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Potential of *Albizia zygia* and *Albizia lebbeck* leafy biomasses as organic soil amendments on the growth and yield of okra, *Abelmoschus esculentus* (L.) Moench

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INFO

Keyworks
Albizia spp
soil fertility
okra
agroforestry

ABSTRACT

In the array to assess the suitability of using amendments from nitrogen fixing trees in agroforestry, the response of okra to *Albizia lebbeck* and *Albizia zygia* leafy biomasses as soil amendments were investigated at the Faculty of Renewable Natural Resources Demonstration Farm in the Kwame Nkrumah University of Science and Technology, Kumasi-Ghana. The objective of this study was to assess the effect of different levels of *A. lebbeck* and *A. zygia* leafy biomasses on the growth and yield of okra in a randomized complete block design. Four treatments were used and allocated as T1 (Control, no biomass), T2 (0.2454 kg of *A. lebbeck* leafy biomass), T3 (0.2932 kg of *A. zygia* leafy biomass), T4 (0.2127 kg of *A. lebbeck* leafy biomass + 0.1466 kg of *A. zygia* leafy biomass). The treatments were replicated four times. Growth in height, stem diameter, fruit yield and fruit dry weight were the parameters investigated on. The application of *A. lebbeck* and *A. zygia* leafy biomasses significantly improve the growth and yield of okra compared to the control treatment during the 12-weeks period of the experiment ($p<0.05$). Therefore, *A. lebbeck* and *A. zygia* leafy biomass amendments are recommended for use by okra farmers, as it has great prospects for use in soil fertility improvement. Also, further investigations with other levels of *A. lebbeck and A. zygia* mulch can be carried out to determine optimum rate for optimum growth and yield of okra, *Abelmoschus esculentus* (L.) Moench.

Palavras-chaves
Albizia spp
fertilidade do solo
quiabo
agrofloresta

RESUMO

Potencial das biomassas foliares de Albizia zygia e Albizia lebbeck como emendas orgânicas do solo no crescimento e rendimento do quiabo, Abelmoschus esculentus (L.) Moench

No intuito de avaliar a adequação do uso de corretivos de árvores fixadoras de nitrogênio na agrossilvicultura, a resposta do quiabo às biomassas folhosas de Albizia lebbeck e Albizia zygia como corretivos do solo foi investigada na Fazenda de Demonstração da Faculdade de Recursos Naturais Renováveis da Universidade de Ciências Kwame Nkrumah. e Tecnologia, Kumasi-Gana. O objetivo deste estudo foi avaliar o efeito de diferentes níveis de biomassas foliares de *A. lebbeck* e *A. zygia* no crescimento e produção de quiabo em delineamento de blocos casualizados. Quatro tratamentos foram utilizados e alocados em T1 (Controle, sem biomassa), T2 (0,2454 kg de biomassa folhosa de *A. lebbeck*), T3 (0,2932 kg de biomassa folhosa de *A. zygia*), T4 (0,2127 kg de biomassa folhosa de *A. lebbeck* + 0,1466 kg de biomassa folhosa de *A. zygia*). Os tratamentos foram replicados quatro vezes. Crescimento em altura, diâmetro do caule, produtividade e massa seca dos frutos foram os parâmetros investigados. A aplicação de biomassas folhosas de *A. lebbeck* e *A. zygia* melhorou significativamente o crescimento e a produção de quiabo em comparação ao tratamento controle durante o período de 12 semanas do experimento ($p<0,05$). Portanto, os corretivos de biomassa foliar de *A. lebbeck* e *A. zygia* são recomendados para uso pelos produtores de quiabo, pois apresentam grandes perspectivas de uso na melhoria da fertilidade do solo. Além disso, investigações adicionais com outros níveis de cobertura morta de *A. lebbeck* e *A. zygia* podem ser realizadas para determinar a taxa ideal para crescimento e rendimento ideais de quiabo, *Abelmoschus esculentus* (L.) Moench.

