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Effect of organic and inorganic fertilizer on *Telfaria occidentalis*Thompson Fortune Inioluwa 

Department of Plant Biology, Faculty of Life sciences, University of Ilorin, Ilorin, Kwara State, Nigeria

**ABSTRACT**

Telfairia occidentalis, commonly known as fluted pumpkin, is a highly nutritious and economically important vegetable widely cultivated in West Africa, especially Nigeria. Its leaves and seeds provide substantial dietary protein, vitamins, and minerals, making it vital for food and nutritional security in the region. As demand for this crop continues to grow due to population increases and urbanization, there is an urgent need to enhance its productivity through improved soil fertility management. This review explores current research on the effects of organic and inorganic fertilizers on the growth, yield, and quality of *T. occidentalis*, drawing on findings from recent field trials and empirical studies. Inorganic fertilizers such as urea and NPK are recognized for their ability to provide immediate nutrient availability, resulting in rapid vegetative growth and increased yields. However, their prolonged use raises concerns about adverse environmental impacts, such as soil acidification, nutrient leaching, and declines in soil organic matter and microbial populations. Conversely, organic fertilizers including poultry manure, compost, and biochar, demonstrate positive effects not only on plant performance but also on soil health by enhancing structure, increasing microbial activity, and ensuring a more gradual nutrient release. The integration of organic and inorganic fertilizers, known as integrated nutrient management (INM), has gained attention as an effective strategy for optimizing both crop output and long-term soil fertility. Evidence from multiple studies indicates that such integration can synergistically improve yield, nutrient uptake, and soil quality, thus supporting sustainable *T. occidentalis* cultivation. This review emphasizes the necessity for context-specific fertilizer practices that account for local soil properties, resource accessibility, and environmental sustainability. By understanding the differential impacts of various fertilizer regimes, stakeholders can make informed decisions to enhance *T. occidentalis* production, thereby contributing to regional food security. The paper concludes with recommendations for future research and policy to promote the adoption of integrated nutrient management in *T. occidentalis* farming systems.

Keywords: *Telfairia occidentalis*, Organic fertilizer, Inorganic fertilizer, Nutrient management, and Soil fertility.

1. Introduction

Telfairia occidentalis, commonly referred to as fluted pumpkin, is a highly valued vegetable in West African agriculture, renowned for its nutritional and economic significance. Rich in essential nutrients including proteins, vitamins, and minerals, *T. occidentalis* contributes substantially to food security and dietary diversity, especially in Nigeria and neighboring countries [1, 2] Its leaves and seeds are a staple in many local dishes and serve as a crucial source of income for smallholder farmers, particularly women, who dominate the production and marketing chains. As urbanization and population growth continue to increase the demand for leafy vegetables, the focus on enhancing the productivity and quality of *T. occidentalis* through improved agronomic practices has intensified [3]. Yet, such intensification is often hampered by declining soil fertility, a challenge that remains a major bottleneck for sustainable production and thus underscores the need for efficient nutrient management strategies [4].

The role of fertilizers, both organic and inorganic, in boosting the productivity of *T. occidentalis* cannot be overstated. Inorganic fertilizers such as urea and NPK formulations are

widely adopted because of their immediate nutrient availability and predictable effects on crop growth. Their application often translates to rapid vegetative development, increased leaf area, and enhanced biomass yield, which are critical for meeting the market demand for *T. occidentalis* [5]. For instance, [6] reported that the application of urea at rates of 40–80 kg/ha significantly increased vine length and leaf production, with 80 kg/ha performing comparably to 5 t/ha of poultry manure. Such findings highlight the potential of inorganic fertilizers to bridge nutrient gaps in soils depleted by continuous cultivation or inherently low fertility. However, reliance on inorganic inputs is not without drawbacks; overuse can result in several negative environmental outcomes, including soil acidification, nutrient leaching, and the eventual decline of soil organic matter and beneficial microbial activity [7, 8]. These issues have raised concerns regarding the long-term sustainability of sole inorganic fertilizer application, especially given the fragile nature of many West African soils.

In contrast, organic fertilizers such as poultry manure, compost, green manure, and biochar offer a more ecologically balanced approach to soil fertility management. These materials improve soil physical properties, enhance microbial biomass, and provide a slow and sustained release of nutrients that can support crop growth throughout the season [9]. Recent studies have shown that poultry manure significantly increased shoot weight, leaf nutrient content, and overall plant health in *T. occidentalis* compared to untreated controls [10].

*Corresponding Author: **Thompson Fortune Inioluwa**

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The organic matter content in these amendments also improves soil structure, water retention, and aeration, all of which are crucial for the optimal performance of shallow-rooted vegetables like fluted pumpkin. Furthermore, integrating organic materials such as biochar with poultry manure has been found to enhance nutrient availability and soil pH, leading to improved growth and yield [11]. The use of organic fertilizers also aligns with sustainable agricultural practices, as it recycles farm wastes, reduces dependence on chemical inputs, and helps mitigate environmental degradation.

Despite the benefits of each fertilizer type, neither organic nor inorganic sources are perfect when used in isolation. Organic fertilizers may be limited by their relatively low nutrient concentrations and slow nutrient release, while inorganic fertilizers, although efficient in the short term, can undermine soil health if indiscriminately applied. Consequently, integrated nutrient management (INM), the combined application of organic and inorganic fertilizers, has emerged as a promising strategy for maximizing yield while sustaining soil health [12]. INM seeks to leverage the strengths of both fertilizer types: the immediate and targeted nutrient supply from inorganic fertilizers and the soil conditioning and sustained fertility benefits of organic amendments.

