags, and cotton wool.

Study Area

The study was conducted in Bayelsa State (latitude 4°15' and 5°23' North and longitude 5°22' and 6°45' East), located in the Niger Delta region of southern Nigeria. The area is characterized by extensive wetlands, mangrove forests, creeks and river networks; a humid tropical climate, with high annual rainfall ranging from 2,500 mm to 4,000 mm, elevated relative humidity and temperatures between 25°C and 32°C. The vegetation consists mainly of mangrove swamp forest, freshwater swamp forest, and tropical rainforest vegetation, which support the abundant growth of plant species such as *Calopogonium mucunoides* and *Chromolaena odorata*. The soils are predominantly

hydromorphic and acidic, with low nutrient retention capacity due to excessive leaching caused by heavy rainfall.

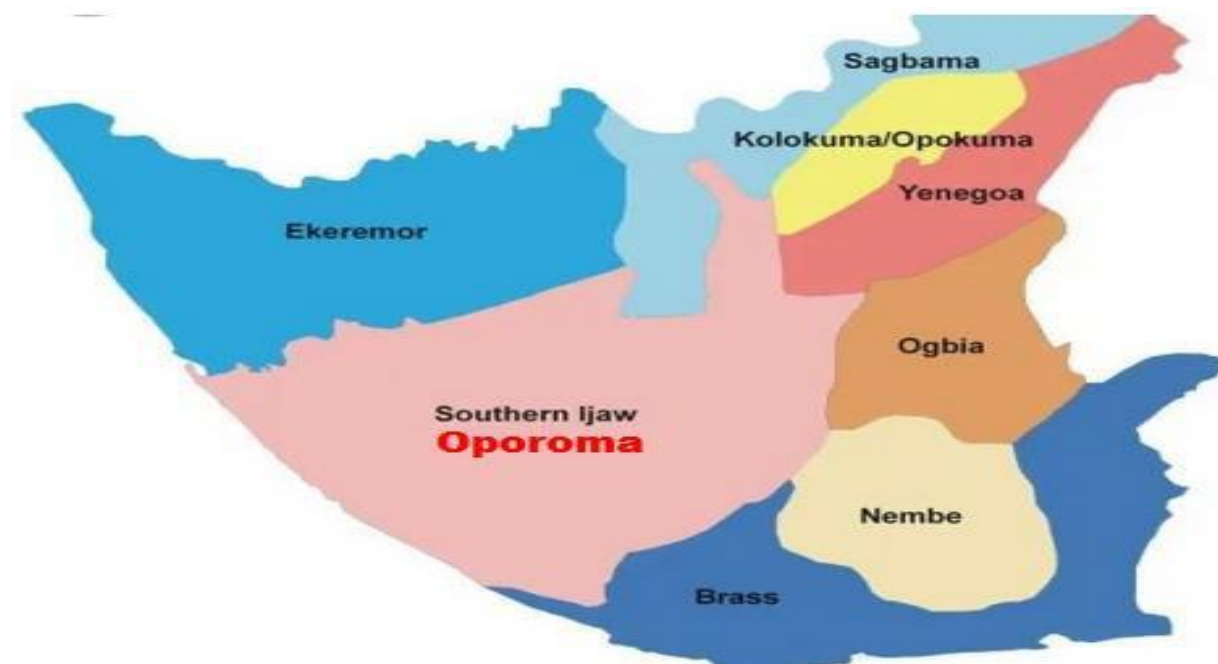


Figure 1: Map of Bayelsa State Showing the eight Local Government Areas

Collection of Plant Samples

Fresh plant samples of *Calopogonium mucunoides* and *Chromolaena odorata* were collected from secondary forest vegetation in Bayelsa State, Nigeria. The samples were carefully harvested, placed in clean polythene bags, and transported to the Department of Biology, Federal University Otuoke laboratory for identification and composting.

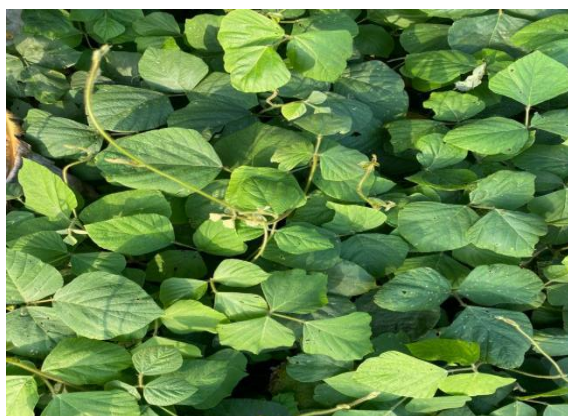


Plate 1: *Calopogonium mucunoides* Leaf



Plate 2: *Chromolaena odorata* Leaf

Determination Of Physico-Chemical Properties Of Plant Samples

Preparation of plant Samples: The composts were prepared in wooden box chambers with the dimensions of 1 m × 1 m × 1 m. Wooden boxes were not tightly sealed to facilitate aeration, and compost preparations were mixed and watered once every week for 12 weeks to maintain adequate moisture. At the end of the 12 weeks, 2 kg of each compost preparation were dried in a hot-air oven at 60 °C for 12 h, slightly ground to finer particles using a large brass mortar and pestle, then sieved with a 2 mm sieve. The remaining samples were then analyzed for both physical and chemical properties of the compost.

