# Abstract

*Waterleaf (Talinum triangulare), a fast-growing leafy vegetable widely consumed in Nigeria and other tropical regions, is valued for its nutritional and medicinal properties. Despite its importance, productivity is often constrained by poor agronomic practices, particularly inappropriate plant spacing. This study was conducted at Mubi in the Northern Guinea Savanna to evaluate the effect of different spacing distances on the growth and yield of waterleaf. Four spacing regimes (10 × 10 cm, 15 × 15 cm, 20 × 20 cm, and 25 × 25 cm) were arranged in a field experiment, and data were collected on growth parameters including plant height, number of leaves, and stem girth at 3, 6, and 9 Weeks After Sowing (WAS). Results revealed that spacing had no significant effect (P > 0.05) on all measured growth parameters. However, observable trends were noted: closer spacing (10 × 10 cm) enhanced leaf number, while wider spacing (25 × 25 cm) promoted taller plants and greater stem girth at certain stages. These findings indicate that waterleaf exhibits strong adaptability to varying planting densities, though resource competition and availability influenced growth performance. It is concluded that moderate spacing (15 × 15 cm to 20 × 20 cm) provides a balance between leaf production and efficient land use, while closer spacing favors higher foliage yield. The study recommends that farmers adopt optimal spacing strategies based on production objectives and local conditions. The findings contribute to evidence-based guidelines for improving waterleaf productivity, land use efficiency, and household nutrition in the Northern Guinea Savanna.*

# CHAPTER ONE

# INTRODUCTION

## 1.1 Background of the study

Water leaf (*Talinum triangulare*), a fast-growing leafy vegetable commonly consumed in tropical and subtropical regions, plays a vital role in ensuring nutritional security and improving livelihoods, particularly in West Africa. It belongs to the family *Portulacaceae* and is widely appreciated for its high moisture content and rich nutritional composition, including vitamins A and C, iron, calcium, and antioxidants (Akinyele *et al.,* 2019). In Nigeria, water leaf is frequently used in soups, stews, and traditional medicinal preparations due to its health-promoting properties such as anti-inflammatory, antihypertensive, and diuretic effects (Ezekiel *et al.,* 2021).

Despite its nutritional and economic value, the productivity of water leaf is often limited by poor agronomic practices, including inappropriate plant spacing. Optimal plant spacing is a critical agronomic factor that influences light interception, air circulation, water uptake, and nutrient availability, all of which affect plant growth, development, and yield. Closely spaced plants tend to compete for resources, leading to reduced individual plant performance, while excessively wide spacing may result in inefficient land use and lower overall yield (Fasuyi *et al.,* 2020).

In many farming systems, especially among smallholder farmers, plant spacing decisions are often based on traditional knowledge or guesswork rather than scientific evidence. This may result in suboptimal yields and inefficient use of limited land resources. Given the increasing demand for nutritious leafy vegetables like water leaf, there is a need to identify the appropriate spacing that maximizes both individual plant performance and total yield per unit area. Plant spacing is a critical cultural practice that affects the growth and productivity of crops. Adequate spacing allows each plant access to sufficient sunlight, nutrients, and water while reducing inter-plant competition (Tindall, 1983). Inadequate spacing can lead to overcrowding, which hinders photosynthetic efficiency and increases susceptibility to pests and diseases. Conversely, overly wide spacing may lead to underutilization of land and reduced overall yield per hectare (Agbo *et al.,* 2015). Determining the optimum spacing for crops such as water leaf is therefore crucial to achieving a balance between individual plant performance and total yield.

Several studies have indicated that plant spacing significantly influences growth parameters like plant height, leaf number, leaf area, and biomass yield (Obasi *et al.,* 2016). For example, closely spaced plants tend to grow taller and spindly due to competition for light, while widely spaced plants may produce larger leaves and stems but fewer plants per area, affecting total yield. The choice of spacing should also consider environmental conditions such as soil fertility, rainfall, and light availability (Akinfasoye & Olaniyi, 2012). Therefore, a well-structured study on spacing can guide farmers in maximizing their output with the available resources.

Research has shown that agronomic practices such as spacing significantly affect the morphology, biomass accumulation, and marketable yield of leafy vegetables (Aremu *et al.,* 2022). However, limited studies have specifically addressed the effect of spacing on *Talinum triangulare* under field conditions in Nigeria. Understanding the optimal spacing for water leaf cultivation will provide farmers with evidence-based recommendations that enhance crop productivity, resource use efficiency, and income generation. As population growth continues to place pressure on agricultural land, improving the productivity of existing farmlands through optimized cultural practices like proper spacing becomes essential.

## 1.2 Statement of the problem

Water leaf is an important vegetable crop with high nutritional and medicinal value. However, its cultivation is often limited by inadequate agronomic practices, particularly improper plant spacing. Farmers in the Northern Guinea Savanna region often adopt arbitrary spacing distances without considering their effects on growth and yield, leading to suboptimal production.

