**CHAPTER ONE**

**INTRODUCTION**

**1.1 Background of the Study**

Agricultural sustainability and food security are major concerns in Nigeria and across the globe, especially in the face of climate change, soil fertility depletion, and declining crop yields. Sorrel (Hibiscus sabdariffa), also known as Roselle, is an important leafy and medicinal plant widely cultivated in tropical and subtropical regions, including Nigeria. It belongs to the *Malvaceae* family and is valued for its multipurpose benefits, including its use in food, beverages, pharmaceuticals, and traditional medicine. The plant is rich in bioactive compounds such as anthocyanins, flavonoids, vitamins, and minerals, which contribute to its numerous health benefits, including antioxidant, anti-inflammatory, and antimicrobial properties (Ali *et al.,* 2020). Despite its nutritional and economic significance, the cultivation of sorrel is often hindered by poor soil fertility, which limits its growth and yield potential.

One of the major constraints affecting sorrel production in Nigeria, particularly in the Northern Guinea Savanna, is the declining soil fertility caused by continuous cropping, erosion, and insufficient organic matter. Many Nigerian soils are naturally low in essential nutrients, particularly nitrogen (N), phosphorus (P), and potassium (K), which are critical for plant growth and productivity. The excessive reliance on synthetic fertilizers to replenish soil nutrients poses several challenges, including high costs, limited accessibility to smallholder farmers, and negative environmental impacts such as soil degradation, groundwater contamination, and increased greenhouse gas emissions (Fageria *et al.,* 2019). Consequently, there is an urgent need for sustainable soil fertility management practices that enhance crop yield while maintaining soil health and environmental integrity. Poultry manure, a rich organic fertilizer derived from poultry waste, has gained attention as a viable alternative to synthetic fertilizers due to its ability to improve soil fertility and crop productivity. Poultry manure is an excellent source of nitrogen, phosphorus, potassium, and micronutrients, making it highly beneficial for soil amendment (Hossain *et al.,* 2021). Unlike chemical fertilizers, poultry manure also enhances soil structure, increases organic matter content, promotes microbial activity, and improves water retention capacity, all of which are essential for sustainable agricultural production. Additionally, organic fertilizers like poultry manure reduce nutrient leaching into groundwater, mitigate soil acidity, and contribute to long-term soil fertility restoration (Atiyeh *et al.,* 2020).

Despite these benefits, optimal poultry manure application rates for specific crops such as sorrel remain largely understudied in Nigeria. Farmers often apply organic fertilizers indiscriminately, leading to either suboptimal nutrient supply or excessive nutrient loading, which may result in reduced plant growth, nutrient imbalance, or environmental pollution. Additionally, variations in soil types, climatic conditions, and crop nutrient requirements make it necessary to establish appropriate manure application rates to maximize crop performance and productivity.

Research has demonstrated that the use of organic manure significantly influences the growth, yield, and quality of leafy vegetables, including sorrel (Gupta *et al.,* 2022). However, there is a lack of comprehensive studies evaluating the effect of different poultry manure rates on the performance of sorrel, particularly in the Northern Guinea Savanna of Nigeria, where sorrel cultivation is common. Understanding the relationship between poultry manure application rates and sorrel growth parameters such as plant height, number of leaves, leaf area, and biomass yield is crucial for optimizing production and ensuring sustainable agricultural practices.

The increasing demand for sustainable agricultural practices has highlighted the importance of organic fertilizers, particularly poultry manure, in enhancing soil fertility and crop productivity. Sorrel (Hibiscus sabdariffa), a widely cultivated plant in tropical and subtropical regions, is valued for its nutritional and medicinal properties. The plant is rich in antioxidants, vitamins, and minerals, making it an important crop for food security and economic benefits (Morton, 2020). However, the cultivation of sorrel in the Northern Guinea Savanna of Nigeria faces significant challenges related to soil fertility management.

Poultry manure is a readily available organic fertilizer that provides essential nutrients for plant growth. It contains high levels of nitrogen (N), phosphorus (P), and potassium (K), which are crucial for plant development (Akanbi *et al.,* 2019). Studies have shown that organic fertilizers like poultry manure improve soil structure, enhance microbial activity, and increase nutrient retention, reducing the need for synthetic fertilizers that contribute to environmental degradation (Oluwatosin *et al.,* 2021).

