



Nutrient Characterization of Selected Plant Leaves and Their Suitability as Organic Nutrient Sources in Tropical Agricultural Soils

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ABSTRACT

Soil fertility decline in the humid tropics of sub-Saharan Africa is a challenge that continues to constrain smallholder crop production, yet the nutrient value locked within plant biomass available on-farm remains largely underutilised. This study examined the physicochemical properties and macronutrient concentrations of leaves collected from five plant species—*Chromolaena odorata*, *Carica papaya*, *Azadirachta indica*, *Psidium guajava*, and *Manihot esculenta*—all sourced within the University of Uyo Permanent Site. Samples were analysed for pH, electrical conductivity, total nitrogen, total phosphorus, potassium, sodium, calcium, and magnesium following standard laboratory procedures, and data were subjected to analysis of variance.

The results revealed statistically significant differences among species for every parameter measured. Total nitrogen ranged from 2.65% in neem to 6.43% in cassava—a range wide enough to have practical implications for green manure selection. Phosphorus variation, while narrower (0.0320–0.0356%), followed a similar trend favouring cassava. Potassium concentrations diverged most sharply: guava leaves reached 3.97% against *Chromolaena*'s 0.015%, underscoring the species-specific nature of nutrient accumulation. *Chromolaena* carried the highest calcium (0.080%), while neem stood apart in magnesium (0.650%), nearly ten times the guava value. Leaf pH ranged from slightly acidic (6.27 in *Chromolaena*) to near-neutral (7.38 in pawpaw), with electrical conductivity spanning 1.00 to 1.92 dS m⁻¹.

These findings confirm that the five species, though commonly treated as agricultural waste or weeds, represent a differentiated portfolio of organic nutrient resources. No single species excels across all parameters; rather, each occupies a distinct nutritional niche. This complementarity suggests that strategic multi-species combinations could approximate a balanced fertiliser blend at minimal cost. The practical implications for resource-limited farmers in southern Nigeria and comparable humid-tropical environments are considerable.

Keywords: organic amendments, soil fertility, nutrient recycling, green manure, tropical agriculture, plant leaf biomass, integrated soil fertility management

INTRODUCTION

Among the many constraints that limit food production across sub-Saharan Africa, soil fertility depletion stands as one of the most persistent and economically significant. In southeastern Nigeria—where the soils are predominantly Ultisols and Alfisols of moderate natural fertility—decades of continuous cultivation without adequate nutrient replenishment have progressively exhausted native soil organic matter and nutrient reserves. The situation is particularly acute for smallholder farmers, who till the vast majority of cultivated land but often cannot afford the quantities of inorganic fertiliser needed to sustain productive crop growth (Lal, 2020; Vanlauwe et al., 2023). With fertiliser prices continuing to rise in response to global supply chain disruptions, the search for locally derived, cost-effective nutrient inputs has taken on renewed urgency.

Organic amendments offer a well-established pathway for rebuilding soil fertility, but their effectiveness is not uniform. The nutrient contribution of any plant material depends on its species-specific chemistry—particularly its concentrations of nitrogen, phosphorus, potassium, calcium, and magnesium—as well as the physical state of the tissue and the environmental conditions that govern decomposition (Palm et al., 2020; Brady and Weil, 2017). These variables

interact in ways that make blanket recommendations for organic nutrient management unreliable. Site-specific data, gathered under local agroecological conditions, are far more informative for guiding farmer decisions than generalisations drawn from studies conducted elsewhere.

The University of Uyo campus and its surrounding landscape support an abundance of plant species that produce substantial leaf biomass annually, most of which is currently discarded. Among these, five species warrant particular attention. *Chromolaena odorata*, known locally as Awolowo, is a prolific invader that dominates field fallows and roadsides across the humid tropics; its biomass is occasionally slashed and incorporated into soil, though the practice remains informal and poorly quantified (Ojeniyi et al., 2012). *Azadirachta indica*, or neem, is widely planted as a shade and amenity tree and has attracted interest for its pesticidal leaf compounds, but its mineral nutrient profile in this environment has received limited systematic attention. *Manihot esculenta* (cassava), *Carica papaya* (pawpaw), and *Psidium guajava* (guava) are familiar food crops whose leaves are routinely stripped and composted or left to decompose; yet the nutrient value of this material has not been rigorously quantified under the climatic conditions of Akwa Ibom State.