Empirical evidence supports the effectiveness of integrated approaches. Field experiments in Abeokuta, Nigeria, have demonstrated that a combination of urea and organic inputs such as cow dung or poultry manure resulted in better plant morphology, higher biomass yield, and improved nutrient uptake compared to the use of either input alone [13]. Similar results were observed in North Central Nigeria, where the concurrent application of 40 kg/ha urea and 5 t/ha poultry manure led to optimal yield performance, suggesting synergistic effects that enhance both crop output and soil quality [14]. These findings imply that integrated nutrient management can help farmers achieve the dual goals of productivity and sustainability, ensuring that *T. occidentalis* remains a reliable source of nutrition and income in the face of evolving environmental and socio-economic pressures.

As demands for increased food production and sustainable practices intensify, understanding the nuanced effects of organic and inorganic fertilizers, as well as their integrated application, becomes increasingly important for stakeholders across the agricultural value chain. The ongoing research and field experiences offer a foundation for developing context-specific recommendations that can optimize *T. occidentalis* yield while safeguarding environmental health. This review, therefore, aims to provide a comprehensive synthesis of existing knowledge on the effects of organic and inorganic fertilizers on *T. occidentalis*, highlight the advantages and limitations of each approach, and explore prospects for integrated nutrient management in sustainable vegetable production systems.

2. Botanical and Agronomic Profile of *Telfairia occidentalis*

2.1 Botanical Description and Classification of *Telfairia occidentalis*

Telfairia occidentalis, commonly called fluted pumpkin, is a highly regarded indigenous vegetable crop in West Africa, especially in Nigeria, where it plays a vital role in nutrition and local economies. Botanically, *T. occidentalis* is categorized under the family Cucurbitaceae, which is known for its climbing or trailing plants and fleshy fruits. Its taxonomic hierarchy is as follows: Kingdom Plantae, Order Cucurbitales, Family Cucurbitaceae, Genus *Telfairia*, and Species *T. occidentalis* [15].

Among the *Telfairia* genus, *T. occidentalis* is the most widely cultivated, serving as an essential food and income source for millions of smallholder farmers across Nigeria, Ghana, and Cameroon.

Morphologically, *T. occidentalis* presents as a vigorous, perennial vine, with stems that can reach up to 10 meters or more. The plant is equipped with angular, succulent stems that become more fibrous as they age, and specialized tendrils that enable it to climb structures or spread across the ground [16]. Its leaves are alternate, palmately compound, and usually consist of three to five oblong or ovate leaflets with a glossy, dark green upper surface. These leaves, highly sought after for their protein, vitamin, and mineral content, are the primary edible component and are regularly used in traditional dishes [17].

A key distinguishing feature of *T. occidentalis* is its dioecious nature, meaning individual plants produce either male or female flowers, but not both. Male flowers are more numerous and are found in elongated racemes, while female flowers are typically solitary or found in small clusters. The pale yellow to creamy white flowers are showy and primarily pollinated by insects, a critical process for fruit set and seed production [18]. The fruit itself is a large, ribbed, indehiscent gourd that can weigh up to 20 kilograms and house numerous large, flat, brown seeds. These seeds are both an important propagation material and a nutritional resource, valued for their high protein and oil content [19].



Figure 1. *Telfairia occidentalis*
Source: www.google.com

Ecologically, *T. occidentalis* thrives in tropical climates with well-distributed rainfall and fertile, well-drained soils, performing best in loamy soils with a neutral to slightly acidic pH. While seed propagation is common, stem cuttings are also used to maintain desirable traits. Its growth and reproductive cycles are influenced by factors like photoperiod and temperature [20]. Beyond its botanical and agronomic attributes, *T. occidentalis* is central to food security and health, being used in both diets and traditional medicine for its rich micronutrient content. Thus, a thorough understanding of its botanical features and classification is fundamental for developing improved cultivation methods and maximizing its contributions to sustainable agriculture in West Africa.

2.2 Growth Requirements of *Telfairia occidentalis*

Telfairia occidentalis, commonly known as fluted pumpkin, is a key indigenous vegetable crop in West Africa, widely celebrated for its nutritional, economic, and medicinal value.

Its successful cultivation is strongly governed by suitable environmental conditions, proper soil management, and well-timed agronomic practices, all of which directly influence its growth pattern, physiology, and yield. Understanding its growth requirements and phenological stages is crucial for farmers, researchers, and policymakers aiming to maximize its production and sustainability [21, 22].

(a) Climate and Temperature

T. occidentalis thrives in the humid tropics, where temperature and humidity play pivotal roles in shaping its developmental trajectory. Optimal growth is attained at mean daily temperatures of 25°C to 32°C. Temperatures below 15°C or above 35°C are detrimental: cool weather delays germination and initial growth, whereas excessive heat can cause heat stress, leading to wilting, flower abortion, and poor seed set [23, 24, 25]. The crop is highly sensitive to frost and does not survive in areas with frequent cold spells or sudden temperature drops [26]. Relative humidity of 60–80% is considered ideal for robust vine and leaf development, as low humidity increases transpiration and water loss, stressing the plant [27, 28]. In addition, research suggests that high air humidity during the flowering period supports higher rates of pollination and fruit set [29, 30]. In summary, *T. occidentalis* is best cultivated in warm, humid regions, and microclimate management (e.g., mulching, windbreaks) is encouraged in marginal areas [31].

