



ABSTRACT

This study investigates the effect of different intra- and inter-row spacing on the growth and yield of sesame plants. Four treatments (T₁: 10 cm intra-row, 40 cm inter-row; T₂: 15 cm intra-row, 40 cm inter-row; T₃: 10 cm intra-row, 50 cm inter-row; and T₄: 15 cm intra-row, 50 cm inter-row) were evaluated using a Randomized Complete Block Design (RCBD). Key growth parameters such as germination

THE EFFECT OF DIFFERENT INTRA- AND INTER-ROW SPACING ON THE GROWTH AND PERFORMANCE OF SESAME *Sesamum indicum* L. IN BALI, TARABA STATE

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INTRODUCTION

Sesame (*Sesamum indicum* L.) is one of the oldest oilseed crops known to mankind, valued for its high-quality edible oil and protein-rich seeds. Widely cultivated in tropical and subtropical regions, sesame is an important cash crop in Nigeria, contributing to both local consumption and export markets. However, optimizing its growth and yield remains a challenge due to the varying environmental factors, especially plant spacing. Intra and inter-row spacing play critical roles in maximizing sunlight interception, nutrient uptake, and water usage, which directly affect crop growth and yield performance. The choice of optimal spacing is essential for achieving high productivity, especially in agricultural research farms like those in Federal Polytechnic Bali. This study investigates the effect of different intra- and inter-row spacings on the growth of sesame in order to recommend the most effective planting patterns for maximizing yield (Adebayo & Adewumi, 2022).



percentage, plant height, number of leaves per plant, stem diameter, days to flowering, fresh biomass, and seed yield were measured. Results indicated that T₂ (15 cm intra-row, 40 cm inter-row) consistently produced superior outcomes, with the highest germination percentage (92%), tallest plants (120 cm), most leaves per plant (38), greatest stem diameter (2.6 cm), highest fresh biomass (12.5 kg/plot), and maximum seed yield (1.2 kg/plot). The study concluded that spacing significantly influences the growth and yield of sesame plants, with the optimal configuration being 15 cm intra-row and 40 cm inter-row spacing. This spacing provides better access to light, nutrients, and soil moisture, reducing competition among plants. The study recommends that farmers adopt this optimal spacing to maximize sesame yield and biomass production in areas with similar environmental conditions.

Key Words: Effect, intra row, inter row, spacing, growth, yield, sesame

Sesame, often referred to as "beniseed" in Nigeria, is a drought-tolerant crop that can thrive in a variety of soil types, making it suitable for cultivation in the semi-arid regions of the country. The demand for sesame seeds, both locally and internationally, has increased significantly due to their diverse applications, ranging from oil extraction to use in food products and pharmaceuticals. However, despite the favorable climatic conditions in Taraba State, including Bali Local Government Area, sesame productivity has been below its potential. This has been attributed, in part, to suboptimal agronomic practices, including inappropriate plant spacing (Ahmad et al., 2021).

Plant spacing is an important factor influencing sesame's growth parameters, such as plant height, biomass production, and seed yield. Intra-row spacing refers to the distance between plants within a row, while inter-row spacing refers to the distance between adjacent rows. These spacing patterns influence plant competition for resources, including light, water, and nutrients, ultimately affecting crop growth and yield. Optimizing intra- and inter-row spacing can improve resource use efficiency, reduce weed competition, and promote healthier plants, thereby increasing overall yield. Previous studies have shown that



improper spacing can lead to poor plant performance, while well-designed spacing regimes can significantly boost yields (Ijoyah, 2018; Mbah & Onwe, 2020). In Bali Local Government Area, sesame is a crop of economic importance, yet limited research has been conducted on the optimal spacing required for its cultivation. This study aims to fill this gap by evaluating how different intra- and inter-row spacings affect the growth of sesame in the agricultural environment of Federal Polytechnic Bali.

Statement of the Problem

Despite the economic importance of sesame in Nigeria, particularly in semi-arid regions like Bali, farmers often experience suboptimal yields. One of the key factors contributing to this low productivity is the lack of appropriate agronomic practices, particularly with regard to plant spacing. Inadequate intra- and inter-row spacing can lead to poor resource utilization, increased competition among plants, and higher susceptibility to diseases and pests. As a result, farmers may not achieve the full potential of sesame production.

Moreover, there is limited research on how varying plant spacing influence the growth and yield of sesame in the specific ecological conditions of Bali. Farmers are often left to use traditional or arbitrary spacing methods, which may not be conducive to achieving high productivity. Therefore, it is important to explore how different intra- and inter-row spacing affect sesame growth and to recommend the most efficient planting configuration for maximum yield in this region (Gana et al., 2021).