Understanding the nutrient composition of these species is not merely an academic exercise. Nitrogen concentration determines the C:N ratio of a residue and, by extension, whether decomposition will proceed rapidly enough to release nutrients in synchrony with crop demand. Phosphorus availability in highly weathered tropical soils is frequently limiting, and even modest contributions from organic residues can be agronomically significant given the strong P fixation capacity of iron- and aluminium-rich substrates (Sanchez, 2021; Gil-Martínez et al., 2025). Potassium, which is not structurally bound in organic molecules, is released quickly during decomposition and can substitute meaningfully for muriate of potash in potassium-hungry cropping systems. Calcium and magnesium, often overlooked in short-term fertility assessments, influence soil structural stability and a wide range of plant physiological processes (Marschner, 2012; Havlin et al., 2021).

Against this background, the present study was undertaken to characterise the physicochemical and macronutrient properties of leaves from the five selected species under the humid tropical conditions of Uyo, Akwa Ibom State, and to evaluate their comparative suitability as organic nutrient sources for tropical agricultural soils. By generating locally relevant, species-resolved nutrient data, the study aims to provide a practical reference for farmers, extension workers, and soil scientists working on integrated soil fertility management in comparable agroecological zones.

MATERIALS AND METHODS

Description of the Study Area

This study was carried out at the Soil Science Laboratory, Department of Soil Science, Faculty of Agriculture, University of Uyo, located on the university's Permanent Site along Nwaniba Road, Uyo, Akwa Ibom State (approximately 5°02,23" N, 7°58,42" E). The site lies within the humid tropical rainforest zone of southern Nigeria. Annual rainfall typically ranges from 2,000 to 3,000 mm, distributed across a long wet season (March–November) with a brief drier period during July and August. Mean annual temperature approximates 27°C, and relative humidity remains above 75% for most of the year. These climatic conditions sustain dense, multi-stratum vegetation and favour rapid organic matter turnover—a factor of considerable relevance to the expected behaviour of the leaf materials examined in this study.

Collection of Plant Samples

Mature, fully expanded leaves of *Chromolaena odorata* (Awolowo), *Carica papaya* (Pawpaw), *Azadirachta indica* (Dogonyaro/Neem), *Psidium guajava* (Guava), and *Manihot esculenta* (Cassava) were collected from multiple plants distributed across the University of Uyo Permanent Site in January 2024, during the dry season when leaf tissue had attained maximum maturity. Only leaves showing no visible signs of disease, insect damage, or senescence were selected, so as to obtain tissue representative of physiologically active canopy leaves rather than senescing material. Samples from each species were bulked, placed in labelled polyethylene bags, and transported to the laboratory within two hours of collection.

Sample Preparation

On arrival at the laboratory, leaf samples were washed thoroughly under running tap water and rinsed twice with distilled water to remove surface dust and epiphytic material. The washed samples were spread on clean absorbent

paper and allowed to air-dry under laboratory conditions (approximately 28°C) for 72 hours, turning periodically to ensure even drying, until constant weight was achieved. Dried samples were ground using a Christy and Norris laboratory grinder and sieved to pass through a 2 mm screen. Ground material was stored in labelled airtight glass containers at room temperature until analysis, which commenced within 48 hours of sample preparation.

Determination of pH

The pH of each leaf sample was determined by preparing a 1:10 (w/v) suspension of ground material in distilled water. After thorough stirring, suspensions were allowed to equilibrate for 30 minutes before measurement with a pre-calibrated digital pH meter (calibration at pH 4.0 and 7.0 using standard buffer solutions). Three replicate readings were recorded per sample. The pH of plant materials is relevant to organic nutrient management because it influences the rate and direction of chemical transformations during decomposition and may affect soil reaction following incorporation (AOAC, 2019).

Determination of Electrical Conductivity (EC)

Electrical conductivity was measured in the same 1:10 (w/v) aqueous suspension used for pH determination, employing a calibrated digital conductivity meter. Values were expressed in dS m^{-1} . Electrical conductivity serves as a proxy for the total dissolved ion load in the extract and provides an indirect index of readily soluble nutrient content (AOAC, 2019). Higher conductivity values generally reflect greater concentrations of soluble mineral nutrients available for rapid release upon soil incorporation.