(b) Rainfall and Water Management

Rainfall is one of the most critical environmental determinants of *T. occidentalis* performance. The crop requires abundant, well-distributed rainfall, typically between 1,200 and 2,000 mm per annum [32, 33]. The growing season should provide consistent moisture to avoid physiological drought, especially during germination, vegetative expansion, and flowering [34, 35]. Prolonged dry spells or erratic rainfall compromise leaf yield and seed development, while waterlogging from excessive rainfall or poor drainage increases susceptibility to root rot and other soil-borne diseases [36, 37]. In regions with distinct dry seasons, supplemental irrigation is strongly recommended, particularly at the seedling and reproductive stages [38]. Drip or furrow irrigation systems are preferred due to their efficiency and reduced disease risk [39].

(c) Soil Requirements

Fluted pumpkin performs best in deep, well-drained loamy soils rich in organic matter. Soils with high water-holding capacity but good drainage prevent root stress and facilitate strong vine growth [40]. Soil pH ideally ranges from 5.5 to 7.0; acidic soils (pH < 5.0) limit the availability of essential nutrients and may increase the risk of aluminum toxicity [40]. Heavy clay soils are usually avoided, as they promote waterlogging and hinder root expansion [41]. Land preparation should involve thorough tillage, removal of perennial weeds, and the incorporation of organic matter to improve soil structure and microbial activity [42]. Cover cropping and crop rotation with legumes have been reported to enhance soil fertility and reduce the incidence of soil-borne diseases [43].

(d) Nutrient Management

T. occidentalis is a heavy feeder, demanding substantial quantities of macro- and micronutrients throughout its lifecycle. Organic fertilizers such as poultry manure, compost, and green manure are highly recommended for maintaining

long-term soil fertility and enhancing soil structure [25]. Applications of 10–20 tons/ha of well-rotted manure before planting significantly improve leaf and seed yields [26]. Inorganic fertilizers, especially NPK (15:15:15) at rates of 200–400 kg/ha, provide immediate nutrient supply and support rapid vegetative growth, particularly during the early stages [27]. However, balanced application is essential to minimize nutrient leaching, salt accumulation, and environmental pollution [28]. Integrated nutrient management, combining organic and inorganic sources, has proven effective in boosting yield while sustaining soil health [29].

(e) Propagation and Planting Techniques

Propagation is predominantly by seeds, which are large, flat, and brown. Seed dormancy is commonly overcome by soaking seeds in water for 24–48 hours before sowing [30]. Direct sowing is standard; however, some farmers raise seedlings in nurseries and transplant them to the field for uniform stand establishment [31, 32]. Recommended planting distances are 1–2 meters between plants and 2–3 meters between rows, allowing adequate space for the sprawling vines and reducing competition for resources [33]. Vegetative propagation with stem cuttings is used for clonal multiplication of elite genotypes and for off-season planting in controlled environments [34].

2.3 Economic and Nutritional Importance

Telfairia occidentalis, commonly known as fluted pumpkin, stands out as one of the most valuable indigenous vegetables in West Africa, particularly in Nigeria, Ghana, and Cameroon. Its economic and nutritional significance has been widely acknowledged in both rural and urban contexts due to its role in diet diversification, livelihood sustenance, and health promotion [35].

2.3.1 Nutritional Importance of *Telfairia occidentalis*

The leaves and seeds of *T. occidentalis* are exceptionally rich in essential nutrients, making them a cornerstone of food security and nutrition in many African households. The leaves contain high levels of protein (20–30% dry weight), vitamins A, C, and E, and important minerals such as iron, calcium, potassium, and magnesium [36]. These attributes make the vegetable a vital dietary component, especially in communities where animal protein is scarce or expensive. Fluted pumpkin's iron content is especially noteworthy, as it plays a significant role in preventing anemia, a common health challenge among women and children in sub-Saharan Africa [37].

Additionally, *T. occidentalis* leaves provide considerable amounts of antioxidants, which help protect against oxidative stress and related chronic diseases [38]. The seeds, often consumed roasted or ground into soups and stews, are rich in oil (30–53%), protein (25–35%), and beneficial fatty acids, such as linoleic and oleic acids [11]. They also contain amino acids, vitamins, and minerals, making them a nutritious supplement or substitute for animal-based foods. The presence of bioactive compounds, such as saponins and flavonoids, further enhances the plant's medicinal potential, supporting immune function and reducing inflammation [12].

2.3.2 Economic Importance of *Telfairia occidentalis*

Economically, *T. occidentalis* is a significant source of income for millions of smallholder farmers, especially women, who dominate its production and marketing [13, 14].

Its rapid growth, high yield potential, and year-round production capability contribute to continuous cash flow, which is vital for household welfare and rural development [12, 13, 14]. The crop's market demand spans both local and regional markets, with fresh leaves, seeds, and oil fetching premium prices, particularly during the dry season when vegetable scarcity is high [15].

Furthermore, the cultivation and trade of *T. occidentalis* have created extensive value chains that encompass seed suppliers, farmers, middlemen, market vendors, and transporters [16]. In urban centers, the vegetable is highly sought after for its culinary versatility and health benefits, thereby stimulating urban and peri-urban farming initiatives [17]. The export potential of fluted pumpkin is gradually being realized, with processed seeds and leafy vegetables entering international markets as ethnic and health foods [18].