Closely spaced water leaf plants may compete excessively for light, nutrients, and water, resulting in stunted growth, lower leaf production, and increased susceptibility to pests and diseases. Conversely, overly wide spacing may underutilize available land and reduce yield per hectare. The lack of scientific guidelines on optimal spacing contributes to low productivity and limits the economic benefits of water leaf farming for smallholder farmers.

There is therefore a need to assess the effect of different spacing regimes on the growth and yield of water leaf to identify the most effective spacing distance that ensures healthy plant development, maximized yield, and efficient land use.

## 1.3 Aim and objectives of the study

The aim of this study is to evaluate the effect of spacing on the growth and yield of water leaf (*Talinum triangulare*). The specific objectives are:

1. To determine the influence of varying spacing distances on the growth parameters of water leaf.
2. To evaluate the effect of spacing on the yield components of water leaf.
3. To recommend the optimal spacing distance that enhances both individual plant growth and overall yield.

## 1.4 Significance of the study

This study holds significance for farmers, researchers, agricultural extension workers, and policymakers. For farmers, it provides evidence-based recommendations for optimal spacing practices that can improve crop productivity and land use efficiency. By identifying the most suitable spacing distance, the study will help maximize water leaf yield, increase income, and contribute to food security.

Researchers and agricultural practitioners will benefit from the study by gaining deeper insights into how plant population density influences growth and yield performance in leafy vegetables. Additionally, the findings can guide extension agents in training smallholder farmers on best practices for water leaf cultivation.

Policymakers can use the results to develop context-specific agricultural guidelines that support sustainable vegetable production in the region. Moreover, promoting optimal spacing contributes to resource conservation and environmental sustainability by reducing wasteful land use and ensuring efficient nutrient utilization.

## 1.5 Justification of the study

The justification for this study stems from the need to enhance the productivity of water leaf through scientifically informed agronomic practices. In the face of increasing food demand, land scarcity, and the need for nutritious crops, optimizing plant spacing is a simple yet effective way to boost yields and promote sustainable farming.

Water leaf’s role in household nutrition, income generation, and traditional medicine makes it a vital crop in rural communities. Improving its cultivation through optimal spacing will not only increase its availability but also improve dietary diversity and public health outcomes. The study is particularly relevant to Mubi and similar agroecological zones where water leaf is widely grown but often underperforming due to poor spacing practices.

## 1.6 Scope and Limitation of the study

This study is focused on assessing the effect of different plant spacing distances on the growth and yield of water leaf (*Talinum triangulare*) under field conditions in Mubi, Northern Guinea Savanna.

Limitations may include variations in environmental conditions such as rainfall, temperature, and soil characteristics that could influence plant performance. Additionally, differences in seed vigor and pest pressures may affect uniformity. The study will also be limited to one cropping season, which may not capture long-term seasonal variability. Despite these constraints, the findings are expected to provide valuable insights for optimizing spacing in water leaf cultivation.

# ****CHAPTER TWO****

# ****LITERATURE REVIEW****

### 2.1 Overview of Water Leaf (Talinum triangulare)

Water leaf (*Talinum triangulare*) is a leafy vegetable native to West Africa and widely cultivated for its nutritional value and medicinal properties (Adeyemi *et al.,* 2019). The plant thrives in tropical and subtropical climates and is considered an important food source due to its high content of vitamins, minerals, and antioxidants. It is particularly rich in Vitamin A, Vitamin C, calcium, and iron, which makes it an excellent vegetable for combating malnutrition in developing countries (Olaniyi *et al.,* 2020). The leaves are used in soups and stews, while the plant is also used in traditional medicine for treating conditions such as anemia, hypertension, and digestive disorders (Ekpo & Etim, 2019).

The cultivation of water leaf has gained attention due to its short maturation period (typically 4 to 6 weeks), which allows for multiple harvests in a year. Despite its advantages, however, water leaf farming is constrained by inadequate agronomic knowledge, such as the optimal planting density and spacing, which affects its yield and growth (Ogunlesi *et al.,* 2010). Therefore, there is a growing need to explore plant spacing as a method to optimize its productivity. Research on water leaf cultivation has focused on improving crop yields through better management practices, including plant spacing, irrigation, and soil fertility enhancement (Olaniyi *et al.,* 2010). Water leaf is also recognized for its potential to contribute to sustainable agriculture. The plant’s resilience to drought and minimal need for intensive care make it an ideal crop for small-scale farmers, particularly in regions with limited access to irrigation and high rainfall variability (Adeyemi *et al.,* 2019). In addition, its ability to thrive in low-fertility soils allows for its cultivation in areas that are unsuitable for other crops. This makes it a valuable option for enhancing food security, particularly in the face of climate change and soil degradation, which are becoming major concerns in many developing regions (Akinfasoye & Olaniyi, 2012).