Despite the benefits of poultry manure, its application rates must be optimized to prevent excessive nutrient loading, which can lead to soil nutrient imbalance, nitrogen leaching, and reduced crop performance. Research on the effects of different poultry manure rates on the growth and yield of sorrel remains limited, particularly in the Northern Guinea Savanna region. Therefore, this study aims to evaluate the influence of varying poultry manure rates on sorrel growth, yield, and nutritional composition in Mubi, Adamawa State.

**1.2 Statement of the Problem**

The cultivation of sorrel in the Northern Guinea Savanna is constrained by declining soil fertility, which adversely affects crop yield and quality. Many farmers rely on inorganic fertilizers to boost productivity; however, these fertilizers are expensive and contribute to soil degradation and environmental pollution. Organic fertilizers, such as poultry manure, offer an eco-friendly alternative, but their appropriate application rates for optimal sorrel growth and yield remain unclear.

Farmers often lack precise guidelines on the suitable poultry manure rates required for maximum productivity, leading to either under-application, which results in poor crop performance, or over-application, which can cause nutrient toxicity. Additionally, the impact of poultry manure

on the nutritional content of sorrel has not been well-documented, limiting its potential as a functional food for addressing micronutrient deficiencies (Gupta *et al.,* 2022).

Given these challenges, this study seeks to determine the optimal poultry manure rates that enhance the growth and yield of sorrel while maintaining soil health and sustainability in the Northern Guinea Savanna of Nigeria.

**1.3 Aim and Objectives of the Study**

The main aim of this study is to evaluate the effects of different poultry manure rates on the growth and yield of sorrel (Hibiscus sabdariffa) in Mubi, Northern Guinea Savanna. The specific objectives are:

1. To assess the impact of varying poultry manure rates on the growth parameters of sorrel.
2. To determine the effect of different poultry manure rates on the yield components of sorrel.
3. To analyze the nutritional composition of sorrel under different poultry manure treatments.

**1.4 Significance of the Study**

This study has significant implications for farmers, agricultural researchers, and policy makers in Nigeria. By identifying the optimal poultry manure rates for sorrel cultivation, the research will provide valuable recommendations that enhance crop yield and soil fertility.

For farmers, the study offers practical insights into the efficient use of poultry manure to maximize sorrel production, thereby improving income and food security. Researchers will benefit from the findings by gaining a deeper understanding of organic fertilizer interactions with crop physiology. Additionally, policymakers can use the research outcomes to develop sustainable agricultural policies that promote organic farming and environmental conservation.

The study also contributes to the broader goal of sustainable agriculture by reducing dependence on chemical fertilizers, improving soil health, and mitigating the environmental impact of synthetic inputs. Furthermore, enhancing sorrel production through optimized organic fertilization can support local industries that utilize sorrel in food processing, beverages, and pharmaceuticals.

**1.5 Justification of the Study**

The justification for this study is based on the need to improve soil fertility and crop productivity using environmentally sustainable approaches. The declining soil fertility in the Northern Guinea Savanna necessitates alternative fertilization strategies that maintain long-term agricultural sustainability. Poultry manure, being a nutrient-rich organic fertilizer, has the potential to enhance sorrel growth and yield while reducing soil degradation and chemical fertilizer dependence.

Moreover, sorrel is a valuable crop due to its economic and nutritional importance. Enhancing its cultivation through appropriate manure management can help combat micronutrient deficiencies, particularly in rural areas where dietary diversity is limited. Understanding the interaction between poultry manure application rates and sorrel productivity will provide essential knowledge for optimizing crop management practices, ensuring food security, and supporting smallholder farmers in Nigeria.

**1.6 Scope and Limitation of the Study**

This study focuses on evaluating the effects of different poultry manure rates on the growth and yield of sorrel (Hibiscus sabdariffa) in Mubi, Northern Guinea Savanna. The research will be conducted under field conditions, examining parameters such as plant height, number of leaves, biomass accumulation, and yield components in 2025 cropping season.

Limitations of the study may include variability in soil properties, climatic factors, and the duration of the research. Additionally, differences in poultry manure composition may affect nutrient availability, necessitating further studies to standardize organic fertilizer application for sorrel cultivation. By addressing these aspects, this study aims to contribute to the optimization of organic fertilization practices for improved sorrel production in Nigeria’s agroecological zones.