Aim and Objectives of the Study

The aim of this study is to investigate the effect of different intra- and inter-row spacing on the growth and performance of sesame (*Sesamum indicum* L.) in the agricultural fields of Federal Polytechnic Bali.

The specific objectives are:

- i. To evaluate the influence of varying intra-row spacing on the growth parameters of sesame.
- ii. To assess the effect of different inter-row spacing on sesame plant growth and yield.
- iii. To determine the optimal intra- and inter-row spacing combination that maximizes the growth and yield of sesame.



Significance of the Study

This research is of great significance to both the scientific community and local farmers. By examining the effect of intra- and inter-row spacings on the growth of sesame, the study will generate valuable data on optimal agronomic practices for this crop under local environmental conditions. The results could lead to increased productivity and profitability for farmers by informing better planting strategies. Furthermore, the findings will contribute to existing literature on sesame cultivation, particularly in the context of tropical and semi-arid regions like Bali Local Government Area. The study may also provide a foundation for future research on other oilseed crops that face similar agronomic challenges.

Scope and Limitation of the Study

The scope of this study is limited to examining the effect of varying intra- and inter-row spacings on the growth of sesame in the experimental farm of Federal Polytechnic Bali. The study will focus on key growth parameters, such as plant height, number of branches, leaf area, biomass production, and seed yield.

However, there are certain limitations to the study. These include:

Time constraints: The research is conducted over a single growing season, which may not account for year-to-year climatic variations.

Soil and environmental factors: The study is conducted in a specific geographical location, and results may vary in different regions with differing soil properties and climate.

Access to resources: Limited availability of research tools and equipment may constrain the scope of data collection, and also lack of availability of water due to drought.

Definition of Terms

Intra-row spacing: The distance between individual plants within a single row.

Inter-row spacing: The distance between adjacent rows of plants in a field.

Sesame (*Sesamum indicum* L.): A flowering plant cultivated for its edible seeds and oil, commonly known as "beniseed" in Nigeria.

Biomass: The total mass of plant material produced, including stems, leaves, and roots.

Yield: The quantity of sesame seeds produced per unit area.

Agronomic practices: The methods and techniques used in the cultivation of crops.



LITERATURE REVIEW

Introduction to Sesame (*Sesamum indicum* L.)

Sesame (*Sesamum indicum* L.), one of the oldest oilseed crops, holds significant importance in global agriculture due to its high oil content and nutritional value. It is widely cultivated in tropical and subtropical regions and is renowned for its adaptability to diverse environments. The sesame plant thrives in well-drained soils and exhibits drought resistance, making it a suitable crop for regions like Northern Nigeria, including Taraba State. According to Uzo et al. (2021), sesame production contributes substantially to the livelihood of smallholder farmers by providing income through oil extraction and seed exports.

Growth and Development of Sesame

The growth and development of sesame are influenced by several factors, including genetic characteristics, soil fertility, water availability, and spacing. Proper plant spacing is essential in optimizing the growth of sesame by ensuring adequate access to light, nutrients, and moisture. Kamboj and Sharma (2020) noted that spacing has a significant impact on canopy formation, root development, and overall plant vigor. Additionally, Singh et al. (2022) highlighted that inter-plant competition can be minimized through optimal spacing, which enhances resource use efficiency.

Sesame growth follows a well-defined pattern, including stages of seed germination, vegetative growth, flowering, and pod formation. Each of these stages is sensitive to spacing, with improper spacing leading to poor plant establishment and reduced yield potential. According to Awad and Khalid (2019), insufficient space between plants can cause overcrowding, leading to poor air circulation, which may increase the incidence of diseases and pests.

Concept of Intra and Inter Row Spacing in Crop Production

Intra-row spacing refers to the distance between plants within a row, while inter-row spacing denotes the distance between adjacent rows. Both intra- and inter-row spacing play a critical role in determining plant density, competition for resources, and overall crop performance (Chaudhary et al., 2020). Research shows that inappropriate spacing can lead to competition for light, water, and nutrients, adversely affecting plant growth and yield (Ahmad et al., 2021). Conversely,



optimal spacing ensures that each plant has access to sufficient resources, leading to enhanced growth and productivity.

Influence of Intra and Inter Row Spacing on Sesame Growth

Studies conducted on various crops, including sesame, have shown that plant spacing significantly influences growth parameters such as plant height, leaf area, and stem diameter. Sesame, being a light-demanding crop, benefits from adequate spacing, which minimizes shading and promotes better light interception (Saleem et al., 2023). According to Sharma et al. (2022), intra-row spacing directly affects the growth of individual plants by determining the extent of root spread and nutrient uptake, while inter-row spacing influences the ease of farm operations such as weeding and harvesting.