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INTRODUCTION

Agricultural sustainability is bolstered by incorporating tree leafy biomass, which enhances soil fertility, provides organic matter, and promotes a balanced ecosystem. Utilizing tree leaves as biomass in agriculture contributes to long-term soil health and productivity while minimizing environmental impact. *Albizia zygia* (J.F) Macbr and *Albizia lebbeck* (L.) Benth, two species of the Albizia genus, are renowned for their significant contributions to agroforestry and sustainable land management (Ogunniyi et al., 2023). These *Albizia* species are local and exotic species, respectively, domiciled in Ghana (Akoto et al., 2022). They are leguminous trees valued for their ability to fix nitrogen, improve soil fertility, and provide valuable biomass in the form of leaves (Adelani, 2023; Akoto et al., 2022). According to Alamu et al. (2023), these attributes have garnered attention as they offer potential benefits to crop growth and yield enhancement in the context of agroecosystems.

In Ghana, vegetable production plays a vital role in the agricultural sector, contributing significantly to food security and economic livelihoods. The diverse agroecological zones in the country allow for the cultivation of a wide variety of vegetables, meeting both local and export demands. Farmers employ sustainable practices, and ongoing initiatives aim to enhance productivity, improve crop resilience, and promote the overall sustainability of vegetable farming in Ghana of which okra production cannot be left out. Okra, *Abelmoschus esculentus* (L.) Moench is a staple vegetable crop in many tropical and subtropical regions due to its nutritional content and culinary versatility (Amin et al., 2022; Elkhalifa et al., 2021). In addition, it is a widely cultivated vegetable crop with economic importance, serving as an ideal candidate for examining the potential influence of *A. zygia* and *A. lebbeck* leafy biomass on crop performance (Kaur et al., 2023; Kumae et al., 2021). However, like many crops, okra growth and yield are often constrained by factors such as inadequate soil fertility and nutrient deficiencies. Amponsah-Doku et al. (2022), Tadele (2019), and Talabi et al. (2022) reported that, suboptimal growth conditions can lead to reduced crop yield and quality, impacting the livelihoods of farmers and food availability in the tropics. The relationship between these nitrogen-fixing trees and okra has the potential to improve agricultural sustainability and food security, particularly in regions with resource limitations in sub-Saharan African countries (Dagar et al., 2020; Kebede, 2021; Roslan et al., 2020).

Furthermore, agricultural systems in the tropics face challenges such as soil degradation, unpredictable climate patterns, and the threat of pests and diseases. These issues hinder sustainable productivity and necessitate innovative solutions for resilient and thriving tropical agriculture. According to Reza & Sabau (2022), agricultural systems in many regions, including those in sub-Saharan Africa, face multifaceted challenges that hinder crop productivity and food security. Tesfaye et al. (2023) and Zanli et al. (2022) indicated that soil degradation, nutrient depletion, and limited access to external fertilizers are some of the primary issues plaguing these systems in the tropics. In addition, conventional monoculture practices often result in reduced soil fertility and increased susceptibility to pests and diseases decreasing crop yields in developing countries (Adedibu, 2023; Altieri, 2019; Armengot et al., 2020). To address these challenges and promote sustainable agricultural practices, the integration of leguminous trees like *A. zygia* and *A. lebbeck* into cropping systems has gained attention (Dev et al., 2022; Hasanuzzaman & Hossain, 2023). According to Adelani (2023), these trees have the potential to enhance soil fertility through biological nitrogen fixation and the provision of leafy biomass, which can serve as green manure or mulch. However, while the benefits of these trees are well-documented in terms of soil improvement, their specific impact on crop growth and yield, especially on crops like okra, remains an area of research that requires deeper exploration (EO et al., 2023).

Therefore, the need for a comprehensive understanding of the influence of *A. zygia* and *A. lebbeck* leafy biomass on okra growth and yield is underscored by the potential advantages this integration can offer to smallholder farmers. Such knowledge can inform evidence-based recommendations for sustainable agroforestry practices that enhance crop performance, reduce the reliance on external inputs, and contribute to food security in resource-constrained regions. The results of this research will help educate poor resource farmers on the potential of *A. zygia* an indigenous agroforestry tree species for soil improvement in crop production in the tropics more importantly Ghana. The objectives of the study were to determine the effect of *A. lebbeck* and *A. zygia* leafy biomasses on the morphological growth (height and stem diameter) of okra and to determine the effect of *A. lebbeck* and *A. zygia* leafy biomasses on the yield (number of fruits and dry weight of fruits) of okra in Ghana.