**CHAPTER TWO**

**LITERATURE REVIEW**

This chapter presents a comprehensive review of relevant literature on the growth and yield of sorrel (*Hibiscus sabdariffa*) in relation to soil fertility management practices, with a focus on poultry manure application. The review covers the botanical and agronomic characteristics of sorrel, the role of soil fertility in plant growth, the benefits of organic fertilizers such as poultry manure, and the effects of different poultry manure application rates on crop productivity. Furthermore, it highlights previous research findings on the use of poultry manure in agriculture, particularly in the context of leafy vegetable production.

**2.1 Origin and Distribution of Sorrel (**[***Hibiscus***](https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/hibiscus)***sabdariffa* L)**

*Hibiscus sabdariffa L.,* commonly known as sorrel or roselle, is a member of the *Malvaceae* family. This plant thrives in tropical and subtropical climates, where warm temperatures and well-drained soils support its growth and productivity. The precise origin of *H. sabdariffa* remains a subject of debate, but it is believed to have originated in Asia, particularly in India or Malaysia. Some scholars suggest that the plant was later introduced to Africa, where it became widely cultivated and integrated into local agricultural and culinary traditions. During the colonial era, *H. sabdariffa* spread to the Americas through trade and migration, where it was adopted into various cultures, particularly in the Caribbean, Central America, and South America. Today, the plant is cultivated on a large scale across multiple continents, with major producers including China, Sudan, India, Malaysia, and Mexico (Shruthi *et al*., 2016).

Its native distribution is uncertain, some believe that it is from India or Saudi Arabia (Ismail *et al.,* 2018), while Murdock (Murdock, 2019) showed evidence that *Hibiscus sabdariffa* (Hs) was domesticated by the black populations of western Sudan (Africa) sometime before 4000 BC. Nowadays, it is widely cultivated in both tropical and subtropical regions including India, Saudi Arabia, China, Malaysia, Indonesia, The Philippines, Vietnam, Sudan, Egypt, Nigeria and México (Ismail *et al.*, 2018; Yagoub *et al*., 2014). There are two main varieties of Hs, the first being Hs var. altissima Wester, cultivated for its jute-like fiber and the second is Hs var. *sabdariffa*. The second variety includes shorter bushy forms, which have been described as races: bhagalpuriensi, intermedius, albus and ruber. The first variety has green, red-streaked, inedible calyces, while the second and third race have yellow-green edible calyces (var. ruber) and also yield fiber (Morton, 2017).

Sorrel is a species of [*Hibiscus*](https://en.wikipedia.org/wiki/Hibiscus) native to West Africa, used for the production of [bast fibre](https://en.wikipedia.org/wiki/Bast_fibre" \o "Bast fibre) and as an [infusion](https://en.wikipedia.org/wiki/Infusion), in which it may also be known as karkade. It is an annual or perennial [herb](https://en.wikipedia.org/wiki/Herb) or woody-based [subshrub](https://en.wikipedia.org/wiki/Subshrub), growing to 2–2.5 m (7–8 ft) tall. The [leaves](https://en.wikipedia.org/wiki/Leaf) are deeply three- to five-lobed, 8–15 cm (3–6 in) long, arranged alternately on the stems. The [flowers](https://en.wikipedia.org/wiki/Flower) are 8–10 cm (3–4 in) in diameter, white to pale yellow with a dark red spot at the base of each petal, and have a stout fleshy [calyx](https://en.wikipedia.org/wiki/Calyx_(flower)) at the base, 1–2 cm (0.39–0.79 in) wide, enlarging to 3–3.5 cm (1.2–1.4 in), fleshy and bright red as the [fruit](https://en.wikipedia.org/wiki/Fruit) matures. It takes about six months to mature. Stalks and leaves range from dark green to reddish color; flowers are creamy white or pale yellow. For fiber crops, seeds are sown close together, producing plants 10 to 16 feet (3 to 5 meters) high, with little branching. The stalks, cut when buds appear, are subjected to a retting process, then stripped of bark or beaten, freeing the fiber. In some areas retting time is reduced by treating only the bark and its adhering fiber. Plants for [fruit](http://www.britannica.com/science/fruit-plant-reproductive-body) crops, more widely spaced, are shorter and many-branched, and their calyxes are picked when plump and fleshy. The fiber strands, 3 to 5 feet (1 to 1.5 meters) long, are composed of individual fiber cells. Roselle fiber is lustrous, with color ranging from creamy to silvery white, and is moderately strong. It is used, often combined with [jute](http://www.britannica.com/plant/jute-plant), for bagging fabrics and twines. India, Java, and the Philippines are major producers.