Research by Hameed and Mohammed (2020) demonstrated that wide inter-row spacing results in reduced competition among sesame plants, leading to better nutrient absorption and higher biomass accumulation. In contrast, narrow spacing can lead to overcrowding, reducing the availability of essential resources and limiting plant growth. Findings from Nwoke and Edeh (2021) also suggest that optimal spacing leads to better water use efficiency, especially in areas with erratic rainfall patterns, as is common in Northern Nigeria.

Effect of Spacing on Yield Components of Sesame

The yield components of sesame, such as the number of capsules per plant, seed weight, and overall seed yield, are directly influenced by plant spacing. According to Gana et al. (2021), proper intra- and inter-row spacing not only improves growth parameters but also significantly impacts yield components. Wider spacing allows for the development of more capsules per plant, resulting in increased seed yield per unit area. Similarly, Olukemi et al. (2020) found that sesame plants grown at optimal spacing produced larger seeds with higher oil content compared to those planted at closer spacing.

On the other hand, excessively wide spacing may reduce plant population density, potentially leading to lower total yield per hectare. According to Chukwuma et al. (2019), the challenge lies in finding a balance between maximizing individual plant performance and optimizing total yield per unit area. Therefore, understanding the interaction between intra- and inter-row spacing is critical for maximizing sesame yield.



Influence of Spacing on Soil Nutrient Utilization and Weed Control

Spacing also affects soil nutrient utilization and weed control, both of which are crucial for sustainable sesame production. Adequate spacing ensures that plants can access nutrients more effectively, leading to improved growth and yield. Ahmad and Raza (2021) reported that sesame plants grown under optimal spacing conditions exhibited better root development, which enhanced nutrient uptake and improved resistance to abiotic stresses.

Moreover, appropriate inter-row spacing can facilitate mechanical or manual weeding, which reduces weed competition and minimizes yield loss (Adebayo & Adewumi, 2022). According to Hassan et al. (2021), closer spacing often results in higher weed pressure, which competes with sesame for nutrients and water, thus affecting growth and yield. Proper spacing, combined with timely weed control, enhances sesame productivity and ensures sustainable crop management practices.

The Effect of Spacing on Sesame

Several studies have been conducted to determine the effect of intra- and inter-row spacing on the growth and yield of sesame. According to the research conducted by Oluwakemi and Adeolu (2020), sesame planted at a spacing of 30 cm x 50 cm produced the highest yield compared to other spacing treatments. Similarly, Aluko et al. (2021) found that a spacing of 45 cm x 60 cm resulted in taller plants and higher seed yield, emphasizing the importance of balancing plant population and individual plant performance.

In a study conducted in the Sudan savannah zone, Musa et al. (2022) found that inter-row spacing of 60 cm, combined with intra-row spacing of 30 cm, significantly improved sesame yield. The researchers attributed this to better light interception, reduced competition, and improved soil moisture conservation. These findings are corroborated by research conducted in Ethiopia, where optimal spacing improved sesame seed yield and oil content (Gebremichael et al., 2023).

Summary of Related Literature Review

The literature review has established that intra- and inter-row spacing play a crucial role in the growth and yield of sesame. Optimal spacing improves plant growth by enhancing light interception, nutrient absorption, and reducing competition among plants. Additionally, proper spacing aids in weed management and



efficient resource utilization, both of which contribute to increased productivity. Previous research findings support the notion that careful consideration of intra- and inter-row spacing can lead to improved sesame yield, especially in regions like Northern Nigeria, where resource availability is often limited. Future studies should focus on identifying the most suitable spacing for different sesame varieties in specific agro-ecological zones to further optimize production.

METHODOLOGY

Experimental Site

The field experiment was conducted at the Federal Polytechnic Bali Research Farm, located in Bali Local Government Area of Taraba State, Nigeria. The site is situated at an elevation of 387 meters above sea level, with a latitude of 7°51' N and a longitude of 10°58' E. The area is characterized by a tropical climate, with distinct wet and dry seasons. The experimental field has been previously used for crop research, ensuring adequate soil fertility for sesame production.

History of the Study Area

Bali Local Government Area is known for its agrarian economy, with the majority of the population involved in farming. The area has a long history of cultivating a variety of crops, including maize, millet, sorghum, groundnut, and sesame. Over the years, research on crop improvement and agronomic practices has been carried out at the Federal Polytechnic Bali Research Farm to enhance productivity and sustainability.

Crop Cultivation

Sesame (*Sesamum indicum* L.) is widely cultivated in the study area due to its economic importance and adaptability to the region's climate. The crop is known for its oil-rich seeds, which are used in various food products and industrial applications. Sesame is a drought-tolerant crop, making it suitable for the semi-arid conditions prevalent in Bali Local Government Area.