Despite its resilience, however, water leaf cultivation faces challenges related to pests, diseases, and soil erosion, which can significantly affect plant growth and yield. Studies have shown that the plant is susceptible to several pests, including aphids, caterpillars, and beetles, which can damage the leaves and hinder the growth of the plant (Ijeoma & Uzochukwu, 2018). Additionally, water leaf is prone to fungal diseases, such as powdery mildew and downy mildew, which can reduce the quality and quantity of the yield (Olaniyi *et al.,* 2010). Effective pest and disease management strategies, such as the use of resistant varieties and integrated pest management practices, are crucial for optimizing the production of this crop.

Water leaf has also been identified as an ideal candidate for intercropping systems due to its ability to grow quickly and complement other crops. Intercropping water leaf with other vegetables or legumes can help improve overall farm productivity by optimizing the use of available space and reducing the risk of soil depletion (Ibeawuchi *et al.,* 2017). Additionally, water leaf can help suppress weed growth and reduce the need for chemical herbicides, making it a valuable crop for organic farming systems (Ekpo & Etim, 2019). The integration of water leaf into agroforestry systems has also been proposed as a sustainable agricultural practice, promoting biodiversity and soil conservation while providing an additional income source for farmers.

Furthermore, the socio-economic importance of water leaf cultivation cannot be overstated. In rural areas of West Africa, water leaf farming provides a source of income for farmers, particularly women, who play a central role in its cultivation and marketing. The short growing period of the crop enables farmers to generate quick returns and improve their livelihoods (Adeyemi *et al.,* 2019). In urban areas, water leaf is a popular vegetable in local markets, and its high demand contributes to the creation of employment opportunities in the vegetable supply chain, from farming to retail (Olaniyi et al., 2020). Thus, the expansion of water leaf production could be an important strategy for poverty alleviation in rural areas and for promoting gender equity in agriculture.

The high nutritional value of water leaf also extends beyond its use as a food source. Studies have highlighted its medicinal properties, particularly in the treatment of conditions such as hypertension, diabetes, and inflammatory diseases. The plant contains bioactive compounds that exhibit antioxidant, anti-inflammatory, and antimicrobial properties, contributing to its role in traditional medicine (Ekpo & Etim, 2009). The medicinal potential of water leaf has prompted interest in exploring its therapeutic benefits, particularly in the context of improving public health outcomes in resource-limited settings. Research into the phytochemical composition of water leaf continues to uncover its potential as a natural remedy for various ailments, supporting its cultivation as both a food and medicinal plant.

## 2.2 Plant Spacing and Crop Growth

Plant spacing is a key agronomic practice that influences the growth and yield of crops. It determines the physical space available for individual plants to grow and interact with their environment (Agbo *et al*., 2015). Inadequate spacing results in overcrowding, which limits access to essential resources such as light, water, and nutrients. This often leads to poor plant growth, reduced photosynthetic efficiency, and stunted development. On the other hand, excessive spacing can lead to inefficient land use and reduced crop yield per unit area (Tindall, 1983).

The relationship between plant spacing and growth is dependent on various factors, including the species being cultivated, soil fertility, and climatic conditions. For instance, closely spaced plants tend to experience increased competition for light, water, and nutrients, which can reduce their overall performance (Obasi *et al.,* 2016). Conversely, plants spaced too far apart may experience underutilization of available space, resulting in lower plant density and suboptimal use of resources. Hence, determining the ideal spacing for each crop species is essential for maximizing both individual plant health and overall crop yield (Akinfasoye & Olaniyi, 2012).

One of the primary factors influencing the optimal plant spacing is the plant's growth habit, which includes its height, width, and root system (Kigel, 1995). Plants that have a high growth potential, such as tall crops or those with wide canopies, require more space to avoid competition and ensure maximum exposure to sunlight for photosynthesis. In contrast, smaller crops, or those with compact growth habits, may benefit from closer spacing (Kossou *et al.,* 2019). For example, densely planted crops such as lettuce or radishes tend to yield better when spaced closer together due to their relatively small size and shallow root systems (Abubakar & Adeniyi, 2018). Thus, the ideal spacing is often species-specific and must be tailored to the unique characteristics of the plant.

Soil fertility plays a crucial role in the effectiveness of plant spacing. Crops grown in soils with high nutrient content can tolerate closer planting distances as the abundant nutrients reduce the severity of competition (Miller *et al.,* 2015). However, in soils with lower fertility, crops are more likely to suffer from nutrient deficiencies if spaced too closely together, leading to poor plant growth. This highlights the need for proper soil management practices, including the use of fertilizers and organic amendments, to complement ideal plant spacing. In some cases, adjusting plant spacing and improving soil fertility can significantly enhance crop yields, especially in marginal lands (Olufayo *et al.,* 2019).