Bamgboye and Adejumo (2019) determined the physical properties of Roselle seeds at different moisture contents using ASAE standards. The mean values of the physical properties of the seeds were determined as 4.75-4.85 mm length, 4.15-4.26 mm width, 2.62- 2.67 mm thickness, 3.73- 3.83 mm geometric mean diameter, 648.31-619.14 kg/m3 bulk density, 20.13°-24.85° angle of repose, 17-18.5 mm2 surface area, 52.6-58.3 % porosity, 1367.0-1487.4 kg/m3 true density, 29.7- 40×10-6 m3 volume, 5.8-7.1 m/s terminal velocity, 1.36-1.44 specific gravity. In many tropical areas, the red, somewhat acid calyxes of H. sabdariffa variety altissima are used locally for beverages, sauces, jellies, preserves, and chutneys; the leaves and stalks are consumed as salads or cooked vegetables and used to season curries; and in Africa the oil-containing seeds are eaten.

The widespread cultivation of *H. sabdariffa* is largely due to its economic and nutritional value. Its calyces are used to produce herbal teas, beverages, jams, and natural dyes, while its leaves and seeds are consumed in different traditional cuisines. Additionally, the plant has gained global recognition for its medicinal properties, particularly for its potential in managing hypertension, obesity, and inflammation.

**2.2 Botanical Description and Importance of Sorrel (*Hibiscus sabdariffa*)**

Sorrel (*Hibiscus sabdariffa* L.) belongs to the *Malvaceae* family and is an annual or perennial herbaceous plant widely cultivated in tropical and subtropical regions. It is characterized by its deep red or green stems, lobed leaves, and distinctive calyces, which are commonly used in food, beverages, and medicinal products (Ali *et al.,* 2020). The plant is primarily grown for its leaves, seeds, and calyces, which contain high levels of vitamins (A, C, and E), minerals (iron, calcium, and magnesium), and bioactive compounds such as flavonoids, anthocyanins, and polyphenols (Oboh & Rocha, 2008).

Hibiscus is an annual herbaceous plant with vertical growth, reaching a height of about two meters. The branches of the plant are reddish-green. The leaves are simple, with long [petioles](https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/petiole) and serrated edges palm-shaped leaves are reddish-green. The plant bears fleshy-shaped, beautiful flowers. It is purple in color, emerging from the axillary leaves, and has a very short [neck](https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/neck), and the flower parts are thick and lubricated with color dark red, the fruits are in the form of capsules with a number of brown seeds, spherical and wrinkled inside surface. The used part is the flower and leaf hibiscus plant is known by several names such as hibiscus Jokers, gypsies, clams, stirrups, red acidosis, hibiscus is known scientifically as *Hibiscus sabdariffa* (Alkahtani, 2020).

The Hibiscus *sabdariffa* is one of the most important economic plants in food and pharmaceutical industries, its used as a refreshing drink, especially after it has been sweetened with sugar, and this extract after its concentration is considered as a colored and enriched material for the distinctive (Cid-Ortega & Guuerrero-Beltran, 2015; Da-Costa-Rocha et al., 2014; Shruthi et al., 2016).

Research conducted on *Hibiscus*[*calyx*](https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/sepal) showed that the extract of this part has effects in exterminating the tuberculosis microbe, and has the ability to kill microbes, particularly many bacterial strains, especially *Bacillus*, *Escherichia coli*, and others, in addition to some parasites. From researches conducted on *Hibiscus calyx* and leaves, they calm the contractions of the uterus, stomach, and intestines, remove its pain, and are also useful against diets. The boiled sirup of hibiscus flowers is one of the best drinks (Alkahtani, 2020).