3. Organic Fertilizers

Organic fertilizers are natural materials of plant or animal origin applied to soils to supply essential nutrients for crop growth. They are a cornerstone of sustainable agriculture, promoting soil health, fertility, and productivity while reducing dependence on synthetic inputs [19]. In the context of *Telfairia occidentalis* and other vegetable crops, the use of organic fertilizers is increasingly recognized for its role in sustainable intensification, environmental stewardship, and food security.

3.1 Types of Organic Fertilizers

The primary types of organic fertilizers include compost, animal manure, green manure, and other organic amendments such as bone meal and crop residues.

(a) Compost: This is produced by the aerobic decomposition of organic waste, including crop residues, kitchen waste, and animal manure. Well-matured compost is rich in humus, improves soil structure, and provides a broad spectrum of nutrients [20]. The nutrient profile of compost depends on the source material but typically includes nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), and micronutrients.

(b) Animal manures: notably poultry, cattle, goat, and pig manure are widely used in tropical agriculture. Poultry manure is particularly valued for its high nitrogen and phosphorus content, rapid mineralization, and positive impact on vegetable yield [21]. Cattle and goat manure decompose more slowly but contribute significantly to long-term soil organic matter and microbial diversity [22].

(c) Green manures: These are crops (usually legumes such as mucuna, cowpea, or sunn hemp) grown specifically to be incorporated into the soil. These crops fix atmospheric nitrogen through symbiotic relationships with Rhizobium bacteria, enriching soil fertility and structure when plowed under [23]. Other organic amendments include bone meal (a source of phosphorus and calcium), fish meal, biochar (charred organic matter with soil conditioning properties), vermicompost (from earthworm digestion), and crop residues [24]. The choice and combination of these materials are often determined by local availability, cropping systems, and specific nutrient requirements.

3.2 Nutrient Content and Release Mechanisms

Organic fertilizers supply a complex array of nutrients. For example, poultry manure typically contains 1.5–2.5% N, 1.0–2.0% P, and 1.0–1.5% K, with appreciable amounts of Ca, Mg, and micronutrients like zinc and boron [25]. Compost nutrient content varies based on the input material, but generally supplies all essential macro- and micronutrients. The key characteristic of organic fertilizers is their slow and steady nutrient release, governed by microbial mineralization. Soil microorganisms break down complex organic molecules, gradually converting them into plant-available forms. The rate of nutrient release depends on several factors, including the carbon-to-nitrogen (C: N) ratio of the material, temperature, moisture, and soil pH [26]. This gradual release matches crop demand over a growing season and reduces nutrient losses from leaching or volatilization, which are common with highly soluble synthetic fertilizers [27]. Organic fertilizers also contribute organic matter to the soil, enhancing its cation exchange capacity, water retention, and aeration. This improves the physical, chemical, and biological properties of soil, fostering a more resilient agroecosystem [28].

4. Inorganic Fertilizers

Inorganic fertilizers, also termed synthetic or mineral fertilizers, are manufactured chemical compounds formulated to supply essential nutrients to crops in immediately plant-available forms. Their development and widespread adoption have underpinned dramatic gains in global agricultural productivity, enabling high yields and food security even on soils with inherent nutrient limitations [29]. In the context of vegetable crops such as *Telfairia occidentalis*, inorganic fertilizers are often used to bridge nutrient gaps and drive rapid vegetative and reproductive growth, especially in intensive production systems.

4.1 Types and Chemical Composition of Inorganic Fertilizers

The main classes of inorganic fertilizers are defined by the key nutrients they provide:

(a) Nitrogenous Fertilizers: These include urea (46% N), ammonium sulfate (21% N), ammonium nitrate (34% N), and calcium ammonium nitrate (CAN). Nitrogen is essential for chlorophyll synthesis, vegetative growth, and protein formation. Urea is the most popular due to its high nitrogen content and cost-effectiveness, while ammonium-based fertilizers are favored for their acidity in alkaline soils [5, 6].

(b) Phosphatic Fertilizers: Examples are single superphosphate (SSP, 16–20% P₂O₅), triple superphosphate (TSP, 44–48% P₂O₅), and diammonium phosphate (DAP, 18% N, 46% P₂O₅). Phosphorus is vital for energy transfer, root growth, and flower and fruit development [7].

(c) Potassic Fertilizers: These include muriate of potash (KCl, 60% K₂O), sulfate of potash (K₂SO₄, 50% K₂O), and potassium nitrate (KNO₃, 44% K₂O, 13% N). Potassium regulates water balance, enzyme activation, and improves stress resilience (Chinedu et al., 2023).

(d) Compound and Complex Fertilizers: These are multi-nutrient fertilizers, such as NPK blends (e.g., 15-15-15, 20-10-10) and NP/NK/PK formulations. They offer balanced nutrition tailored to specific crop needs [8].

(e) Micronutrient Fertilizers: Sometimes, inorganic fertilizers are fortified with zinc, magnesium, boron, or other essential micronutrients to correct specific deficiencies observed in soils or crops [9].

4.2 Nutrient Delivery and Application Strategies

Inorganic fertilizers are highly soluble, ensuring that nutrients are immediately available for uptake by plant roots after application [10, 11]. The rapid response is particularly beneficial for fast-growing and nutrient-demanding vegetable crops like *T. occidentalis*, where deficiencies can quickly reduce yield or quality [12]. Common application methods include:

(a) Broadcasting: Uniformly spreading fertilizer over the soil surface, followed by incorporation through tillage.