In addition to soil fertility, water availability is another critical factor influencing plant spacing. Crops that require significant amounts of water, such as water-intensive vegetables like cucumbers or tomatoes, may benefit from wider spacing to ensure that each plant has adequate access to water (Koehler *et al.,* 2016). Overcrowding in water-scarce environments can lead to water stress, reducing crop vigor and increasing susceptibility to diseases. Conversely, in areas with abundant water, narrower plant spacing may be more suitable, as it allows for better utilization of available moisture, thereby improving crop yield per unit area (Okwu, 2017).

The impact of plant spacing on crop growth also varies with climatic conditions. In hot and dry climates, crops spaced too closely together may suffer from heat stress and reduced transpiration, which can negatively affect photosynthesis and overall plant health (Wang et al., 2020). Conversely, in cooler and more humid climates, close spacing may be beneficial as it helps create a microclimate that retains moisture and reduces temperature fluctuations, providing a more stable growing environment for the plants (Mohammed *et al.,* 2021). Therefore, farmers must consider local weather patterns and temperature ranges when determining the ideal spacing for each crop.

Another important consideration when deciding plant spacing is the potential for disease spread. Overcrowded plantings create a more favorable environment for the transmission of pathogens, particularly fungal and bacterial diseases, due to the increased humidity and reduced air circulation between plants (Mishra & Singh, 2020). In some crops, such as tomatoes and peppers, closer spacing has been associated with higher incidences of foliar diseases, as the dense canopy restricts airflow and creates a humid environment conducive to pathogen growth (Fischer *et al.,* 2021). Proper spacing can therefore reduce disease risk and improve the overall health of the plants.

Plant spacing also has implications for weed control. In closely spaced plantings, the canopy of the plants can naturally suppress weed growth by shading the soil and reducing light availability for weeds (Li *et al.,* 2017). This natural weed suppression can reduce the need for chemical herbicides, leading to more sustainable farming practices. In contrast, plants spaced too far apart may leave more bare soil exposed, creating opportunities for weed growth and competition with the crops. Thus, plant spacing plays a vital role in integrated pest and weed management strategies (Olufayo *et al.,* 2019).

In agroforestry systems, plant spacing is particularly important for optimizing land use. Agroforestry integrates trees and crops to increase farm productivity and biodiversity while providing additional income streams. Proper spacing between trees and crops ensures that both plant types have access to adequate resources without significant competition. For instance, in intercropping systems, crops like water leaf (*Talinum triangulare*) can be grown alongside tree species with wider spacing to reduce shading and ensure efficient resource allocation (Kossou *et al.,* 2019). Agroforestry systems that consider optimal plant spacing have been shown to improve soil quality, water retention, and biodiversity while supporting sustainable agricultural practices.

The concept of plant spacing also extends to the practice of precision agriculture, which utilizes advanced technologies such as remote sensing, drones, and GPS to monitor plant health and optimize resource use (Cai *et al.,* 2020). In precision agriculture, plant spacing is tailored to real-time data about soil moisture, nutrient levels, and environmental conditions. By using this technology, farmers can adjust plant spacing dynamically to improve crop performance and reduce input costs. This technological approach has the potential to revolutionize the way plant spacing is managed, offering more precise control over crop growth and yield (Zhao *et al.,* 2021).

Finally, plant spacing is a critical aspect of sustainable agricultural practices. By optimizing spacing, farmers can improve land productivity, reduce the need for chemical inputs, and minimize the environmental impact of farming. Research continues to explore how different plant spacing techniques can be used in various cropping systems to promote sustainability, especially in the face of climate change and growing global food demands (Mohammed *et al.,* 2021). In this regard, understanding the interactions between plant spacing, soil health, water management, and crop variety will be essential for developing resilient farming systems that can support future food security.

### 2.3 Effect of Plant Spacing on Water Leaf Growth and Yield

Research on the effect of plant spacing on the growth and yield of water leaf has shown that the spacing between plants has a significant impact on various growth parameters, including plant height, leaf area, and biomass yield. A study by Olaniyi *et al.* (2020) found that closer spacing led to increased plant height and stem elongation due to competition for light. However, these plants exhibited fewer leaves, which reduced their photosynthetic capacity and biomass production. In contrast, plants spaced further apart had larger leaves, more branches, and a higher biomass yield but a lower plant density. These findings indicate that while closer spacing can encourage vertical growth, it may not necessarily translate into higher yields due to the reduction in leaf area and photosynthetic activity.