Figure 2.1: Sorrel plant

Sorrel is highly valued for its medicinal and nutritional properties. Traditionally, it has been used in the treatment of hypertension, fever, digestive disorders, and bacterial infections due to its antimicrobial, antioxidant, and anti-inflammatory activities (Ali *et al.,* 2020). The plant also has significant economic importance, as its dried calyces are widely processed into juices, teas, and pharmaceutical products. In Nigeria, sorrel is a common leafy vegetable consumed in soups and sauces, and it plays a vital role in local food security and income generation among smallholder farmers.

Despite its economic and nutritional benefits, sorrel production is constrained by poor soil fertility, inadequate nutrient supply, and unsustainable farming practices, necessitating the adoption of effective soil fertility management strategies to optimize its yield.

**2.3 Climatic and Soil Requirement of Sorrel**

Sorrel thrives in cool to temperate climates, with optimal growth occurring in temperatures ranging from 50°F to 75°F (10°C to 24°C). It exhibits remarkable cold tolerance, enduring temperatures as low as -30°F (-34°C), corresponding to USDA hardiness zones 3a to 9b. This resilience allows sorrel to withstand light frosts, making it suitable for early spring and late fall cultivation. However, exposure to excessive heat can induce bolting—premature flowering that diminishes leaf quality—necessitating partial shade in hotter regions to mitigate heat stress. Adequate sunlight is crucial for sorrel's robust growth. The plant flourishes in full sun to partial shade, requiring 6 to 8 hours of direct sunlight daily. Insufficient light can lead to leggy growth and reduced leaf production, underscoring the importance of selecting a planting site with appropriate sun exposure (Fageria *et al.,* 2019).

Sorrel prefers well-draining, fertile soils rich in organic matter. Loamy or sandy loam soils are ideal, as they provide the necessary balance between moisture retention and drainage. Incorporating well-rotted compost or aged manure enhances soil fertility, structure, and nutrient availability, promoting healthy plant development. The optimal soil pH for sorrel cultivation lies between 6.0 and 7.0, ensuring nutrient availability and uptake. Regular soil testing is recommended to monitor pH levels, with amendments applied as necessary to maintain the desired range. Consistent soil moisture is vital for sorrel's health. The soil should remain evenly moist but not waterlogged to prevent root rot and other fungal diseases. Implementing mulching practices aids in moisture retention, temperature regulation, and weed suppression, contributing to optimal growing conditions (Atiyeh *et al.,* 2020).

Soil fertility is a critical factor influencing plant growth, yield, and overall productivity. Fertile soils provide essential macronutrients (nitrogen, phosphorus, potassium) and micronutrients (calcium, magnesium, zinc) required for plant metabolic activities, photosynthesis, and structural development. However, many Nigerian soils, especially in the Northern Guinea Savanna, are characterized by low organic matter content, poor nutrient retention capacity, and high susceptibility to erosion, leading to declining soil fertility and reduced crop yields. The continuous depletion of soil nutrients due to intensive farming, overgrazing, and deforestation has necessitated the use of soil amendments such as organic and inorganic fertilizers to enhance soil fertility and promote sustainable crop production. Among the available soil fertility management practices, the use of organic fertilizers such as poultry manure has gained increasing attention due to its ability to improve soil health, enhance microbial activity, and provide long-term nutrient supply (Atiyeh *et al.,* 2020).

**2.4 Effects of Poultry Manure Application on Sorrel Growth and Yield**

Poultry manure is a rich organic fertilizer obtained from poultry droppings, which contains high levels of essential nutrients, particularly nitrogen (N), phosphorus (P), and potassium (K). It is widely used in agriculture as an alternative to synthetic fertilizers due to its ability to improve soil structure, increase organic matter content, and enhance soil microbial activity (Hossain *et al.,* 2021). Compared to other organic fertilizers, poultry manure has higher nutrient content and faster mineralization rates, making it an effective soil amendment for crop production.