pH: Sample pH was measured in water at a 1:1 (soil: water) by glass electrode pH meter (Mclean, 1982). Exchangeable bases of soils (Ca, Mg, K and Na) were extracted using NH₄OAC buffered at pH 7.0 (Thomas, 1982).

Organic carbon and Organic matter: The percent organic carbon (OC%) was measured using the Walk-Black (1934) wet oxidation method. 10 g of compost was put in a crucible and kept in the furnace at 550 °C for 4 h and allowed to cool; then the final weight was noted (Tadesse *et al.*, 1991).

Moisture content: Moisture content or water retention was measured using a soil moisture unit with a pressure of 0.1 Bar. Each sample was placed in a dish filled with distilled water until the sample was moist, then the instrument was turned on. Once the pressure instrument stopped, the weight of the dish containing the fresh sample was recorded. Then, the sample was dried in the laboratory's oven at 100 °C for 12 h and cooled down. The weight of the dry sample was taken, and the water retention percentage of each sample was calculated using the average of replicates (Tadesse *et al.*, 1991).

Electrical conductivity (EC) was measured using an electrical conductivity meter. Each sample was diluted in a ratio of 1:5 with distilled water, stirred, and allowed to settle overnight before getting the reading (Tadesse *et al.*, 1991).

Water holding capacity (WHC): A wet sample of known initial moisture content was weighed (W_i) and placed in a beaker. After soaking in water for 1-2 days and draining excess water through Whatman No. 2 filter paper, the saturated sample was weighed again (W_s). The amount of water retained by the dry sample was calculated as the WHC (Ahn *et al.*, 2008).

Bulk density and porosity: Bulk density was measured using an approximately 10 liters volume container. The container was filled with the sample material and slightly compacted to ensure the absence of large void spaces. The bulk density was calculated by dividing the weight of the material by the volume of material in the container. Compost porosity (ϵ_a) was determined using the known density of water (ρ_w ; 1000 kg m⁻³) and estimated densities of organic matter (ρ_{om} ; 1600 kg m⁻³), and ash (ρ_{ash} ; 2500 kg m⁻³), as well as the moisture content and bulk densities of the sample. Porosity was calculated based on the known moisture content (MC), dry matter (DM), organic matter (OM), and wet bulk density (ρ_{wb}) of the samples (van- Cingel *et al.*, 1999).

Effective Cation Exchange Capacity: ECEC was calculated by the summation of the exchangeable bases and acidity (Tan, 1996).

Ca and K content: This method was done using the official methods of analysis (AOAC, 2003). The ash of each sample obtained was digested by adding 5ml of 2 M hydrochloric acid (HCL) to the ash in a crucible and heated to dryness on a heating mantle; then 5ml of 2 M hydrochloric acid (HCL) was added again, heated to boiling, and filtered through a Whatman No. 1 filter paper into a 100 mL volumetric flask. The filtrate was made up to the mark with distilled water, stoppered, and made ready for reading the concentration of Calcium and Potassium on the Jenway Digital Flame Photometer (PFP7 Model) using the filter corresponding to each mineral element, while the iron and magnesium were read in a PerkinElmer AAS model 2300AA.

The concentration of each of the elements was calculated using the formula: % Ca or % K or % Na

$$= \frac{\text{Meter Reading (MR)} \times \text{Slope} \times \text{Dilution factor}}{1000}$$

NB: MR x slope x dilution factor will give the concentration in parts per million(ppm) or mg/kg.

Phosphorus: Phosphorus was determined routinely by the vanadomolybdate colorimetric or spectrophotometric method. The ash of each sample obtained was treated with a 2 M concentration of hydrochloric acid solution. Then 10 mL of the filtrate solution was pipetted into a 50 mL standard flask, and 10 mL of vanadate yellow solution was added, and the flask was made up to the mark with distilled water, stoppered, and left for 10 minutes for full yellow development. The concentration of phosphorus was obtained by taking the optical density (OD), or absorbance, of the solution on a Spectronic 20 spectrophotometer or colorimeter at a wavelength of 470 nm.

The percentage phosphorus was calculated using the formula:

% Phosphorus =
$$\frac{\text{Absorbance} \times \text{Slope} \times \text{Dilution factor}}{10000}$$

Nitrogen content: Nitrogen content of the samples was determined by the Kjeldahl method. The method involves: Digestion, distillation, and Titration.