In a study by Agbo *et al.* (2015), it was observed that a spacing of 30 cm × 30 cm was optimal for maximizing the yield of water leaf, as it allowed for sufficient sunlight penetration and nutrient availability while maintaining a reasonable plant population per unit area. Similarly, Ekpo & Etim (2009) reported that spacing treatments of 25 cm × 25 cm and 30 cm × 30 cm resulted in significant increases in both leaf area and fresh weight of water leaf plants. However, wider spacing (greater than 40 cm) resulted in underutilization of the land, leading to lower overall yields. The balance between plant density and available resources is crucial to optimizing water leaf productivity.

Moreover, spacing affects not only the growth of water leaf but also its susceptibility to pests and diseases. Closer spacing can promote the spread of fungal and bacterial infections due to higher humidity and poor air circulation, which may negatively affect the health of the plants and reduce yield (Ogunlesi *et al.,* 2010). Thus, optimal spacing can also contribute to better pest and disease management in water leaf farming. Proper spacing between plants allows for better airflow and sunlight penetration, which helps to reduce the conditions that favor the proliferation of pathogens.

Plant spacing also influences water leaf's ability to capture and utilize light for photosynthesis. According to a study by Nwachukwu *et al.* (2021), plants spaced at 30 cm × 30 cm were able to capture more light compared to those planted at wider spacings, leading to increased photosynthetic efficiency and enhanced growth. These plants exhibited improved leaf area index (LAI), which is a key indicator of the plant’s ability to absorb sunlight. In contrast, plants spaced too far apart had lower LAI and, consequently, less efficient light utilization.

In addition to light availability, the spacing of water leaf affects the plant’s root system. A study by Adesanya *et al.* (2019) found that plants with closer spacing developed shallower root systems due to competition for space and nutrients. Shallow roots reduce the plant’s ability to access deep soil moisture and nutrients, leading to reduced growth and lower biomass production. On the other hand, plants spaced farther apart tend to have deeper root systems, which allow for better water and nutrient absorption, thus promoting healthier growth and higher yields.

The effect of spacing on water leaf yield is also influenced by the fertility of the soil. Research by Ogunleye *et al.* (2020) highlighted that water leaf plants grown in high fertility soils benefitted more from closer spacing, as the abundant nutrients helped compensate for the competition between plants. However, in low fertility soils, wider spacing allowed for better resource utilization, as the plants had more room to access soil nutrients. This suggests that the optimal spacing for water leaf may vary depending on soil nutrient levels.

A study conducted by Ekanem *et al.* (2021) examined the effect of plant spacing on the growth and yield of water leaf under varying water regimes. It was found that under rain-fed conditions, closer spacing led to better yield, as the plants could take advantage of rainfall more efficiently. However, under irrigated conditions, wider spacing resulted in higher yields, likely due to better root expansion and more efficient water usage. This highlights the importance of considering irrigation methods when determining the ideal spacing for water leaf.

Moreover, water leaf is sensitive to inter-plant competition, particularly in the early stages of growth. In a study by Ibrahim *et al.* (2022), it was shown that water leaf plants grown at a spacing of number during the first four weeks of growth showed significant stunting due to competition for light, water, and nutrients. After the first month, however, the plants began to adapt to the competition and exhibited increased growth and biomass production. This suggests that plant spacing should not only consider the final spacing but also account for the plant's early growth phase.

The management of plant spacing in water leaf farming also plays a role in optimizing harvest frequency. According to Adeyemi *et al.* (2019), closer spacing led to faster canopy closure, which enabled earlier harvesting of the leaves. This allowed farmers to harvest multiple times within a growing season, contributing to increased overall yield. However, if the spacing is too tight, the plants may not reach their full potential, leading to smaller leaves and lower biomass accumulation over time.

Another aspect of plant spacing is its influence on the plant's ability to resist environmental stress. Water leaf, like other crops, can experience stress due to factors such as drought, heat, and nutrient deficiencies. Studies by Nwankwo *et al.* (2020) have shown that water leaf plants spaced at 30 cm × 30 cm tend to be more resilient under stress conditions. The optimal spacing allows for better access to water and nutrients, which helps the plants cope with adverse environmental conditions. In contrast, overcrowded plants are more susceptible to stress-induced damage, which can reduce overall yield. Farmers may also consider the economic implications of plant spacing. A study by Akinmoladun *et al.* (2021) demonstrated that while wider spacing may result in higher individual plant yield, the total yield per hectare can be reduced due to lower plant density. Therefore, farmers must carefully balance plant spacing to ensure they maximize their land's productivity and economic return. The economic benefits of optimal spacing extend beyond just yield, as better pest and disease management, improved water use, and efficient use of inputs contribute to sustainable farming practices.

### 2.4 Agronomic Practices for Improved Water Leaf Cultivation

In addition to plant spacing, other agronomic practices, such as soil fertility management, irrigation, and pest control, play a crucial role in improving the yield of water leaf. According to Olaniyi *et al.* (2010), the application of organic and inorganic fertilizers significantly enhances the growth of water leaf, with a marked increase in biomass and leaf production. Similarly, proper irrigation practices, such as drip irrigation, ensure that the plants receive adequate water, especially during dry spells, thus supporting continuous growth and preventing water stress (Adewusi & Afolayan, 2018).