Determination of Total Nitrogen (TN)

Total nitrogen was determined by the macro-Kjeldahl method as described by Bremner (1996). A one-gram sub-sample of ground leaf material was digested with 10 mL of concentrated sulphuric acid in the presence of a selenium-based catalyst mixture. After digestion, the digest was steam-distilled, and the liberated ammonia was trapped in a 4% boric acid solution containing mixed indicator. Trapped ammonia was titrated against 0.1 M standard hydrochloric acid to determine nitrogen concentration, which was expressed as a percentage of oven-dry sample weight.

Determination of Total Phosphorus (TP)

Total phosphorus was determined following nitric-perchloric acid wet digestion. Phosphorus in the resulting digest was quantified colorimetrically using the molybdenum blue method of Murphy and Riley (1962). Absorbance was read at 882 nm on a UV-visible spectrophotometer, and phosphorus concentrations were computed from a standard calibration curve constructed with potassium dihydrogen phosphate solutions. Results were expressed as a percentage of dry-weight material.

Determination of Potassium (K) and Sodium (Na)

Following wet acid digestion, potassium and sodium concentrations in the digests were determined by flame photometry (Model 410 Corning flame photometer), using standard solutions of each element for instrument calibration. Concentrations were read directly from calibration curves and expressed as percentages of dry material (AOAC, 2016; Jackson, 2005).

Determination of Calcium (Ca) and Magnesium (Mg)

Calcium and magnesium were determined by atomic absorption spectrophotometry (AAS) following wet acid digestion. Matrix-matched calibration standards were prepared in 1% nitric acid, and lanthanum chloride was added to suppress interferences. Concentrations were expressed as percentages of dry sample weight (AOAC, 2019).

Experimental Design and Statistical Analysis

The experiment was arranged in a Completely Randomised Design (CRD) with five plant species as treatments and three replications per treatment. Data were subjected to one-way analysis of variance (ANOVA) using SPSS version 25.0. Where ANOVA revealed significant treatment effects ($P < 0.05$), treatment means were separated using Fisher's Least

Significant Difference (LSD) test. Descriptive statistics—including means, standard deviations, and coefficients of variation—were computed for each parameter. Statistical significance was accepted at the 5% probability level throughout.

RESULTS AND DISCUSSION

Overview of Physicochemical Properties and Nutrient Composition

The physicochemical properties and macronutrient concentrations of the five plant species are presented in Table 1. Analysis of variance revealed significant differences among species for all measured parameters ($P < 0.05$), indicating that species identity is a primary driver of nutrient accumulation in these plant materials. This result aligns with the well-established principle that nutrient uptake efficiency, root architecture, metabolic demand, and phenological stage vary substantially between plant taxa, leading to species-specific foliar nutrient profiles (Palm et al., 2020; Brady and Weil, 2017).

What is perhaps most striking about the dataset as a whole is the magnitude of the inter-species variation. Whereas pH and sodium showed relatively narrow ranges, potassium and magnesium varied by factors of approximately 265 and 12, respectively. This suggests that species selection—rather than application rate alone—will be the critical decision variable when using these materials as targeted nutrient supplements.

Table 1. Physicochemical Properties and Nutrient Composition of Selected Plant Leaves

Species	pH	EC (dS m ⁻¹)	TN (%)	TP (%)	K (%)	Na (%)	Ca (%)	Mg (%)
<i>Chromolaena odorata</i>	6.27	1.00	4.50±0.08c	0.0325±0.00 04bc	0.015±0.0 01e	1.085±0.0 15cd	0.080±0. 002a	0.070±0. 002d
<i>Carica papaya</i>	7.38	1.00	3.00±0.05d	0.0320±0.00 02c	2.50±0.05 c	1.095±0.0 06bc	0.050±0. 001e	0.090±0. 002c
<i>Azadirachta indica</i>	7.12	1.92	2.65±0.04e	0.0350±0.00 02a	1.25±0.03 d	1.105±0.0 06ab	0.075±0. 002b	0.650±0. 010a
<i>Psidium guajava</i>	6.86	1.00	5.00±0.08b	0.0333±0.00 02b	3.97±0.06 a	1.075±0.0 06d	0.060±0. 002d	0.055±0. 002e
<i>Manihot esculenta</i>	7.06	1.90	6.43±0.07a	0.0356±0.00 03a	3.32±0.06 b	1.115±0.0 06a	0.065±0. 002c	0.105±0. 003b

Means followed by the same letter within a column are not significantly different at $P \leq 0.05$ (Fisher's LSD). Values represent mean ± standard deviation.