Digestion: Two grams of the sample were placed into a round-bottom flask, and add 25mls of concentrated sulphuric acid, 0.5g of copper sulphate, and 5g of sodium sulphate were added. The samples were then heated using a heating mantle in a fume cupboard, slowly at first to prevent undue frothing; continue to digest for 45 min until the sample becomes clear pale green. The samples were allowed to cool and 100mls of distilled water. Distillation was done against 10 mL of the boiled digest using 10 mL of sodium hydroxide and 50 mL of 2% boric acid containing screened methyl red indicator. The alkaline ammonium borate formed is titrated directly with 0.1N HCl. The titre value, which is the volume of acid used, is recorded. The volume of acid used is fitted into the formula, which becomes

$$\%N = \frac{14 \times VA \times 0.1 \times w \times 100}{1000 \times 100}$$

VA = volume of acid used

w= weight of sample

Statistical Analysis

Results were expressed as mean $\pm$ standard error in triplicate. Data obtained were subjected to analysis of variance (ANOVA), and differences between means were separated using Duncan's Multiple Range (DMR) Test at $p < 0.05$ (Alika, 2006).

RESULTS

The physical characteristics of compost samples of *Calopogonium mucunoides* and *Chromolaena odorata* are presented in Table 1.

Table 1: Physical characteristics of compost samples of *Calopogonium mucunoides* and *Chromolaena odorata*

Parameters	<i>Calopogonium mucunoides</i>	<i>Chromolaena odorata</i>
Moisture content (%)	40.22 $\pm$ 0.62	36.11 $\pm$ 0.50
Bulk density (kg/m ³)	340.19 $\pm$ 0.71	320.02 $\pm$ 0.43
Water holding capacity (g water/g water sample)	3.72 $\pm$ 0.60	3.46 $\pm$ 0.51
Porosity (%)	78.60 $\pm$ 0.63	76.33 $\pm$ 0.55

Values are presented as Mean $\pm$ Standard error from three replicates.

The physical characteristics of the compost samples showed that *Calopogonium mucunoides* compost had higher moisture content (40.22%), bulk density (340.19 kg/m³), water holding capacity (3.72 g water/g sample) and porosity (78.60%) compared to *Chromolaena odorata* compost, which recorded moisture content of 36.11%, bulk density of 320.02 kg/m³, water holding capacity of 3.46 g water/g sample and porosity of 76.33%.

Table 2: Chemical characteristics of compost samples of *Calopogonium mucunoides* and *Chromolaena odorata*

Parameters	<i>Calopogonium mucunoides</i>	<i>Chromolaena odorata</i>
pH	5.60 $\pm$ 0.12	5.30 $\pm$ 0.15
EC (ds/m)	1.71 $\pm$ 0.30	1.47 $\pm$ 0.43
Nitrogen (%)	6.90 $\pm$ 0.21	1.85 $\pm$ 0.24
Phosphorus (%)	2.26 $\pm$ 0.80	1.08 $\pm$ 0.45
Organic carbon (%)	10.36 $\pm$ 0.56	8.27 $\pm$ 0.30
Organic matter (%)	20.71 $\pm$ 0.65	14.36 $\pm$ 0.23
C/N ratio	1.47 $\pm$ 0.22	4.53 $\pm$ 0.67
Potassium (%)	1.38 $\pm$ 0.76	2.04 $\pm$ 0.53
Calcium	3.35 $\pm$ 0.39	3.12 $\pm$ 0.54

Values are presented as Mean $\pm$ Standard error from three replicate

The Chemical characteristics of compost samples of *Calopogonium mucunoides* and *Chromolaena odorata* are presented in Table 2. The chemical properties of the composts showed that *Calopogonium mucunoides* compost had higher values for pH (5.60), electrical conductivity (1.71

dS/m), nitrogen (6.90%), phosphorus (2.26%), organic carbon (10.36%), organic matter (20.71%), and calcium (3.35%) compared to *Chromolaena odorata*, while *Chromolaena odorata* compost recorded higher potassium (2.04%) and C/N ratio (4.53).

DISCUSSION

The findings of this study showed that composts produced from *Calopogonium mucunoides* and *Chromolaena odorata* both possessed essential physico-chemical properties, indicating their suitability as organic amendments for sustainable agricultural production. However, *Calopogonium mucunoides* compost exhibited superior performance in most of the parameters assessed, indicating a greater potential for improving soil fertility and supporting sustainable agricultural productivity. The higher moisture content (40.22 ± 0.62) observed in *Calopogonium mucunoides* compost indicates greater microbial decomposition efficiency and improved compost maturity, which aligns with the findings of Musa and Ibrahim (2023) that composts with adequate moisture content supported enhanced microbial breakdown and nutrient release. The higher water-holding capacity observed in this study suggests that it can improve soil moisture availability and reduce drought stress in crops. Similarly, Ojo *et al.* (2023) reported that organic amendments with high water holding capacity improve soil water retention and enhance plant growth under tropical conditions. This study reported a slightly lower bulk density, which can affect soil aeration and root penetration.