The integration of spacing with other crop management techniques is also vital for optimizing water leaf production. For instance, the combination of proper spacing and the use of mulching can help maintain soil moisture and reduce the growth of weeds, which compete with water leaf for nutrients (Akinfasoye & Olaniyi, 2012). In addition, crop rotation and intercropping with complementary species have been found to improve soil fertility and reduce the build-up of pests and diseases in water leaf fields (Ibeawuchi *et al.,* 2007).

Despite the recognition of plant spacing as a crucial factor in crop production, there is still a lack of specific research on the ideal spacing for water leaf cultivation in various ecological zones, including the Northern Guinea Savanna of Nigeria. The diversity of environmental conditions in different regions of the country necessitates localized research to develop site-specific recommendations for water leaf farmers. This is particularly important in areas like Mubi, where climatic conditions, soil types, and farming practices may vary significantly from other parts of the country.

Recent studies have underscored the importance of region-specific agronomic research to enhance crop yield and sustainability (Adeyemi *et al.,* 2019). Given the growing demand for leafy vegetables in urban and rural markets, optimizing water leaf production through proper plant spacing could lead to increased income for farmers, greater food security, and better health outcomes for consumers. Additionally, improving water leaf yield could contribute to the diversification of vegetable farming in Nigeria, providing farmers with an alternative source of income and enhancing rural development (Ogunlesi *et al.,* 2010).

The reviewed literature demonstrates that plant spacing is a key factor influencing the growth, yield, and quality of water leaf (Talinum triangulare). Research has shown that optimized spacing improves photosynthesis, nutrient absorption, and overall plant health, while also reducing the risks of pest and disease outbreaks. However, a gap remains in the research regarding the ideal spacing for water leaf cultivation, particularly in areas like Mubi. Therefore, further studies on plant spacing, coupled with other agronomic practices, are essential to improving the productivity of water leaf in these regions.

# CHAPTER THREE

# RESEARCH METHODOLOGY

## 3.1 Study Area

The study will be conducted at the student research and practical farm of the department of Agricultural Technology, Federal Polytechnic, 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, 2014).

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, 2014);

## 3.2 Experimental Design and Layout

The experiment will be conducted to evaluate the effect of different plant spacings on the growth and yield of water leaf (*Talinum triangulare*). The study consisted of four (4) different spacing, namely: T₀ = 10 cm × 10 cm, T₁ = 15 cm × 15 cm, T₂ = 20 cm × 20 cm, and T₃ = 25 cm × 25 cm. Each treatment will be replicated three (3) times and arranged in a Randomized Complete Block Design (RCBD) to reduce the effect of variability across the field. A total of twelve (12) plots will be constructed, with each sub-plot measuring 2 m × 3 m, and separated by an alley of 0.5 meters on all sides, and 1 meter between replication bringing the total experimental area to 115.5 m². The soil will be manually tilled using a hoe to achieve a fine tilth, after which the beds were uniformly levelled.

3m

2m

REP III

REP II

REP I

.

1m

Figure 3.1: Field layouts of the experiment

**Key:**

**Rep 1 -** means replication 1

**Rep 2 -** means replication 2

**Rep 3 -** means replication 3

## 3.3 Cultural Practice

The cultural practice to be employed for this experiment include the following

***3.3.1 Ploughing***

After clearing the field and demarcating each plot will be prepared manually with a hoe. The soil will be dugged mixed with cow dung manure in each case and levelled flat after which beds will be made.

***3.3.2 Sowing***

For the purpose of this research, a vegetable crop (Water leaf) a variety will be selected. Two (2) will be placed into the soil at a depth of 40+40cm both between crop row as well as between stands.

***3.3.3 Weeding***

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

***3.3.4 Harvesting***

Matured Water leaf 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 will be taken during this experience.

**GROWTH** **PARAMETERS**

***3.4.1 Establishment count***

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

***3.4.2 Plant height***

Five (5) plants will be randomly selected from the center of each plot and tagged. The height of plant will be taken from the base of each plant to tip of the plant at 2, 3, 4 and 5 WAS using a meter rule.

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

The number of leaves appeared on the selected seedlings will be counted systematically and record at 2, 3, 4 and 5 WAS using a meter rule.

* + 1. ***Stem diameter***

Data on stem diameter from the selected Water leaf plant in each plot will be measured carefully using a digital Vanier calliper and will be record at 2, 3, 4 and 5 WAS using a meter rule.

## 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/plots***

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

* + 1. ***Grand yield***

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 (L.S.D) at 50% probability level.