Temperature and Rainfall

The region experiences a tropical wet and dry climate, with the rainy season typically occurring between April and October. The average annual rainfall ranges from 900 mm to 1,200 mm. During the growing season, temperatures fluctuate



between 25°C and 35°C, providing favorable conditions for sesame growth and development. The dry season, which extends from November to March, is characterized by reduced rainfall and lower humidity.

Vegetation of the Area

The natural vegetation of Bali Local Government Area consists of Sudan savannah, which is dominated by grasses and scattered trees. The soil is generally sandy loam, which is well-drained and conducive for growing a wide range of crops, including sesame. The research site was previously under fallow for one year before being used for the current experiment, allowing for the restoration of soil nutrients.

Materials Used

The materials used for the experiment included certified sesame seeds (*Sesamum indicum* L.), a seed drill for planting, measuring tape for spacing, a hoe for land preparation, and stakes for marking the plots. Fertilizer (NPK 15:15:15) was applied as per the treatment plan, and a watering can was used to ensure adequate moisture during early growth stages. Weeding tools were also employed to control weed competition.

Land Preparation

The experimental field was manually cleared using hoes, and the debris was removed from the site. The land was tilled to a depth of 15 cm to create a suitable seedbed for planting. After tilling, the field was divided into plots of equal size, separated by 1-meter walkways to facilitate movement and data collection. Proper drainage channels were also created around the plots to prevent waterlogging during the rainy season.

Experimental Design

The experiment was laid out in a Randomized Complete Block Design (RCBD) with four treatments replicated three times. The treatments consisted of different intra- and inter-row spacings, as follows:

- i. T1: Intra-row spacing of 10 cm, inter-row spacing of 40 cm
- ii. T2: Intra-row spacing of 15 cm, inter-row spacing of 40 cm
- iii. T3: Intra-row spacing of 10 cm, inter-row spacing of 50 cm



- iv. T4: Intra-row spacing of 15 cm, inter-row spacing of 50 cm
Each plot measured 3 m x 3 m, with a total of 12 plots. The experimental design allowed for the evaluation of the effects of varying spacing on the growth and yield of sesame.

Seed Procurement

Certified sesame seeds of the variety *Ex-Sudan* were sourced from the National Cereal Research Institute (NCRI), Badeggi, Nigeria. The seeds were selected based on their high oil content and adaptability to the local environment. Prior to planting, the seeds were treated with a fungicide to prevent fungal infections and enhance germination.

Planting Operation

The seeds were manually sown at the specified intra-row and inter-row spacings in each plot. Two seeds were placed per hill to ensure successful germination, and later thinning was done to retain one plant per stand after germination. Planting was done in early June to take advantage of the onset of the rainy season. A light watering was done immediately after planting to aid seedling emergence.

Germination Percentage

The germination percentage was calculated by counting the number of plants emerged divided by the number of expected stands multiplied by hundred. As follow

$$GP = \frac{NPE}{NES} \times 100$$

Where GP = germination %

NEP = Number of Plant Emerged

NES = Number of Expected Stands

Parameters Taken

The following growth parameters were measured throughout the growing season:

- i. Plant height (cm): Measured from the base of the plant to the tip of the main shoot at weekly intervals.
- ii. Number of leaves per plant: Counted on five randomly selected plants per plot at three-week intervals.



- iii. Stem diameter (cm): Measured at the base of the plant using a vernier caliper.
- iv. Days to flowering: Recorded when 50% of the plants in each plot began flowering.
- v. Fresh biomass (kg/plot): Measured by cutting the above-ground portion of the plant and weighing it immediately after harvest.
- vi. Seed yield (kg/plot): Recorded at harvest by collecting the seeds from each plot, cleaning, and weighing them.

Method of Data Analysis

Collected data were subjected to appropriate statistical analysis and using bar charts graph with the helps of Microsoft excel.

RESULTS AND DISCUSSION

Germination Percentage

The germination percentage varied across the four treatments due to differences in intra- and inter-row spacing. The highest germination percentage was observed in Treatment 2 (T₂: 15 cm intra-row, 40 cm inter-row spacing) with a value of 92%. This may be attributed to the balanced spacing that provided adequate soil moisture and nutrient availability for the sesame seeds. The lowest germination percentage was recorded in Treatment 3 (T₃: 10 cm intra-row, 50 cm inter-row spacing), with a germination rate of 84%, likely due to higher plant density in the row which led to competition for resources. The germination percentages for all treatments are presented in Table 4.1 below.