The benefits of poultry manure in crop production include:

1. **Improved Soil Fertility:** Poultry manure increases soil organic matter content, enhances nutrient availability, and improves soil cation exchange capacity, which promotes better nutrient retention (Atiyeh *et al.,* 2020).
2. **Enhanced Soil Microbial Activity:** The application of poultry manure stimulates microbial populations in the soil, leading to improved nutrient cycling and soil fertility maintenance.
3. **Increased Water Retention:** The organic matter in poultry manure enhances soil water-holding capacity, reducing the impact of drought stress on crops.
4. **Sustainable Crop Production:** Unlike synthetic fertilizers, poultry manure does not contribute to soil acidification or groundwater contamination, making it an environmentally friendly soil amendment.

However, the effectiveness of poultry manure as a fertilizer depends on factors such as application rates, timing, soil type, and environmental conditions. Excessive application of poultry manure can lead to nutrient imbalances, nitrate leaching, and potential environmental pollution, underscoring the need for appropriate manure management practices.

Several studies have investigated the impact of poultry manure on the growth and yield of various crops, including leafy vegetables and medicinal plants. Research has shown that poultry manure significantly enhances plant height, leaf area, number of leaves, and overall biomass production in leafy crops (Gupta *et al.,* 2022).

For example, a study by Ojeniyi *et al.* (2019) reported that poultry manure application at 5–10 tons per hectare resulted in a significant increase in the yield of amaranth (*Amaranthus spp.*) compared to synthetic fertilizers. Similarly, Osundare *et al.* (2020) found that poultry manure application improved the growth performance of *Hibiscus sabdariffa*, leading to increased leaf biomass and higher calyx yield.

Research has also shown that poultry manure enhances chlorophyll content, leading to improved photosynthetic efficiency and higher crop productivity (Hossain *et al.,* 2021). However, excessive poultry manure application beyond optimal levels may lead to nutrient toxicity, delayed flowering, and increased susceptibility to pests and diseases.

The optimal rate of poultry manure application varies depending on crop species, soil conditions, and environmental factors. Studies conducted in Nigeria suggest that poultry manure application rates ranging from 5 to 15 tons per hectare provide the best results for leafy vegetables, including sorrel (Aliyu *et al.,* 2020). However, more research is needed to determine the most effective application rates for sorrel cultivation in different agro-ecological zones.

Poultry manure significantly influences sorrel (Hibiscus sabdariffa) growth through its impact on vegetative development, especially in early growth stages. Studies have shown that the nitrogen component of poultry manure is readily available for plant uptake, promoting rapid leaf and stem development. Nitrogen plays a crucial role in the formation of chlorophyll and amino acids, which are essential for vigorous vegetative growth (Adediran et al., 2022). This vegetative boost is particularly important for sorrel since leaf and stem biomass directly contribute to the plant’s calyx production, the major economic part.

Furthermore, phosphorus from poultry manure contributes to improved root development, enhancing nutrient and water uptake from the soil. Strong root systems allow sorrel to withstand moderate drought conditions and support higher biomass accumulation. In a recent study by Adekiya et al. (2023), poultry manure application at 10 tons/ha significantly improved root length and mass in Hibiscus sabdariffa compared to unfertilized controls, suggesting better anchorage and nutrient utilization efficiency.

Potassium, another vital nutrient present in poultry manure, plays a significant role in enhancing flower and calyx development in sorrel. It is essential for enzyme activation, protein synthesis, and regulation of water balance in plant cells. Studies conducted in humid tropics have indicated that higher potassium availability leads to an increase in calyx size and weight, directly boosting sorrel yield (Ibrahim & Danjuma, 2022). Thus, balanced nutrient composition in poultry manure contributes to the quality and quantity of sorrel yield.

Soil health is another critical factor influenced by poultry manure application. Poultry manure increases the microbial biomass carbon and enzymatic activity of the soil, leading to enhanced mineralization of nutrients and organic matter turnover (Obiora et al., 2022). These processes improve nutrient availability for sorrel at critical stages of its growth cycle, thereby enhancing productivity. The increased microbial diversity also contributes to soil disease suppression, promoting healthier sorrel stands.

In addition to soil fertility, poultry manure positively impacts sorrel's physiological traits. A study by Uka et al. (2021) demonstrated that poultry manure-treated sorrel plants exhibited higher stomatal conductance and relative water content, traits associated with increased drought tolerance and photosynthetic efficiency. These physiological improvements are attributed to the organic matter's effect on soil water retention and the hormonal activity induced by humic substances in poultry manure.