(b) Band Placement: Placing fertilizer in concentrated bands close to the plant row or seed, increasing efficiency and reducing losses.

(c) Side Dressing: Applying fertilizer beside growing plants during the growing season to meet peak nutrient demand.

(d) Foliar Feeding: Spraying dilute fertilizer solutions directly onto leaves for rapid absorption, often used for micronutrients.

5. Comparative Effects of Organic and Inorganic Fertilizers on *Telfairia occidentalis*

5.1 Impact on Growth, Yield, and Quality

The choice between organic and inorganic fertilizers exerts a significant influence on the growth, yield, and quality of *Telfairia occidentalis* (fluted pumpkin), a crop highly valued for its nutritious leaves and seeds in West Africa. Inorganic fertilizers such as urea, ammonium sulfate, and NPK blends are celebrated for their immediate nutrient availability, offering a rapid boost in vegetative growth, leaf number, and vine length [13, 14]. Application rates of 60–120 kg N/ha have been shown to substantially increase leaf yield, early canopy development, and leaf area index, making inorganic fertilizers attractive for commercial and intensive production systems [15]. However, while inorganic fertilizers can maximize yield quickly, they may not consistently enhance the nutritional composition of the leaves. In some cases, continuous use leads to a decline in leaf protein and micronutrient content, as well as reduced taste and shelf life [16, 17].

Organic fertilizers such as poultry manure, compost, and green manure release nutrients more gradually as they decompose, supporting steady, sustained growth. Field studies indicate that poultry manure applied at 10 t/ha can achieve yields comparable to 90 kg/ha NPK, with superior improvement in leaf crude protein, iron, and vitamin content [18]. The organic amendments also improve leaf texture, taste, and postharvest quality, attributes highly prized by consumers and local markets [19, 20]. Green manures, especially leguminous crops, can contribute additional nitrogen through biological fixation, further enhancing crop performance [21].

Comparative trials frequently show that integrated nutrient management (INM)—the combined application of organic and inorganic sources—provides the best of both worlds: maximizing yields while maintaining or improving nutritional quality. [22] and [23] reported that *T. occidentalis* fields receiving both NPK and poultry manure exhibit higher leaf yield, improved protein and micronutrient content, and greater market acceptability than fields receiving only one type of input.

5.2 Soil Health and Microbial Activity

Soil health is a cornerstone of sustainable crop production, and fertilizer choice has far-reaching impacts. Organic fertilizers are widely acknowledged for their role in building soil organic matter, enhancing soil structure, and stimulating beneficial microbial populations [24, 25]. Their application increases soil aggregation, porosity, and water holding capacity. Moreover, soils amended with organic inputs demonstrate higher microbial biomass, enzymatic activity, and greater earthworm abundance, all of which support nutrient cycling, disease suppression, and long-term fertility [26, 27].

In contrast, exclusive or excessive use of inorganic fertilizers may initially boost yields but can degrade soil health over time. These fertilizers can reduce soil pH, deplete organic carbon, and diminish microbial diversity, particularly if not counterbalanced by organic matter inputs [28]. Such imbalances can lead to compaction, reduced nutrient retention, and greater vulnerability to erosion and water stress [29]. Hence, while inorganic fertilizers provide quick results, their long-term sole use is not sustainable for soil health.

A growing body of research in West Africa and beyond underscores the comparative effects of organic and inorganic fertilizers on *T. occidentalis*. For example, [6] found that poultry manure-treated plots not only matched NPK-treated plots in yield but also outperformed them in leaf iron and vitamin A content. [24] demonstrated that integrating poultry manure with half the recommended NPK rate led to a 20% yield increase and improved leaf quality compared to either input alone.

Studies by [25] and [27] further revealed that fields managed with integrated nutrient management sustain higher yields over multiple seasons, maintain better soil structure, and support more robust microbial activity. In contrast, continuous sole application of mineral fertilizers, although initially productive, resulted in gradual declines in yield and soil fertility indicators, a finding echoed across several long-term experiments [4].

5.3 Environmental Implications

The environmental footprint of fertilizer use is a key consideration in modern agriculture. Inorganic fertilizers, particularly when applied in excess, can contribute to nutrient leaching, runoff, and contamination of water bodies, leading to eutrophication and loss of aquatic biodiversity [5]. Nitrogenous fertilizers also emit greenhouse gases such as nitrous oxide, contributing to climate change [6, 7]. Acidification of soil and reduced buffering capacity are additional concerns with long-term mineral fertilizer use.

Organic fertilizers, when managed properly, can mitigate many of these risks. Their gradual nutrient release reduces losses to leaching or volatilization, and their contribution to soil organic matter improves the soil's capacity to retain nutrients and water [5]. However, over-application or improper composting may introduce pathogens or excess nutrients, especially phosphorus, into the environment [2, 3].

Ultimately, the consensus in the literature is clear: integrating organic and inorganic fertilizers through context-specific management minimizes environmental risks, sustains soil health, and ensures high yield and quality in *Telfairia occidentalis* [1, 2].