# CHAPTER FOUR

# RESULTS AND DISCUSSION

**4.1 Effects of Spacing on the Height (cm) of Waterleaf (*Talinum triangulare*) at Various Weeks (3, 6 & 9)**

The effects of spacing on the height of Waterleaf (Talinum triangulare) at various weeks (3, 6 & 9) are presented in Table 1. The results showed that plant height did not differ significantly (P > 0.05) among the spacing treatments across the weeks of observation. Mean values ranged from 19.17 cm to 22.75 cm at 3 WAS, 18.71 cm to 21.82 cm at 6 WAS, and 16.91 cm to 25.04 cm at 9 WAS. The tallest plants were observed at 20 cm × 20 cm spacing (22.75 cm) at 3 WAS, and at 25 cm × 25 cm spacing (25.04 cm) at 9 WAS, while the lowest height was recorded at 15 cm × 15 cm (19.17 cm) and 20 cm × 20 cm (16.91 cm) at 3 WAS and 9 WAS, respectively.

Although the differences were not statistically significant, the trend indicates that wider spacing (25 cm × 25 cm) allowed for greater height at later stages, likely due to reduced competition for growth resources such as light, water, and nutrients. This agrees with the findings of Akinmoladun *et al.* (2022), who reported that plant spacing influences canopy development and height in leafy vegetables. Conversely, the relatively lower values at closer spacing (15 cm × 15 cm) suggest that competition among plants for available resources might have limited vertical growth.

The absence of significant differences across treatments implies that Waterleaf possesses strong adaptive ability to varying spacing distances, as also noted by Eze & Ikeh (2021), who observed that Waterleaf exhibits plasticity in growth parameters under different planting densities.

**Table 1: Effects of Spacing on the Height (cm) of Waterleaf (*Talinum triangulare*) at Various Weeks (3, 6 & 9)**

| **Spacing (cm)** | **3WAS** | **6WAS** | **9WAS** |
| --- | --- | --- | --- |
| 10×10 | 22.74ᵃ | 18.71ᵃ | 20.88ᵃ |
| 15×15 | 19.17ᵃ | 21.04ᵃ | 20.78ᵃ |
| 20×20 | 22.75ᵃ | 21.82ᵃ | 16.91ᵃ |
| 25×25 | 22.42ᵃ | 21.03ᵃ | 25.04ᵃ |
| ± SEM | 0.86 | 0.75 | 0.68 |
| LOS | NS | NS | NS |

a, b, c, d Means in the same column bearing different superscripts are significantly (P < 0.05) different, SEM = Standard Error of the Mean, LOS = Level of Significance, \*\* = Significant at P < 0.01, \* = Significant at P < 0.05, NS = Not significant, WAS = Weeks After Sowing.

**4.2 Effects of Spacing on the Number of Leaves of Waterleaf (Talinum triangulare) at Various Weeks (3, 6 & 9)**

The effects of spacing on the number of leaves of Waterleaf at various weeks (3, 6 & 9) are presented in Table 2. The results revealed no significant differences (P > 0.05) in leaf number among the spacing treatments. However, mean values showed variation across the weeks, ranging from 38.93 to 47.80 at 3 WAS, 40.30 to 48.45 at 6 WAS, and 34.52 to 46.80 at 9 WAS. The highest number of leaves was observed at 10 cm × 10 cm spacing (47.80 and 46.80) at 3 and 9 WAS, while the lowest was recorded at 15 cm × 15 cm spacing (34.52) at 9 WAS.

The trend suggests that closer spacing favored higher leaf production per plant, possibly due to competition-induced morphological adjustments that promote leaf proliferation. This observation is in line with the findings of Okon & Essien (2020), who reported that leafy vegetables produce more foliage under higher plant population density to maximize light interception.

On the other hand, wider spacing (25 cm × 25 cm) recorded moderate leaf numbers, indicating that while competition was reduced, individual plants may have prioritized stem and height development over excessive leaf formation. These findings are consistent with Olasantan (2021), who noted that leaf production in vegetables is strongly influenced by both spacing and the stage of growth.

**Table 2: Effects of Spacing on the Number of Leaves of Waterleaf (*Talinum triangulare*) at Various Weeks (3, 6 & 9)**

| **Spacing (cm)** | **3WAS** | **6WAS** | **9WAS** |
| --- | --- | --- | --- |
| 10×10 | 47.80ᵃ | 43.62ᵃ | 46.80ᵃ |
| 15×15 | 41.40ᵃ | 40.80ᵃ | 34.52ᵃ |
| 20×20 | 38.93ᵃ | 48.45ᵃ | 39.23ᵃ |
| 25×25 | 43.20ᵃ | 40.30ᵃ | 35.10ᵃ |
| ± SEM | 0.59 | 0.51 | 0.49 |
| LOS | NS | NS | NS |

a, b, c, d Means in the same column bearing different superscripts are significantly (P < 0.05) different, SEM = Standard Error of the Mean, LOS = Level of Significance, \*\* = Significant at P < 0.01, \* = Significant at P < 0.05, NS = Not significant, WAS = Weeks After Sowing.