Moreover, poultry manure has been reported to enhance chlorophyll content and photosynthetic efficiency in sorrel. Increased chlorophyll content boosts the plant’s ability to convert light energy into biochemical energy, leading to better biomass accumulation and ultimately, higher yield (Akinyemi et al., 2023). The study also reported that poultry manure-treated plants showed a greener appearance and more vigorous growth compared to those treated with inorganic fertilizers.

Field experiments conducted in northern Nigeria showed that poultry manure outperformed NPK fertilizer in promoting calyx yield and quality under rainfed conditions. Specifically, poultry manure at 12 tons/ha produced the highest yield of calyx with superior color intensity and flavor, which are important quality traits for both local consumption and export markets (Yahaya et al., 2023). This finding underscores the dual benefit of poultry manure in enhancing both quantitative and qualitative attributes of sorrel.

Environmental sustainability is another significant advantage of poultry manure application. Long-term use of poultry manure has been shown to build soil organic carbon stocks, reduce greenhouse gas emissions, and enhance ecosystem services (Nwachukwu & Okoroafor, 2022). In the context of sorrel cultivation, this implies that continuous poultry manure use can maintain or even improve productivity without compromising environmental integrity.

However, caution must be taken to avoid over-application. Studies have shown that excessive poultry manure (above 20 tons/ha) can lead to high soil salinity and heavy metal accumulation, which may inhibit sorrel growth or reduce calyx quality (Anyanwu et al., 2023). Therefore, proper composting and analysis of poultry manure before application are essential to minimize environmental risks and ensure safe food production.

Lastly, integrated nutrient management combining poultry manure with minimal synthetic fertilizer has emerged as a promising strategy for optimizing sorrel production. Such an approach balances rapid nutrient availability from chemical fertilizers with long-term soil improvement from organic amendments. Research by Bamidele et al. (2024) concluded that combining 5 tons/ha of poultry manure with 50 kg/ha of NPK fertilizer increased sorrel calyx yield by 35% compared to using either input alone, demonstrating the potential of synergy in nutrient management.

# CHAPTER THREE

# RESEARCH METHODOLOGY

## 3.1 Study Area

Field experiment was conducted in 2025 cropping season at the teaching and research farm, Department of Agricultural Technology, Federal Polytechnic Mubi, to assess the effects of poultry manure on the growth and yield of Sorrel.

The study was conducted within Mubi North Local Government Area of Adamawa State in Eastern region of Northern guinea savannah of Nigeria, latitude 90°20' and longitude 13°501 East and covers an area of 24,00km2. The rainfall range between 700 -900mm with highest in the month of August, the temperature is highest at 30dc during March and April, and the minimum is 15dc in January (Adebayo, 2020).

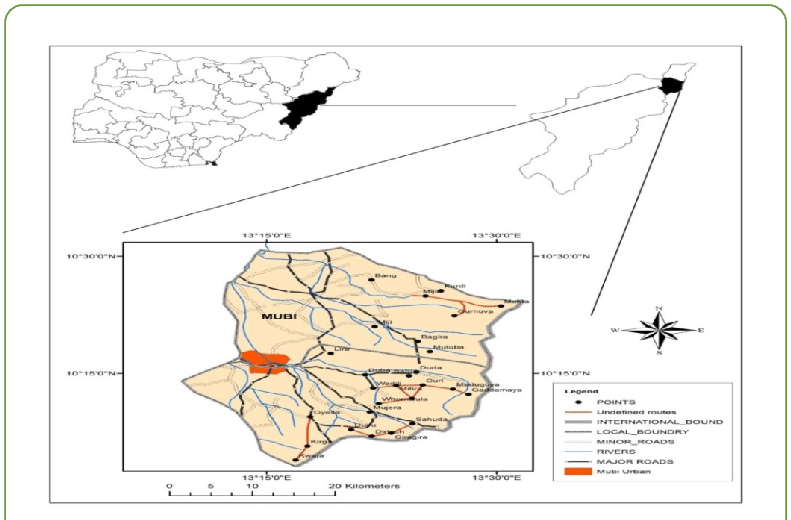


Figure 3.1: Map of the study area

Mubi North Local Government shares common borders with Mubi South, Hong Local Government Areas and it's also shares an international border with Cameroon Republic (Adebayo, 2014). Mubi North local government is inhabited by many tribes such as Fulani, Fali, Hausa, and others with Fali and Fulani as the predominant tribes, the people have rich cultural heritage and are predominantly farmers (Crop production and Animals like cattle).The climate condition helps the people to practice agriculture as the occupation particularly farming, cattle rearing and marketing. Because of the international border with Cameroon, this makes the study area a marketing, farming, and cattle route (Adebayo, 2020);