METHODOLOGY

Location of the study area

The experiment was conducted at the Agroforestry Department Faculty's demonstration farm,

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which is located on the Kwame Nkrumah University of Science and Technology (KNUST) campus in Kumasi, Ghana. The site is located within the Oforikrom municipality within the Ashanti region of Ghana. According to the 2021 National Population and Housing census, Oforikrom Municipal Assembly's population is 213,126 made up of 107,426 males and 105,700 females. This farm is positioned in the humid Semi-Deciduous Forest zone of Ghana, with geographical coordinates approximately at 6.40°N latitude and 1.37°W longitude and elevated 250 to 300 meters above sea level (Mohammed et al., 2023).

Rainfall

The area experiences a distinct rainfall pattern, manifesting in two primary cycles annually. Typically, the average precipitation ranges from 1250 to 1500 mm. The primary rainy season, termed the major wet season, spans from May through July, followed by a minor rainy season from September to November. Moreover, there are two dry spells, one extending from December to March, constituting the lengthier dry season, and the other occurring in August, representing the shorter dry period (Mohammed et al., 2023). The predominant climate in the region is tropical wet and dry or savanna climate.

Temperature and Humidity

The typical daily temperature at the location averages at 25.6°C. In the coldest period spanning from December to February, the mean temperature decreases to about 20°C, whereas in the warmest month of March, the average peak temperature reaches 33°C. On an annual average, the temperature at this site is approximately 26.61°C, and the relative humidity stands at 67.6% (Mohammed et al., 2023).

Soil type

The soil at the experimental site is characterized as Ferric Acrisol, displaying strong acidity and effective drainage. Additionally, the texture of the soil was identified as sandy-loam (Mohammed et al., 2023).

Soil properties at the study site

pH	N (%)	P (mg/kg)	K (mg/kg)	O.C (%)	O.M (%)	Moisture (%)	Bulk density (g/cm^3)	Temperature	C/N ratio
5.4	0.17	33.2	18.9	0.85	1.5	9.6	1.02	30.4	6.6