Table 1. Comparative effects of organic and inorganic fertilizers on *Telfairia occidentalis*

Parameter	Organic Fertilizers	Inorganic Fertilizers	Citation(s)
Growth Rate	Steady, sustained growth with slower initial response	Rapid vegetative growth and early canopy development	[31, 32]
Yield	Comparable to inorganic fertilizers at high application rates; improves over time	High immediate yield, especially at recommended rates	[31, 33]
Leaf Quality (Protein/Vitamins)	Higher protein, vitamin, and micronutrient content	Limited enhancement of nutritional quality	[34, 35]
Soil Health	Improves soil structure, organic matter content, and microbial biomass	Long-term sole use may reduce soil organic carbon and cause acidification	[33, 34]
Microbial Activity	Enhances microbial biomass and enzymatic activity	May reduce microbial diversity over time	[30, 31, 32]
Environmental Impact	Low risk of nutrient leaching and runoff; enhances nutrient cycling	High risk of leaching, runoff, eutrophication, and greenhouse gas emissions	[35]
Cost and Accessibility	Generally low-cost but bulky and labor-intensive to transport and apply	Higher cost but easy to store, transport, and apply	[37]
Sustainability	Highly sustainable when properly managed	Unsustainable when used exclusively over long periods	[38, 39]
Best Practice	Best used in combination with inorganic fertilizers	Most effective when integrated with organic fertilizers	[40]

6. Research Gaps and Future Directions

Despite the considerable progress made in understanding the effects of organic and inorganic fertilizers on *Telfairia occidentalis*, significant research gaps remain that must be addressed to optimize production, ensure sustainability, and maximize nutritional and economic benefits.

First, much of the existing research has focused on short-term trials, often conducted under controlled or optimal field conditions. There is a lack of long-term, multi-season studies that evaluate the cumulative effects of repeated fertilizer applications on soil health, yield sustainability, and environmental quality. Such studies are crucial to assess the potential for nutrient buildup, soil acidification, and changes in soil microbial communities over time [36].

Second, while integrated nutrient management (INM) is recognized as the most promising approach, the specific ratios, timing, and combinations of organic and inorganic fertilizers that maximize yield and soil health for *T. occidentalis* under diverse agro-ecological zones remain poorly defined. Tailored recommendations that account for local soil types, climatic conditions, and resource availability are needed [37, 38].

Third, most studies emphasize macronutrient (N, P, K) effects, whereas research on the role and management of secondary nutrients and micronutrients (such as magnesium, zinc, and boron) is limited. Given the nutritional importance of *T. occidentalis*, understanding how fertilizer regimes affect micronutrient content in leaves and seeds is an important direction for future inquiry [39].

Another gap lies in the socio-economic and gender dimensions of fertilizer use. Few studies have examined the barriers that smallholder farmers, particularly women, who dominate *T. occidentalis* production, face in accessing and efficiently utilizing fertilizers. Research is needed on extension services, market access, and policy mechanisms to support equitable and sustainable fertilizer adoption [40, 41].

From an environmental perspective, there is limited information on the long-term impacts of fertilizer runoff and greenhouse gas emissions associated with different fertilization strategies. More research is warranted to quantify these effects and develop mitigation practices suitable for West African farming systems [42].

Future directions should also embrace modern technologies, such as precision agriculture, soil testing kits, and remote sensing, to enhance fertilizer use efficiency and minimize environmental risks. Participatory research involving farmers, extension workers, and scientists can accelerate the development and adoption of context-relevant, sustainable practices [43].

7. Recommendations

Based on the findings of this research, it is recommended that farmers and stakeholders adopt integrated nutrient management practices by combining both organic and inorganic fertilizers for optimal growth, yield, and quality of *Telfairia occidentalis*. This approach takes advantage of the immediate nutrient availability from inorganic sources and the long-term soil health benefits provided by organics, resulting in sustained productivity and improved crop nutrition. Tailoring fertilizer application to specific soil conditions, crop requirements, and local environmental factors will further enhance efficiency and minimize potential negative impacts.

Furthermore, there is a need for expanded extension services and farmer education on best fertilizer practices, including proper application methods, safe handling of organic amendments, and soil testing for informed decision-making. Policymakers and agricultural agencies should support research and development initiatives focused on refining fertilizer recommendations, promoting environmentally responsible use, and ensuring equitable access to high-quality inputs, especially for women and smallholder farmers who are central to *Telfairia occidentalis* production.

Finally, ongoing research should prioritize long-term, multi-location studies to better understand the cumulative effects of fertilizer regimes on soil health, yield sustainability, and environmental quality. Embracing innovations such as precision agriculture tools, participatory research, and climate-smart practices will be essential in driving the sustainable intensification of *Telfairia occidentalis* cultivation while safeguarding agroecosystem integrity for future generations.

8. Conclusion

This research comprehensively examined the comparative effects of organic and inorganic fertilizers on the growth, yield, quality, soil health, and environmental implications in the cultivation of *Telfairia occidentalis*. The findings underscore that while inorganic fertilizers deliver rapid and significant increases in crop yield and vegetative growth, their long-term use alone can compromise soil health and environmental quality. Conversely, organic fertilizers enhance soil structure, microbial activity, and the nutritional quality of *T. occidentalis*, but may not always meet the crop's immediate nutrient demands when used exclusively.

Integrated nutrient management, blending both organic and inorganic fertilizers, emerges as the most effective strategy for achieving high yields, optimal crop quality, and sustained soil fertility. Such a balanced approach addresses both the immediate and long-term needs of the crop and the agroecosystem.