**4.3 Effects of Spacing on Stem Girth (mm) of Waterleaf (*Talinum triangulare*) at Various Weeks (3, 6 & 9)**

The effects of spacing on stem girth of Waterleaf at various weeks (3, 6 & 9) are presented in Table 3. Results showed no significant differences (P > 0.05) among the treatments across the weeks. Mean stem girth values ranged from 6.22 mm to 8.22 mm at 3 WAS, 7.08 mm to 7.65 mm at 6 WAS, and 4.50 mm to 6.68 mm at 9 WAS. The widest stem was observed at 25 cm × 25 cm spacing (8.22 mm) at 3 WAS, while the narrowest was at the same spacing (4.50 mm) at 9 WAS.

Though the differences were not statistically significant, the observed trend suggests that wider spacing may promote stem thickening at the early stages due to greater availability of resources per plant. However, by 9 WAS, stem girth values tended to converge across treatments, implying that Waterleaf plants exhibit compensatory growth regardless of initial spacing.

This observation corroborates the findings of Adeyemi *et al.* (2022), who noted that spacing influences early vegetative traits such as stem girth, but its effect diminishes as plants mature and self-regulate growth. Similarly, Adediran *et al.* (2021) reported that waterleaf has high resilience to density stress, with stem girth adjusting to optimize nutrient uptake and canopy support.

**Table 3: Effects of Spacing on Stem Girth (mm) of Waterleaf (*Talinum triangulare*) at Various Weeks (3, 6 & 9)**

| **Spacing (cm)** | **3WAS** | **6WAS** | **9WAS** |
| --- | --- | --- | --- |
| 10×10 | 7.27ᵃ | 7.08ᵃ | 6.17ᵃ |
| 15×15 | 6.31ᵃ | 7.14ᵃ | 6.02ᵃ |
| 20×20 | 6.22ᵃ | 7.65ᵃ | 6.68ᵃ |
| 25×25 | 8.22ᵃ | 7.47ᵃ | 4.50ᵃ |
| ± SEM | 0.20 | 0.17 | 0.34 |
| LOS | NS | NS | NS |

a, b, c, d Means in the same column bearing different superscripts are significantly (P < 0.05) different, SEM = Standard Error of the Mean, LOS = Level of Significance, \*\* = Significant at P < 0.01, \* = Significant at P < 0.05, NS = Not significant, WAS = Weeks After Sowing.

**CHAPTER FIVE**

**CONCLUSION AND RECOMMENDATIONS**

**5.1 Conclusion**

This study was carried out to evaluate the effect of different plant spacing distances on the growth and yield of waterleaf (*Talinum triangulare*) under field conditions in Mubi, Northern Guinea Savanna. The specific objectives were to determine how spacing influences growth parameters such as plant height, number of leaves, and stem girth, to assess its effect on yield components, and to recommend the optimal spacing distance for maximizing growth and yield.

Data were collected on establishment count, plant height, number of leaves, and stem girth at different Weeks After Sowing (WAS). The results showed that plant spacing did not significantly (P > 0.05) affect plant height, leaf number, or stem girth across the treatments. However, observable trends indicated that closer spacing (10 × 10 cm) promoted higher leaf production, while wider spacing (25 × 25 cm) tended to favor taller plants and thicker stems at early stages. These findings suggest that waterleaf exhibits strong adaptability to different spacing regimes, though competition and resource availability influenced the growth trends.

The findings of this study reveal that plant spacing has an influence on the morphological traits of waterleaf, even though the effects were not statistically significant. Closer spacing enhanced foliage production, which is desirable for leaf yield, while wider spacing encouraged stem girth and height development at certain stages. This demonstrates that the choice of spacing depends on whether the production goal is maximizing leaf biomass or optimizing plant vigor.

**5.2 Recommendations**

Based on the results and observations of this study, the following recommendations are made:

1. Adopt moderate spacing (15 × 15 cm to 20 × 20 cm): This provides a balance between leaf production and overall plant growth, ensuring efficient land use and resource distribution.
2. Closer spacing (10 × 10 cm): Farmers who prioritize higher leaf yield for commercial or subsistence purposes may adopt closer spacing to encourage greater foliage development.
3. Wider spacing (25 × 25 cm): This can be practiced where soil fertility is low, or where larger individual plants are required, but it may reduce overall yield per hectare.
4. Further research: Multi-season studies should be conducted to validate the long-term effects of spacing on waterleaf growth and yield under different soil and climatic conditions.
5. Extension services: Agricultural extension agents should educate farmers on evidence-based agronomic practices, including optimal spacing, to improve productivity and sustainability in waterleaf farming.