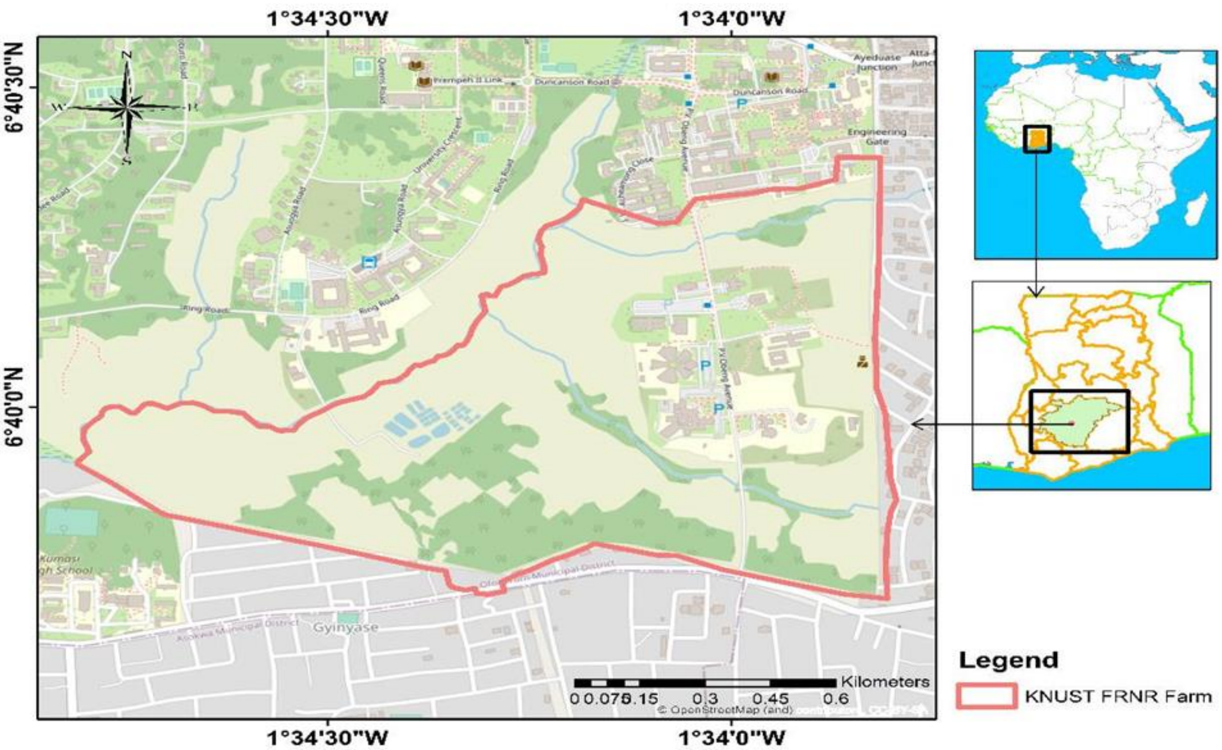

Figure 01 - Map of the study area showing the Faculty of Renewable Natural Resources Demonstration Farm, KNUST-Kumasi, Ghana

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Experimental Approach and Procedure

Sources of leafy biomasses

The *A. lebbeck* and *A. zygia* leafy biomasses were obtained at the department of Agroforestry research farm in the Kwame Nkrumah University of Science and Technology (KNUST), Kumasi-Ghana. These components were applied separately or in combination at different levels of dosage.

Source of okra seeds and planting

The seeds of okra were obtained from the Crop Research Institute of Ghana, Kwadaso-Kumasi. Irrigation was carried out before and after sowing consistently throughout the dry season of the experiment. Each hill was planted with four seeds at a depth of 1.5 cm and spaced at 0.6–0.5 m a week after integrating the biomass into the soil. Okra seeds were sown at stake at a planting distance of 0.6 m x 0.5 m. One week after germination, the okra seedlings were selectively reduced to one seedling per hill through thinning. This thinning process aimed to promote consistent growth among the remaining plants in the field, reducing competition for nutrients and water (Manrique-Alba et al., 2020). Watering was carried out as required using a watering can.

Albizia lebbeck and *Albizia zygia* leafy biomasses application

Different quantities of *A. lebbeck* and *A. zygia* biomasses were weighed using an electronic balance and applied to each sub plots as a sole application and in combinations at a rate of 75kg N/ha by incorporation. Leafy biomasses of *A. lebbeck* and *A. zygia* was applied through incorporation into the soil two weeks before planting (WBP) in various treatments during the field experiment (0.4254, 0.2932, 0.21271 and 0.1466 kg per plot).

Weed control

Manual weed control was carried out using a hoe, cutlass, and by hand.

Pest and disease control

Cyber force was administered at a concentration of 0.5 liters per hectare (Mohammed et al., 2022) for caterpillar and beetle control. The application started two weeks after germination (2 WAG) and continued until the fruiting stage.

Harvesting

At maturity, the okra fruits were harvested by hand and using a knife.

Experimental Design and Treatments Allocation

The experiment was laid out in a Randomized Complete Block Design (RCRD) with four treatments randomly allocated and replicated four times. The size of the experimental site was 8.7 m x 7.5 m (65.25 m^2) with a total of 16 plots. Each unit plot size was 1.8 m × 1.5 m (2.7 m^2) with 16 hills per plot. An alley of 0.5 m between plots and blocks was maintained to ensure a true reflection of each treatment per plot.