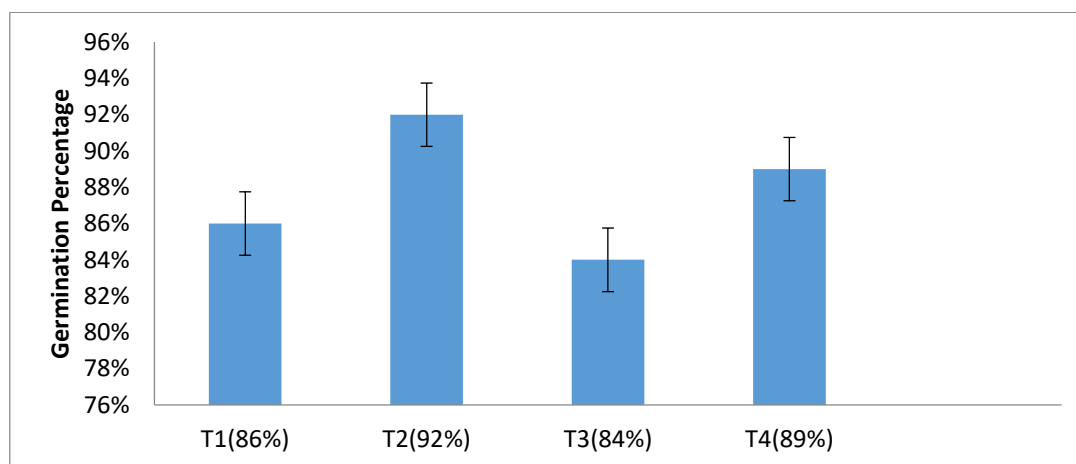


Figure 1: Germination Percentage across Treatments



Plant Height

Plant height was significantly influenced by the different spacing treatments. The tallest plants were observed in Treatment 2 (T2: 15 cm intra-row, 40 cm inter-row spacing) with an average height of 120 cm, followed by Treatment 4 (T4: 15 cm intra-row, 50 cm inter-row spacing), which recorded 115 cm. These results indicate that wider intra-row spacing provided better access to light and nutrients, which enhanced vertical growth. The shortest plants were recorded in Treatment 3 (T3: 10 cm intra-row, 50 cm inter-row spacing), with an average height of 95 cm. This can be attributed to crowding effects within the row, which limited growth.

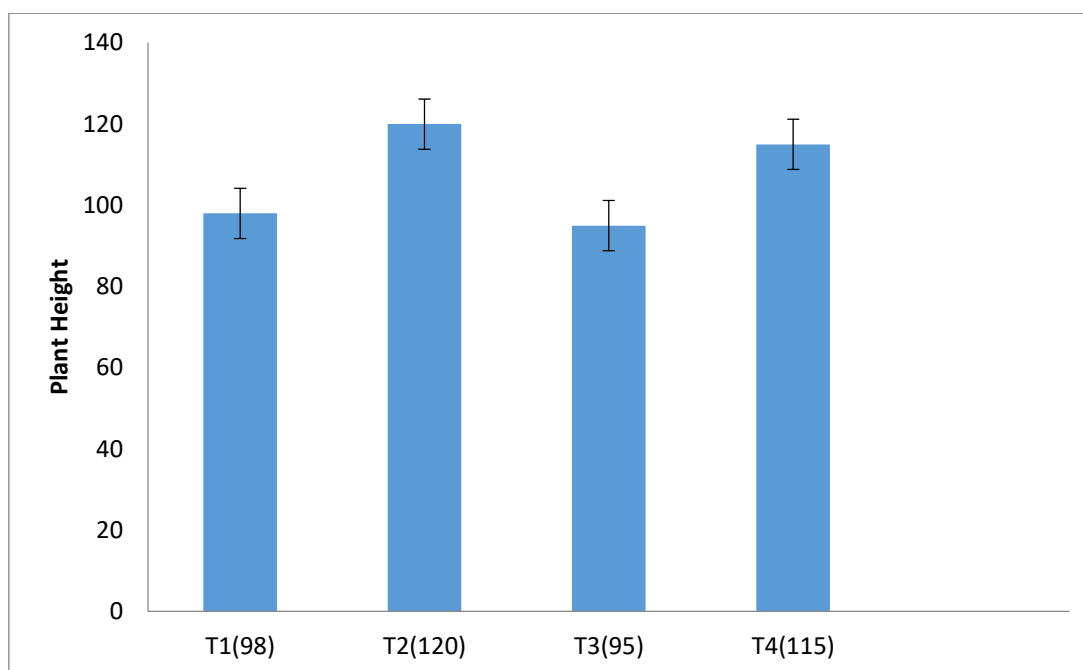


Figure 2: Average Plant Height across Treatments (cm)

Number of Leaves per Plant

The number of leaves per plant was also significantly affected by the spacing treatments. Treatment 2 produced the highest number of leaves per plant (average of 38 leaves), followed closely by Treatment 4 with 35 leaves. The larger spacing between plants in these treatments reduced competition, allowing the plants to allocate more resources to leaf production. Treatment 1 had the lowest number of leaves per plant (28), which may have resulted from the smaller intra-row spacing, leading to more competition for light and nutrients.