According to the United States Composting Council (2001), the acceptable bulk density for mature compost ranges from 400-600 kg/m³. Similarly, Sanchez-Monedero *et al.* (2018) reported that the moderate bulk density considered acceptable for mature plant compost also ranges from 400-600 kg/m³, which promotes adequate aeration and water retention for plant growth. Accordingly, Okeke *et al.* (2024) reported that composts with moderate bulk density improve soil structure and promote root development without causing soil compaction. This characteristic is particularly beneficial in Bayelsa State, where soils are often poorly structured due to high rainfall and nutrient leaching. The high porosity values recorded in both composts indicate good aeration potential, but the slightly higher porosity (78.60 ± 0.63) of *Calopogonium mucunoides* suggests better capacity for improving soil aeration and microbial activity.

The slightly acidic pH values obtained from both composts fall within the acceptable limits for organic soil amendments. The application of organic compost helps buffer soil pH and improves nutrient availability for crop uptake (Ikechukwu & Friday, 2023). *Calopogonium mucunoides* compost recorded a slightly higher pH, suggesting greater buffering potential when applied to acidic soils. Correspondingly, Ahmed *et al.* (2025) reported that composts with near-neutral to slightly acidic pH improve nutrient solubility and enhance microbial activity in tropical soils. The EC values observed suggest moderate nutrient concentrations that are unlikely to cause salinity problems. Adeleye *et al.* (2023) reported that composts with moderate electrical conductivity improve nutrient supply while maintaining favorable soil conditions for crop growth. Nitrogen was significantly higher in *Calopogonium mucunoides* compost (6.90%) than in *Chromolaena odorata* compost (1.85%), which is attributable to the leguminous nature of *Calopogonium mucunoides* as a nitrogen-fixing species. It accumulates more nitrogen in its tissues, resulting in nitrogen-rich compost. Nwankwo *et al.* (2023) observed that composts derived from leguminous biomass contained higher nitrogen levels than those from non-leguminous sources.

Nitrogen is a key nutrient for vegetative growth. Hence, the high nitrogen content of *Calopogonium mucunoides* compost makes it particularly valuable for soil fertility improvement. Phosphorus is germane to root development and energy transfer in plants. The higher phosphorus content obtained in this study may better support root establishment and crop development. This aligns with the work of Adebayo *et al.* (2024), who reported improved phosphorus availability in composts derived from nutrient-rich plant biomass. Organic matter contributes to soil aggregation, water retention, and cation exchange capacity, all of which are essential for sustainable soil productivity (Bassey *et al.*, 2026). The lower carbon-to-nitrogen ratio (1.47) recorded in *Calopogonium mucunoides* compost indicates faster decomposition and quicker nutrient release, whereas the higher ratio in *Chromolaena odorata* compost suggests slower nutrient mineralization (Ibrahim *et al.*, 2025). The higher potassium content (2.04 ± 0.53) obtained from *Chromolaena odorata* is beneficial for water regulation and stress tolerance. Therefore, the findings of this study support the growing body of

evidence that locally available plant biomass can be converted into high-quality compost to enhance soil productivity, reduce dependence on synthetic fertilizers, and promote sustainable agricultural systems (Yusuf *et al.*, 2024; Bassey *et al.*, 2026).

CONCLUSION

This study revealed that composts produced from *Calopogonium mucunoides* and *Chromolaena odorata* possess invaluable physicochemical properties that can support sustainable agricultural production in Bayelsa State. Arguably, both composts showed adequate moisture content, porosity, nutrient composition, and slightly acidic pH levels that are suitable for improving soil fertility in tropical soils. The use of these locally available plant materials for compost production provides an environmentally friendly and cost-effective strategy for nutrient recycling, waste reduction and sustainable soil management. This study therefore highlights the importance of utilizing indigenous biomass resources as sustainable organic amendments for soil fertility management in the study area.

Recommendations

Based on the findings of this study, the following recommendations are proposed:

- i. Adoption of *Calopogonium mucunoides* Compost for Soil Fertility Improvement.
- ii. Utilization of Locally Available Biomass for Compost Production.
- iii. Integration of Organic Compost into Sustainable Farming Systems.
- iv. Extension Services and Farmer Education.
- v. Government Support for Organic Fertilizer Promotion.
- vi. Further Field Trials on Crop Performance.
- vii. Investigation of Combined Compost Formulations.
- viii. Long-Term Soil Fertility Monitoring.

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