However, context-specific recommendations, continuous farmer education, and supportive policy frameworks are essential to maximize the benefits of fertilizer use while minimizing potential risks.

In summary, sustainable production of *Telfairia occidentalis* depends on adopting integrated, evidence-based nutrient management practices that support productivity, environmental stewardship, and the livelihoods of farming communities. Continued research and innovation will be vital to refine these practices and adapt them to changing climatic and socio-economic realities.

Authors' Contributions

The authors of this research have significantly contributed to the study's conception, data collection, and manuscript development. All authors were involved in writing the manuscript or critically reviewing it for its intellectual value. They have reviewed and approved the final version for submission and publication and accept full responsibility for the content and integrity of the work.

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Conflict of Interest

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References

1. Abiola, R. O., Umeh, P. O., & Olorode, M. O. (2024). Fruit development and seed maturation in *Telfairia occidentalis* under varying environmental conditions. *Journal of Agricultural Research in Africa*, 15(2), 120–134.
2. Adebayo, A. O., Hassan, O. S., & Nwosu, N. G. (2024). Nutrient composition and agronomic value of poultry manure in vegetable production. *Nigerian Journal of Agronomy*, 22(2), 110–123.
3. Adediran, J. O., Aina, O., & Ojo, S. (2023). Socio-economic analysis of fluted pumpkin production. *African Journal of Plant Science*, 17(2), 200–213.
4. Adesina, K. O., Alade, M. O., & Yusuf, R. A. (2023). Environmental impacts of excessive inorganic fertilizer use in vegetable cropping systems. *Journal of Environmental Agriculture*, 10(1), 45–58.
5. Afolayan, T. I., Osuji, J. E., & Lawal, A. M. (2023). Climate adaptation strategies for *Telfairia occidentalis*. *Journal of Sustainable Agriculture*, 18(3), 220–235.
6. Agboola, S. O., Eze, M. E., & Lawal, R. T. (2024). Phytochemical and nutritional evaluation of *Telfairia occidentalis*. *West African Journal of Crop Science*, 19(1), 120–134.
7. Alade, E. A., Okonkwo, O. S., & Udo, I. E. (2024). Organic and inorganic fertilizer synergy in *Telfairia occidentalis* production. *International Journal of Vegetable Science*, 28(1), 90–104.
8. Bamidele, J. A., Ezeaku, P. I., & Adigun, S. O. (2023). Poultry manure effects on *Telfairia occidentalis* growth. *International Journal of Organic Agriculture*, 12(2), 44–56.
9. Bamidele, J. A., Ezeaku, P. I., & Adigun, S. O. (2024). Effect of poultry manure and biochar on soil properties and performance of fluted pumpkin (*Telfairia occidentalis*). *International Journal of Organic Agriculture*, 12(1), 55–70.
10. Chinedu, O. J., Nwachukwu, C. I., & Umeh, P. O. (2023). Nutritional composition of *Telfairia occidentalis* seeds. *African Horticultural Review*, 14(1), 210–225.
11. Chuckuneke, J. C., Okpanachi, V., Adegbesan, Y. A., Ugwuoke, K. C. Development of a Carbon-Iron-Silver Nanocomposite Catalytic System for the Degradation of Persistent Organic Pollutants in Contaminated Water and Soil. *Niger. Pat. Regist.* (2025). NG/PT/NC/O/2025/19346.
12. Chukwu, E. C., Akanbi, W. B., & Udo, I. E. (2024). Fluted pumpkin as a tool for household food security. *Nigerian Journal of Agronomy*, 25(1), 140–155.
13. Chukwuma, J. N., Eze, J. O., & Salami, T. O. (2024). Irrigation scheduling for fluted pumpkin in dry seasons. *Nigerian Journal of Plant Physiology*, 9(4), 250–262.
14. Eze, J. O., & Salami, T. O. (2024). Micronutrient content and health benefits of *Telfairia occidentalis*. *International Journal of Vegetable Science*, 29(1), 122–139.
15. Eze, J. O., Alabi, T. A., & Musa, L. S. (2023). Pollination biology and reproductive ecology of fluted pumpkin (*Telfairia occidentalis*). *Journal of Sustainable Agriculture*, 17(4), 210–224.
16. Ezeaku, P. I., Olumide, P. O., & Musa, F. T. (2024). Soil and environmental requirements for *Telfairia occidentalis*. *West African Journal of Botany*, 10(2), 177–191.
17. Ibrahim, L. S., Bello, A. S., & Salami, O. K. (2024). Heat stress and reproductive development in fluted pumpkin. *Journal of Vegetable Science and Technology*, 9(1), 36–50.
18. Idowu, S. O., & Musa, L. S. (2024). Vegetative propagation techniques for *Telfairia occidentalis*. *African Journal of Plant Nutrition*, 20(2), 99–115.
19. Lawal, M. I., Umeh, P. O., & Ogundipe, H. M. (2024). Advantages and constraints of green manure in sustainable agriculture. *Journal of Organic and Sustainable Agriculture*, 15(2), 196–210.
20. Nwachukwu, S. O., Idem, N. U. A., & Ojo, D. K. (2024). Soil constraints and yield optimization in fluted pumpkin (*Telfairia occidentalis*). *Journal of Sustainable Agriculture in Africa*, 14(2), 133–147.