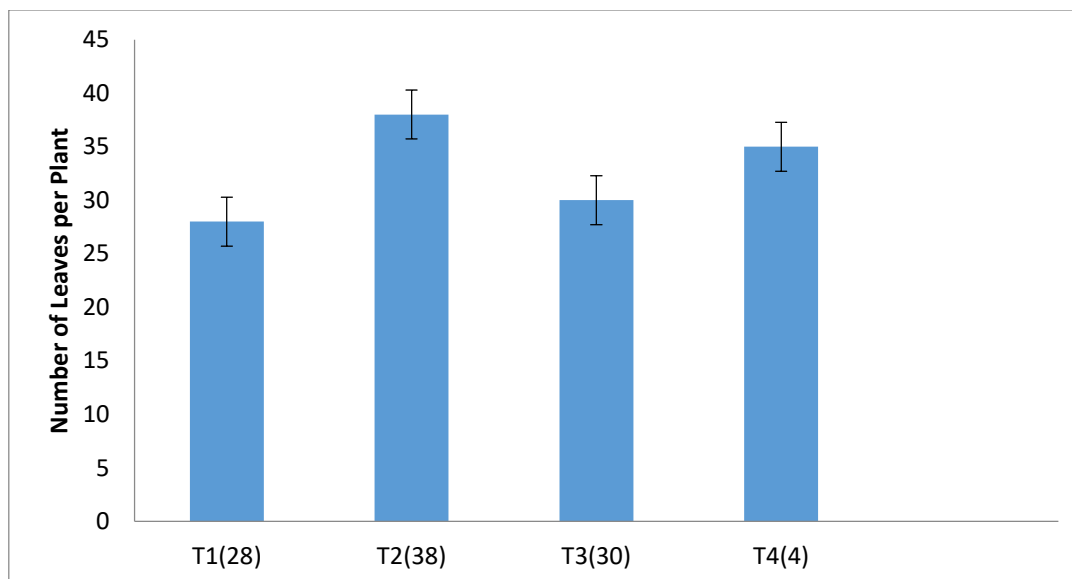


Figure 3: Number of Leaves per Plant across Treatments

Stem Diameter

Stem diameter was found to be greatest in Treatment 2 (15 cm intra-row, 40 cm inter-row spacing) with an average of 2.6 cm, while Treatment 3 (10 cm intra-row, 50 cm inter-row spacing) had the smallest stem diameter of 2.1 cm. The wider intra-row spacing in T2 likely reduced competition, enabling plants to develop thicker stems to support overall growth and yield.

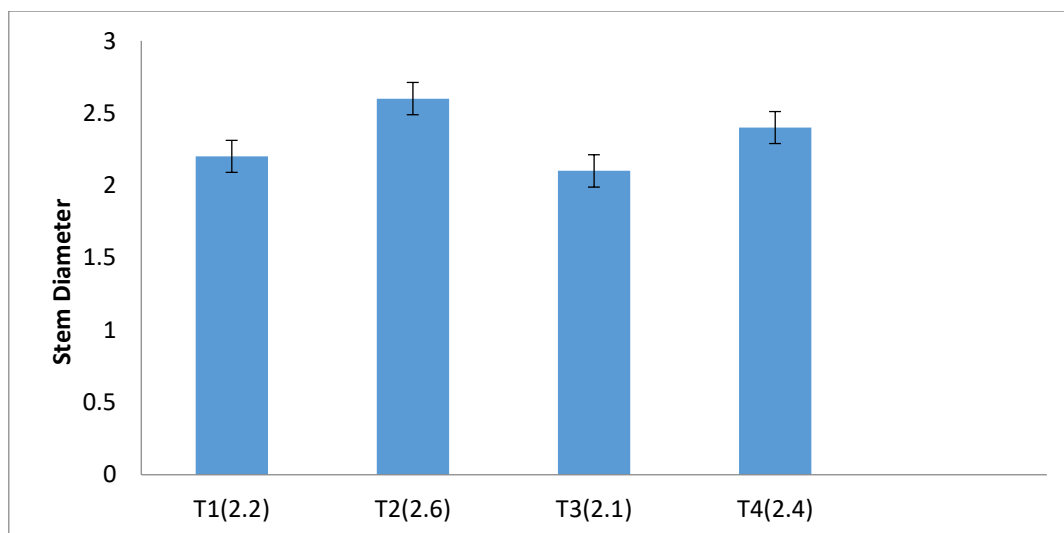


Figure 4: Stem Diameter across Treatments (cm)