Soil Reaction (pH)

Leaf pH values ranged from 6.27 in *Chromolaena odorata* to 7.38 in *Carica papaya*, placing all five species within the slightly acidic to near-neutral range. This observation is agronomically favourable: residues with pH values in this range are unlikely to introduce appreciable acidity into the receiving soil, and the near-neutral conditions should support active microbial communities responsible for decomposition. Research by Rousk et al. (2009) demonstrated that soil bacterial diversity and activity peak in the pH range 6.0–7.0, with measurable suppression of key decomposer populations below pH 5.5. The pH values recorded here therefore suggest that incorporation of any of the evaluated

species should initiate rapid microbial colonisation and residue breakdown under the warm, moist conditions of Akwa Ibom State.

The relatively higher pH in pawpaw and neem leaves compared to chromolaena deserves comment. *Carica papaya*, a fast-growing fruit tree with high water-use efficiency, is known to draw strongly on soil calcium and bicarbonate pools, which may buffer foliar pH upward (Havlin et al., 2021). The implication for soil management is that pawpaw leaves, though not exceptional in any single nutrient, represent an amendment unlikely to cause temporary pH depression during the active decomposition phase—a consideration of practical importance on marginally acid soils where temporary acidification could affect crop germination or early growth.

Electrical Conductivity (EC)

Electrical conductivity values showed a bimodal distribution: *Azadirachta indica* and *Manihot esculenta* recorded notably higher values (1.92 and 1.90 dS m⁻¹, respectively) compared to

Chromolaena odorata, *Carica papaya*, and *Psidium guajava*, all of which measured 1.00 dS m⁻¹. This pattern is consistent with the higher potassium, sodium, and total nitrogen concentrations observed in neem and cassava leaves, since dissolved ions of these elements are the principal contributors to electrical conductivity in plant tissue extracts (Barker and Pilbeam, 2015).

In practical terms, the elevated EC of neem and cassava leaf extracts indicates a greater concentration of readily soluble nutrients that could be released rapidly into the soil solution following decomposition—a characteristic sometimes described as 'nutrient pulse' capacity (Agegnehu et al., 2016; Adekiya et al., 2021). While such rapid release can be advantageous in synchronising nutrient supply with crop demand during the vegetative growth phase, it also increases the risk of short-term leaching in highly permeable sandy soils of the type common across parts of Akwa Ibom State. This trade-off should inform decisions about application timing, particularly whether to incorporate these materials at sowing or as a split application.

Total Nitrogen (TN)

Total nitrogen concentrations exhibited the widest proportional variation of all macronutrients measured, ranging from 2.65% in *Azadirachta indica* to 6.43% in *Manihot esculenta*. Cassava leaves stood apart not only from neem but from all other species, with a nitrogen concentration that exceeded the threshold of 2.5% generally cited as the minimum for net nitrogen mineralisation rather than immobilisation following residue incorporation (Palm et al., 2020; Brady and Weil, 2017). Guava and chromolaena also exceeded this threshold, with concentrations of 5.00% and 4.50%, respectively.

The exceptionally high nitrogen content of cassava leaves is a recurring finding in the literature (Howeler, 2014; Adekayode and Ogunkoya, 2011) and appears to reflect the vigorous vegetative growth and high metabolic nitrogen demand of the species during the rainy season. Cassava's high foliar nitrogen concentration is partly attributable to the large pool of amino acids and proteins associated with active photosynthetic tissue in the upper canopy. Given that the leaves in the present study were collected from mature plants during their active growing phase, it is likely that these concentrations represent near-peak foliar nitrogen values for the species.

From an application perspective, the nitrogen data suggest that cassava leaf meal, if produced in sufficient quantity, could rival or exceed the nitrogen content of standard compost (typically 1.5–3.0% N) and might approach that of blood meal or poultry manure in terms of N concentration (Havlin et al., 2021). Even chromolaena and guava, at 4.50% and 5.00% N respectively, compare favourably with many legume green manures reported from West Africa. Neem (2.65% N) and pawpaw (3.00% N), while below the other three species, still exceed the mineralisation threshold and therefore represent net nitrogen contributors rather than nitrogen sinks when incorporated.

Total Phosphorus (TP)

Phosphorus concentrations across the five species were considerably lower than nitrogen values in both absolute and proportional terms, which is consistent with the generally lower phosphorus requirement and tissue phosphorus

content of non-leguminous plants. Values ranged from 0.0320% in pawpaw to 0.0356% in cassava—a statistically significant but agronomically narrow range.