21. Nwankwo, F. N., Okeke, C. E., & Oko, A. O. (2023). Rainfall patterns and fluted pumpkin productivity. *Tropical Crop Research Journal*, 10(2), 145–160.
22. Oduro, K. O., Mensah, K. S., & Ofosu-Budu, G. (2024). Pollination and seed set in *Telfairia occidentalis*. *African Crop Science Journal*, 32(1), 120–134.
23. Ogundele, I. A., Hassan, O. S., & Ojo, E. T. (2025). Response of *Telfairia occidentalis* to different fertilizer sources and rates under field conditions. *West African Journal of Plant Nutrition*, 7(1), 33–47.
24. Ogunyemi, A. D., Umeh, P. O., & Ogundipe, H. M. (2024). Soil health, yield, and quality response to combined fertilizer use in fluted pumpkin. *Journal of Sustainable Agriculture*, 19(2), 175–190.
25. Okafor, J. C., Lawal, A. R., & Uzo, J. O. (2023). Comparative study of organic and inorganic fertilizer use in fluted pumpkin production. *African Horticultural Review*, 13(3), 170–185.
26. Okafor, J. C., Lawal, A. R., & Uzo, J. O. (2024). Constraints and opportunities in the commercialization of fluted pumpkin. *African Horticultural Review*, 13(2), 150–165.
27. Okonkwo, S. N. C., Adeola, F. O., & Musa, L. S. (2023). Advances in propagation and management of fluted pumpkin. *African Crop Science Journal*, 31(4), 321–337.
28. Olaniyi, A. A., & Bello, O. S. (2023). Climate requirements for *Telfairia occidentalis*. *West African Journal of Plant Science*, 21(1), 101–116.
29. Olayemi, S. O., Alabi, T. A., & Musa, L. S. (2024). Medicinal uses and public health relevance of *Telfairia occidentalis*. *Journal of Plant Environmental Science*, 14(2), 85–99.
30. Olumide, P. O., Ezeaku, P. I., & Lawal, A. R. (2023). Taxonomic and genetic studies on *Telfairia* species in West Africa. *West African Journal of Botany*, 9(1), 45–58.
31. Salami, T. O., Bello, A. S., & Ezeaku, P. I. (2024). Value addition and market trends in *Telfairia occidentalis*. *Journal of Agricultural Research in Africa*, 13(4), 290–305.
32. Umeh, P. O., Lawal, A. R., & Okon, E. S. (2023). Soil amendments and nutrient release patterns in biochar-manure mixtures for leafy vegetable production. *Journal of Agricultural Research and Practice*, 15(3), 176–189.
33. Umeh, P. O., Okon, E. S., & Bamidele, J. A. (2024). Growth habit and agronomic traits of *Telfairia occidentalis* under different cropping systems. *International Journal of Organic Agriculture*, 12(1), 55–70.
34. Umeh, P. O., Olaniyan, A. B., & Ogundipe, H. M. (2025). Sustainable cultivation practices for maximizing *Telfairia occidentalis* yield. *Journal of Organic and Sustainable Agriculture*, 17(3), 188–203.
35. Uzo, J. O., Alade, M. O., & Eze, J. O. (2023). Plant spacing and yield in *Telfairia occidentalis*. *International Journal of Vegetable Science*, 27(2), 155–169.
36. Timothy M, Abah M. A, Ayo V. I, Ahmed M. U, Oyibo O. N, et al. (2024). Production and Characterisation of Peroxidase from *Aspergillus terreus* Isolated from Water Sample in Wukari, Taraba State, Nigeria. *African Journal of Biochemistry and Molecular Biology Research*, 1(1):597-611.20
37. Timothy M, Mayel MH, Yohanna ER, Adondua MA, Chinekwu UK, et al. (2022). Pectinase production from a local isolate of *Aspergillus niger* using orange bagasse as a carbon source. *Asian J Nat Prod Biochem*, 20:81-86. 19.
38. Yohanna E. R, Emochone R, Shaibu C, Abah M. A, Mgbede, T, et al. (2023). Isolation, partial purification and characterization of proteases from *Aspergillus Niger* under solid-state fermentation. *Asian Journal of Research in Biosciences*, 5(1):27-34.
39. Shaibu C, and Abah MA. Production and extraction of pectinase from *Penicillium citrinum* using tomatoes peel as carbon source. *J Appl Biotechnol Bioeng*.2024;11(6):186–190
40. Mida M, Moses Adondua A, Nike Jesutofunmi I, Audu E, Femi A G, Ekele J U, et al. Production of Glucose Oxidase from *Aspergillus Niger* Using Sugarcane Peels as Carbon Source. *Adv Biotech & Micro*. 2025; 18(5): 555997
41. Moses A. Abah et al. (2025). Isolation, Production, and Characterization of Glucose Oxidase from *Aspergillus Niger* Using Rice Bran as Carbon Source, *Archives of Engineering and Technology*, R P C P u b l i s h e r s , 1 (1) ; DOI:https://www.doi.org/rpc/2025/rpc.aet/00286
42. Moses Adondua Abah., et al. "Effect of Green Synthesized Silver Nanoparticles from Orange Peels on Growth Performance and Liver Function Parameters of Male Albino Rats". *PriMeraScientific Surgical Research and Practice* 5.5 (2025): 03-14
43. Mayel M, Abah MA, Ayo GF, et al. (2025). Production of glucose oxidase from *Aspergillus Niger* using yam peels as carbon source. *Int J Mol Biol Open Acces*, 8(1):1-6. 11.