Days to Flowering

The time to 50% flowering was relatively consistent across treatments, with a slight delay in Treatment 1 and Treatment 3, both of which had closer intra-row spacing. The plants in these treatments took an average of 45 days to reach 50% flowering, while plants in Treatments 2 and 4, with wider intra-row spacings, reached 50% flowering in 42 days.

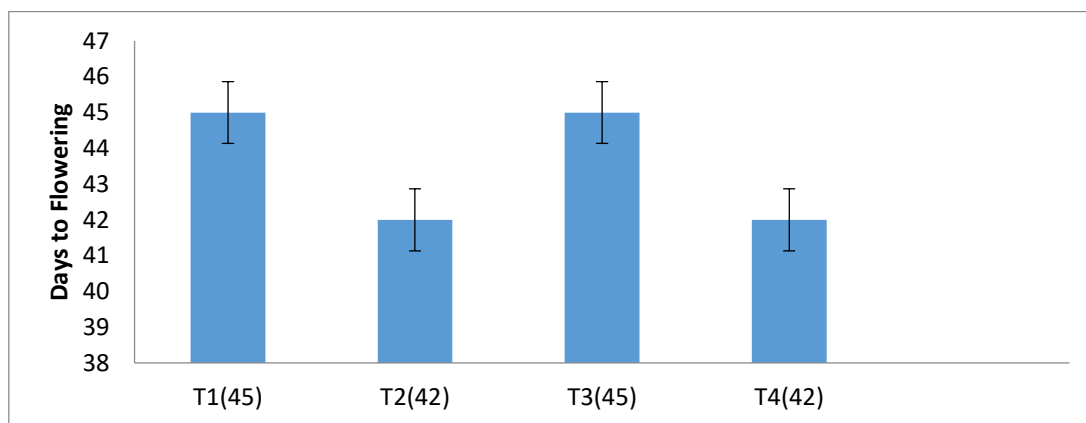


Figure 5: Days to Flowering across Treatments

Fresh Biomass

Fresh biomass production was highest in Treatment 2 (15 cm intra-row, 40 cm inter-row spacing), with a yield of 12.5 kg/plot. Treatment 1, which had the closest spacing, produced the lowest fresh biomass of 9.1 kg/plot. This suggests that the more spaced plants in Treatment 2 had better access to resources, leading to higher biomass production.

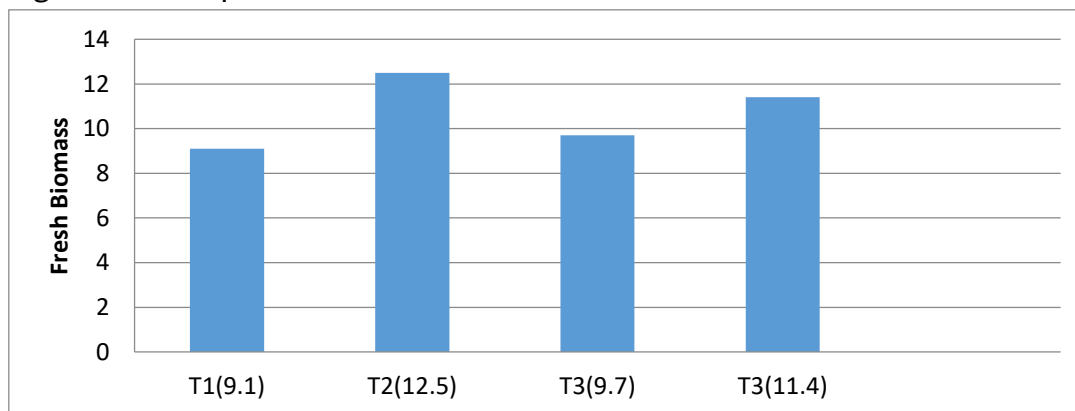


Figure 6: Fresh Biomass



Seed Yield

The seed yield followed a similar trend to fresh biomass, with Treatment 2 producing the highest seed yield of 1.2 kg/plot, followed by Treatment 4 with 1.1 kg/plot. Treatment 1, which had the closest intra-row spacing, recorded the lowest yield at 0.85 kg/plot. This highlights the importance of optimal spacing in maximizing sesame seed production.