Nevertheless, the phosphorus contribution of these materials should not be dismissed. In highly weathered Ultisols and Oxisols of southern Nigeria, where phosphorus fixation by iron and aluminium oxides severely limits inorganic P availability, even modest additions of organic phosphorus can improve crop P nutrition through two mechanisms: direct mineralisation of organic P compounds and indirect suppression of mineral P fixation by organic acids released during decomposition (Richardson and Simpson, 2011; Gil-Martínez et al., 2025). Furthermore, when organic materials with elevated phosphorus content are co-applied with small amounts of single superphosphate, synergistic effects on P availability have been documented in comparable tropical soils (Nziguheba et al., 2002).

The similar phosphorus concentrations across species indicate that phosphorus cycling capacity is more uniform among the evaluated species than nitrogen or potassium. This may reflect a common physiological constraint on maximum foliar P concentration regardless of species, or may indicate that soils at the collection site were similarly phosphorus-limited for all species. A more definitive interpretation would require concurrent measurement of soil phosphorus and rhizosphere chemistry, which could form the basis of a future investigation.

Potassium (K)

Potassium data revealed the most dramatic inter-species contrast of the study. *Psidium guajava* recorded the highest concentration at 3.97%, followed by cassava (3.32%) and pawpaw (2.50%), while neem reached only 1.25% and *chromolaena* a remarkably low 0.015%—nearly three orders of magnitude below guava. This pattern is counterintuitive given *chromolaena*'s reputation as a fertility-restoring fallow species, and warrants careful interpretation.

Potassium in plants is predominantly found in ionic form in the vacuole and cytosol, rather than in covalently bonded organic molecules, which means it is released from residues very rapidly upon decomposition—often within the first few weeks following incorporation (Brady and Weil, 2017). This makes high-K residues particularly valuable in potassium-deficient soils because the nutrient becomes plant-available quickly. The guava leaf's potassium concentration of 3.97% is notably high relative to values reported for common green manures in West Africa, which generally range from 1.0 to 2.5% (Palm et al., 2020), suggesting that guava leaf biomass is an unusually potassium-rich organic resource that has been significantly underutilised in local farming systems.

The very low potassium in *chromolaena* leaves (0.015%) was unexpected and may reflect either a constitutive limitation in potassium uptake by this species or, more likely, the particular growth stage and soil conditions at the collection site. Previous studies from southwestern Nigeria reported *chromolaena* potassium concentrations in the range of 0.6–1.5% (Ojeniyi et al., 2012), considerably higher than the values recorded here. This discrepancy should be investigated in future work, as it has practical implications for the fertiliser-replacement value attributed to *chromolaena*-based green manure systems in Akwa Ibom State.

Sodium (Na)

Sodium concentrations varied from 1.075% in guava to 1.115% in cassava. While these differences were statistically significant, their agronomic interpretation requires caution. Sodium is generally not considered an essential macronutrient for most crops, though it can substitute functionally for potassium in some physiological processes at low concentrations (Marschner, 2012). The relatively narrow range recorded here—less than 4% variation between the highest and lowest values—indicates that sodium accumulation is broadly similar across the five species and is unlikely to constitute a meaningful basis for species selection in organic amendment programmes.

From a soil management perspective, the sodium concentrations observed, when considered against realistic application rates, are not expected to induce ionic stress or sodicity in well-drained tropical soils. Concerns about sodium accumulation from plant residues are generally confined to situations involving repeated high-rate application on poorly drained, high-clay soils where sodium can displace calcium on exchange sites and impair aggregate stability. Such conditions are not representative of the cultivated landscapes around Uyo.

Calcium (Ca)

Calcium concentrations ranged from 0.050% in pawpaw to 0.080% in *Chromolaena odorata*, with significant differences observed among all species. The ranking—chromolaena > neem > cassava > guava > pawpaw—highlights chromolaena's distinctiveness relative to its low potassium content. Calcium in plant residues serves both as a direct nutrient source and as a soil chemical conditioner: it contributes to aggregate stabilisation, reduces aluminium toxicity in acidic soils, and supports the integrity of root cell walls (Brady and Weil, 2017; Sposito, 2021).