## 3.2 Treatments and Experimental Design

The experiment consisted of four (4) treatments Viz, (T0=0kg of control, T1=4kg of PM T2=8kg of PM, and T3= 12kg of PM). replicated three (3) times and was laid out in a Randomized Block Design (RCBD) as shown in figure one (1) below. A total number of 12 sub-plots were constructed with each sub-plot measured 2m x 3m with an alley of 0.5meters from each angle totalling 115.5m2. The beds were tilled manually with a hoe and treatments mixed off properly with the soil in each bed one week before planting for decomposition. Two (2) Seeds of Sorrel dropped at the depth of 2cm, covered with soil and firmed genteelly. Four (4) crop rows were made with six (6) stands on each row making the sum of 24 stands in each bed. Weeding commenced two (2) weeks after sowing and an interval of two (2) weeks, three (3) times throughout duration of this experiment.

3m

2m

REP III

REP II

REP I

.

1m

11m

Figure 1: Field layout of the experiment

**Key:**

**Rep 1 -** means replication 1

**Rep 2 -** means replication 2

**Rep 3 -** means replication 3

**To** - 0kg of Poultry Manure (Control)

**T1** - 4kg of Poultry Manure

**T2** - 8kg of Poultry Manure

**T3** - 12kg of Poultry Manure

## 3.3 Cultural practice

The cultural practice employed for this experiment include the following

***3.3.1 Ploughing***

After clearing the field and demarcation each sub- plot was prepared manually with a hoe. The soil was dogged mixed with cow dung manure in each case and levelled flat. The experiment being conducted during the raining season raised beds were made.

***3.3.2 Sowing***

For the purpose of this research, a vegetable crop (Sorrel) a variety was selected. Two (2) seeds were 40 x 40cm both between crop row as well as between stands.

***3.3.3 Weeding***

It was also done manually with a simple farm tool (hoe). Weeding started two (2) weeks after sowing and continued at interval of two (2) week, three (3) times throughout the growing period.

***3.3.4 Harvesting***

Matured Sorrel will be harvested manually and carefully with the help of a very sharp knife to avoid causing injuring to parent crop at an interval of three (3) days for three (3) times in all.

**3.4 Data collection**

Data from the following growth andyield parameters were taken during this experiment.

**GROWTH** **PARAMETERS**

***3.4.1 Establishment count***

The number of established Seedling from each plot will be take and record three (3) week after planting.

***3.4.2 Plant height (CM)***

Three (3) seedlings were randomly selected from the center of each plot and tagged. The height of plant will be taken from them with aid of ruler meter at an interval of two (2) weeks after planting, three (3) time in all, with the exception of first reading which will be taken three (3) weeks after planting. A ruler meter will be placed at the base of each seedling runs to the terminal end, reading will be taken and record appropriately.

* + 1. ***Number of leaves/plants***

The number of leaves appeared on the selected seedlings will be counted systematically and recorded.

* + 1. ***Stem diameter (Girth) (MM)***

Data on stem diameter from the selected Sorrel seedling in each plot will be measured carefully using a digital Vanier calliper and will be recorded.

## 3.5 Yield Parameters

***3.5.1 Days to 50% Flowering***

The number of days to which half of the crop in each plot begin to flowers will be determined and record via physical counting.

***3.5.2 Days to 50% podding***

The number of days to which half of the crop in each plot commenced podding will also be determined and record.

* + 1. ***Number of pods/plant***

The number of pods or fruits for each plot will be collected and record properly.

* + 1. ***Number of seeds/pod***

1000 seeds weight (g)

* + 1. ***Grand yield (kg)***

The output collected from plot will be merged together, total will be taken and record.

## 3.6 Data Analysis

The collected data will be analyze using analysis of variance and means will be separated using the least significance difference (LSD) at 5% probability level.