Blocks allocation

BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4
T4	T1	T2	T3
T1	T3	T4	T2
T3	T2	T1	T4
T2	T4	T3	T1

Fertilizer treatments

Treatments	Interpretation
T1	No biomass (Control)
T2	0.4254 kg of *A. lebbeck* leafy biomass/plot (1575 kg/ha of *A. lebbeck* leafy biomass)
T3	0.2932 kg of *A. zygia* leafy biomass/plot (1086 kg/ha of *A. zygia* leafy biomass)
T4	0.21271 kg of *A. lebbeck* leafy biomass + 0.1466 kg of *A. zygia* leafy biomass/subplot (788 kg/ha of *A. lebbeck* + 542 kg/ha of *A. zygia* leafy biomasses)

Nitrogen demand of okra is 75 kgN/ha (Mohammed et al., 2022)

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Data collection and analysis

Weekly data on the growth and yield aspects of okra were gathered starting from the second week after planting (2 WAP) up to the twelfth week after planting (12 WAP). Growth parameters included plant height and stem diameter. Plant height was determined by measuring from the ground surface to the top of the tallest leaf using a meter ruler while stem diameter was measured at a point 5 cm above the ground using a digital caliper.

Data concerning yield parameters were gathered, specifically the quantity of fruits and their dry weight upon harvest. Counting the number of pods or fruits was done visually, while the dry weight of pods per fruit was determined by employing an electronic balance after subjecting them to oven drying at 105°C within a laboratory setting. Subsequently, statistical analysis utilizing the Analysis of Variance (ANOVA) method was performed using STATISTIX 10 software at a significance level of 5% (Analytical software, 2013). To compare the means that displayed significant differences, the Least Significant Difference (LSD) was utilized. The outcomes were then displayed through tables and graphs, generated using Microsoft Excel version 2021.

RESULTS

Effect of *Albizia lebbeck* and *Albizia zygia* leafy biomass on the morphological growth of okra

Height (cm) of okra from 2 to 12 weeks after planting (WAP)

The effect of various leafy biomass treatments of *A. lebbeck* and *A. zygia* on the height of okra during the 12-week growth period is summarized in Table 01. Weekly height measurements indicated significant differences ($p < 0.05$) from 2 to 12 weeks after planting (WAP) for each treatment. At 2 WAP, the tallest okra plants were observed in T3 (8.9 cm), followed by T2 (8.76 cm) and T4 (8.6 cm), while the shortest plants were in T1 (5.08 cm) with a percentage difference of 54.65%. Although there were no notable differences between T3, T2, and T4, they all exhibited significant variation from the control (T1). Similar trends persisted from 4 to 12 WAP with percentage difference of 32.65% and 18.84% respectively.

Table 01 - Effect of *Albizia lebbeck and Albizia zygia* leafy biomass on the Height (cm) of okra from 2 to 12 weeks after planting (WAP)

TREATMENT	2 WAP (±SeM)	4 WAP (±SeM)	6 WAP (±SeM)	8 WAP (±SeM)	10 WAP (±SeM)	12 WAP (±SeM)
T1	5.08±1.2^{b}	18.28±1.1^{b}	23.8±0.6^{b}	24.18±0.5^{b}	26.18±0.5^{b}	28.08±0.8^{b}
T2	8.76±0.4^{a}	25.28±0.6^{a}	29.34±0.4^{a}	29.82±0.3^{a}	31.82±0.6^{a}	33.72±0.4^{a}
T3	8.90±0.3^{a}	25.40±2.^{4a}	29.34±0.4^{a}	30.02±1.2^{a}	32.02±0.4^{a}	33.92±0.9^{a}
T4	8.60±0.8^{a}	25.40±1.5^{a}	31.04±0.8^{a}	31.34±0.3^{a}	33.34±1.2^{a}	35.21±0.7^{a}
P-VALUES	0.0087	0.0156	0.0000	0.0000	0.0003	0.0000
LSD	2.28	4.78	1.99	2.15	2.56	2.26
CV (%)	18.86	13.15	4.55	4.84	5.39	4.48

Means in the column accompanied by the same letter (s) are not significantly difference at ($P \leq 0.05\%$) using Least Significance Difference (LSD), where CV=Coefficient of Variation, WAP=Weeks After Planting, SeM=Standard error of Mean

Mean Height (cm)

There was a significant difference between the treatments means with respect to growth in height of okra over the experimental period, ($p < 0.05$) (p= 0.0372, F= 2.94, DF= 3, CV=34.18, LSD=4.97). The tallest plants were recorded in T4 (27.5 cm), followed by T3 (26.6 cm), T2 (26.5 cm) and finally, T1 had the shortest plants (20.9 cm). There were no significant differences between T4, T3 and T2, however, they were significantly different from T1 (control) (Figure 02). Therefore, the percentage difference between T4 (27.5 cm) and T1 (20.9 cm) is approximately 27.27%.