In the context of Akwa Ibom State, where some soils exhibit mild to moderate acidity that can limit calcium availability, the relatively higher calcium concentration in chromolaena leaves offers an additional dimension to their fertility-restoring value that extends beyond nitrogen supply. This may partly explain the observed improvement in soil physical properties and crop performance reported by Ojeniyi et al. (2012) following chromolaena green manuring, though attribution of those effects to calcium rather than nitrogen or organic matter requires further experimental disentanglement.

Magnesium (Mg)

The magnesium data were dominated by one notably exceptional value: *Azadirachta indica* leaves contained 0.650% Mg—nearly six times the concentration recorded in the next highest species (cassava at 0.105%) and almost twelve times that of guava (0.055%). This level of magnesium accumulation in neem foliage has not, to the authors' knowledge, been widely documented in the West African literature and represents a potentially important finding.

Magnesium occupies the central position in every chlorophyll molecule and is essential for the activation of numerous phosphate-transferring enzymes, making it indispensable for photosynthesis and energy metabolism (Marschner, 2012). Magnesium deficiency is increasingly recognised as a widespread, if often undiagnosed, constraint on crop production in intensively cropped tropical soils where high rainfall leaches exchangeable Mg from the root zone (Tanoi and Kobayashi, 2015). The application of neem leaf biomass as a green manure or mulch could plausibly provide sufficient magnesium to correct mild deficiencies in such soils—a hypothesis that warrants testing under controlled field conditions. Until such experiments are conducted, the very high magnesium content of neem leaves stands as a compelling indicator of this species' untapped potential in organic nutrient management systems.

Implications for Sustainable Soil Fertility Management

Taken together, the nutrient data reveal a picture of remarkable species complementarity. Cassava leads in nitrogen and phosphorus; guava dominates in potassium; chromolaena contributes the most calcium; and neem is unmatched in magnesium. No single species provides the full complement of macronutrients at comparable levels—yet the ensemble of five species collectively covers the spectrum of major plant nutrient requirements. This pattern suggests that the most agronomically rational use of these materials would involve combining species in proportions that approximate the nutrient requirements of the target crop, rather than applying any single species uniformly.

For example, a maize–cassava rotation system in Akwa Ibom State might benefit from a pre-season incorporation of cassava leaf compost to address nitrogen demand, supplemented with guava leaf mulch to sustain potassium levels through the growing season, and a background application of neem leaves to build up exchangeable magnesium on magnesium-depleted soils. Such an approach represents a form of precision organic nutrient management that, while not yet common among smallholders, could be promoted through farmer field schools and extension programmes with relatively low entry barriers, since all five species are locally abundant.

The cost dimension also deserves explicit attention. At prevailing fertiliser prices in Nigeria, the commercial value of the nutrients contained in one tonne of fresh cassava leaf material (assuming 30% dry matter and the nutrient concentrations recorded here) is estimated to approximate ₦25,000–₦35,000 in nitrogen and phosphorus equivalents alone—a significant sum relative to the zero acquisition cost of on-farm leaf biomass. This calculation underscores the economic logic of organic nutrient recycling and may provide a persuasive message for farmer adoption.

Practical Implications For Sustainable Agriculture

The nutrient data generated by this study have a number of concrete implications for agronomic practice in southern Nigeria that extend beyond the immediate experimental context. First, the identification of cassava leaves as a nitrogen- and phosphorus-rich material supports their targeted use as green manure in food crop systems, particularly for nitrogen-hungry crops such as maize, leafy vegetables, and early-season yam. Given the ubiquity of cassava cultivation in Akwa Ibom State, the leaf biomass produced during routine canopy management represents a substantial, regularly renewable nutrient resource that is currently largely wasted.

Second, the high potassium content of guava leaves has practical relevance for root and tuber crop production—yam, cocoyam, sweet potato—which have relatively high potassium requirements and are grown extensively in the region. At a foliar potassium concentration of 3.97%, guava leaf mulch could provide a meaningful proportion of the potassium requirement of a yam crop if applied at rates consistent with biomass availability on mixed homestead farms where guava trees are commonly grown.

Third, chromolaena—already informally used as a short-cycle fallow species in parts of southern Nigeria—deserves more systematic integration into cropping calendars based on its calcium contribution and soil pH buffering capacity, even if its potassium content in this study was unexpectedly low. The widespread availability of chromolaena on field boundaries and fallow plots means that the transaction cost of collecting and incorporating its biomass is minimal, making it an accessible entry point for farmers beginning to transition toward organic nutrient management.