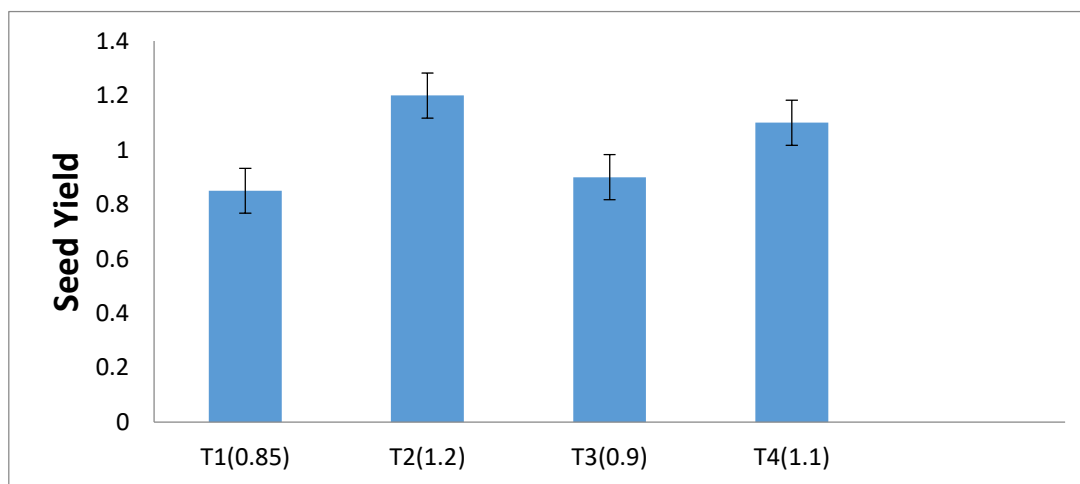


Figure 7: Seed Yield across Treatments (kg/plot)

SUMMARY, CONCLUSION, AND RECOMMENDATION

Summary

The study evaluated the effect of intra- and inter-row spacing on the growth and yield of sesame plants. Four spacing treatments were assessed: T1 (10 cm intra-row, 40 cm inter-row), T2 (15 cm intra-row, 40 cm inter-row), T3 (10 cm intra-row, 50 cm inter-row), and T4 (15 cm intra-row, 50 cm inter-row). The parameters measured included germination percentage, plant height, number of leaves per plant, stem diameter, days to flowering, fresh biomass, and seed yield.

Germination Percentage: The highest germination rate was observed in T2 (92%), while the lowest was recorded in T3 (84%). Wider inter-row spacing combined with an optimal intra-row distance (T2) allowed for better resource availability and higher germination.

Plant Height: T2 recorded the tallest plants (120 cm), followed by T4 (115 cm). Closer intra-row spacing, as in T3, led to crowding, which stunted plant growth.

Number of Leaves per Plant: T2 had the highest number of leaves (38), showing that balanced spacing reduced competition, allowing the plants to allocate resources more efficiently.



Stem Diameter: T2 produced the thickest stems (2.6 cm), while T3 had the smallest stem diameter (2.1 cm). Increased spacing facilitated the development of stronger stems.

Days to Flowering: T2 and T4 achieved 50% flowering faster (42 days), indicating that wider spacing accelerated flowering compared to T1 and T3, which took 45 days.

Fresh Biomass: T2 generated the highest fresh biomass (12.5 kg/plot), while T1 had the lowest (9.1 kg/plot), highlighting the role of spacing in biomass production.

Seed Yield: T2 produced the highest seed yield (1.2 kg/plot), followed by T4 (1.1 kg/plot). Closer spacing in T1 resulted in lower seed yield (0.85 kg/plot).

Conclusion

The results of this study demonstrated that spacing significantly influences the growth and yield of sesame plants. Treatment 2 (15 cm intra-row, 40 cm inter-row) consistently outperformed other treatments across all measured parameters. Wider spacing allowed plants to access more resources, which led to improved growth, higher fresh biomass, and better seed yields. Conversely, closer intra-row spacing resulted in competition among plants for essential nutrients and light, limiting their growth potential.

The study concludes that the optimal spacing for sesame in the study area is 15 cm intra-row and 40 cm inter-row spacing, as it maximizes growth, biomass production, and seed yield.

Recommendation

Based on the findings, the following recommendations are made:

Optimal Spacing for Sesame Cultivation: Farmers should adopt 15 cm intra-row and 40 cm inter-row spacing to maximize sesame yield and biomass in areas with similar environmental conditions.

Resource Management: Farmers should be mindful of plant density to minimize competition for resources, particularly in regions with limited water or nutrient availability.

Extension Services: Agricultural extension officers should promote awareness and educate sesame farmers on the benefits of proper plant spacing to enhance production efficiency.



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