Fourth, the exceptional magnesium content of neem leaves opens a niche that has not previously been well articulated in the local agronomic literature. Where foliar chlorosis associated with magnesium deficiency has been observed but attributed to nitrogen limitation—a common diagnostic error—the targeted application of neem leaf material as a mulch could provide a low-cost intervention worth investigating through participatory farmer trials.

Finally, the study reinforces the broader principle that organic nutrient management in smallholder systems is most effective when it draws on a portfolio of locally available materials matched to specific soil and crop requirements, rather than relying on a single organic input applied uniformly. Extension programmes that help farmers understand the distinct nutrient profiles of familiar plant species, and that provide practical guidance on collection, preparation, and application rates, could significantly improve the uptake and effectiveness of organic amendment practices.

CONCLUSION

This study set out to characterise the physicochemical properties and macronutrient composition of leaves from five plant species commonly found within the University of Uyo environment, and to evaluate their comparative potential as organic nutrient sources for tropical agricultural soils. The results provide a clear and differentiated picture: all five species contain nutritionally meaningful concentrations of major plant nutrients, but each occupies a distinct niche in the organic nutrient management toolkit.

Manihot esculenta stands out as the superior source of nitrogen and phosphorus, making its leaf biomass particularly well-suited to systems where these nutrients are the primary limiting factors. *Psidium guajava*'s high potassium content positions it as a valuable amendment for potassium-deficient soils and potassium-demanding crops. *Chromolaena odorata*, while lower in potassium than expected, contributes the highest calcium concentration among the species tested, reinforcing its value in slightly acidic soils. *Azadirachta indica*'s extraordinary magnesium accumulation—at a concentration that far surpasses the other four species—emerges as the most novel finding of the study and warrants dedicated follow-up investigation to quantify its effect on soil magnesium availability under field conditions.

The generally near-neutral pH and moderate electrical conductivity values recorded across all species indicate that their incorporation into tropical soils is unlikely to have adverse short-term effects on soil reaction or ionic balance. Combined with their potential to supply multiple macronutrients simultaneously, these characteristics support the suitability of all five species as organic soil amendments in the humid tropical context of southern Nigeria.

What the data most compellingly argue for, however, is a shift from single-species to multi-species organic nutrient management strategies. The complementary nutrient profiles of the five species suggest that thoughtfully designed

combinations could collectively address a wider range of soil nutrient deficits than any individual species alone. Translating this principle into practical farmer guidance will require additional research on decomposition rates, C:N ratios, nutrient release kinetics, and crop yield responses under field conditions—work that this study is intended to help motivate and inform.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are offered for research, extension, and policy action:

1. Cassava leaf biomass should be actively promoted as a green manure and compost ingredient for smallholder cropping systems in Akwa Ibom State and comparable humid-tropical environments, given its high nitrogen and phosphorus concentrations and the large volumes already available on-farm. Extension services should develop simple protocols for leaf collection, drying, and incorporation that are compatible with existing farm labour patterns.
2. Guava leaf material, currently underutilised on homestead farms, should be targeted for use in root and tuber crop production where potassium demand is highest. Composting guava leaves with lower-K materials such as chromolaena could produce a more balanced amendment than either material alone.
3. The unexpectedly low potassium concentration recorded for chromolaena in this study should be replicated and investigated further, including assessment of the influence of soil type, sampling season, and plant age on foliar potassium concentration. Until this discrepancy with the published literature is resolved, potassium credits attributed to chromolaena-based green manure systems in this region should be applied cautiously.
4. The high magnesium content of neem leaves warrants targeted field experimentation to determine whether incorporation at practical application rates can correct magnesium deficiency and improve photosynthetic performance in magnesium-stressed crops. This work should include soil and plant tissue sampling before and after application to quantify magnesium transfer efficiency.
5. Future laboratory work should determine the C:N ratios, polyphenol and lignin contents, and in vitro decomposition rates of these five species, as these factors are critical determinants of nutrient release timing and therefore of the practical value of each material as a synchronised nutrient source.
6. Long-term field trials under farmers' conditions are needed to document the cumulative effects of repeated application of these plant residues on soil organic matter, nutrient availability, microbial biomass, and crop yield across multiple seasons and cropping systems.
7. Agricultural policy in Nigeria should recognise the economic value of on-farm leaf biomass as a nationally significant nutrient resource and should incorporate organic amendment promotion—supported by locally generated nutrient composition data such as those presented here—into national soil health and food security strategies.

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