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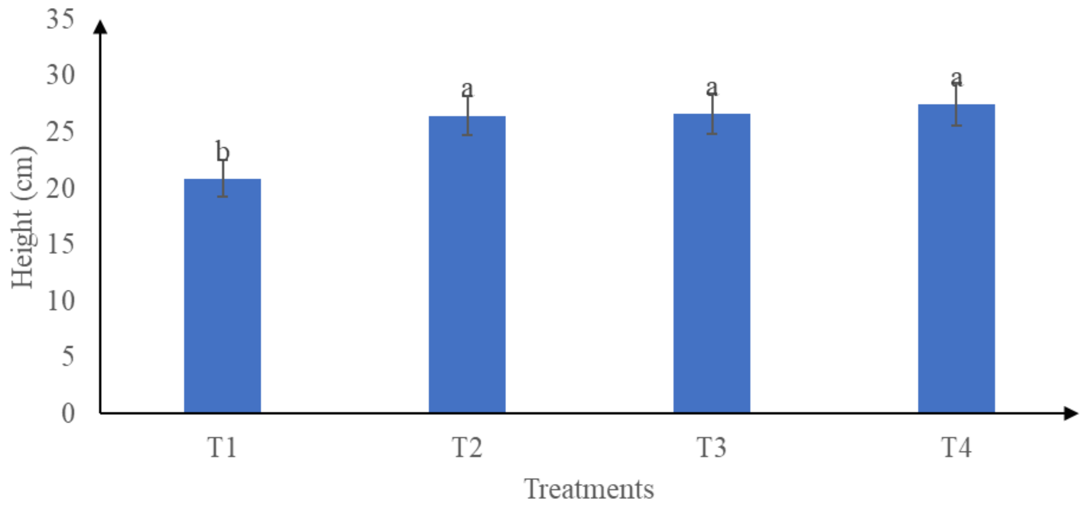

T1= Control; T2= 0.4254 kg of *A. lebbeck*; T3= 0.2932 kg of *A. zygia*; and T4= 0.2127 kg of *A. lebbeck* + 0.1466 kg of *A. zygia*

Figure 02 - Effect of *Albizia lebbeck* and *Albizia zygia* leafy biomass on the height (cm) of okra

Stem diameter (mm) of okra from 2 to 12 weeks after planting (WAP)

The effect of *A. lebbeck* and *A. zygia* leafy biomass on the stem diameter is summarized in Table 02. The growth pattern of okra stem diameter mirrored that of its height between 2 to 12 weeks after planting (WAP). Initially, at the second week, no significant variations were observed among the treatments, p>0.05 with a percentage difference between T4 (1.5 mm) and T1 (1.2 mm) being approximately 22.22%. However, starting from the 4th to the 12th WAP, Analysis of Variance revealed notable differences in the treatment means. In the fourth week, the most robust plant growth was observed in T3 (3.8 mm), statistically comparable to T4 (3.7 mm) and T2 (3.6 mm), but significantly distinct from the control treatment (T1) (1.5 mm) with a percentage difference of 86.79%. Similar trends were observed between the 6th and 12th WAP with the percentage difference being 106.25% and 100% respectively.

Table 02 - Effect of *Albizia lebbeck and Albizia zygia* leafy biomass on the Stem diameter (mm) of okra 2 to 12 WAP

TREATMENT	2 WAP (±SeM)	4 WAP (±SeM)	6 WAP (±SeM)	8 WAP (±SeM)	10 WAP (±SeM)	12 WAP (±SeM)
T1	1.2±0.3	1.5±0.1^{b}	1.5±0.2^{b}	1.5±0.2^{b}	1.6±0.4^{b}	1.6±0.4^{b}
T2	1.4±0.2	3.6±0.3^{a}	4.9±0.6^{a}	3.4±0.2^{a}	4.8±0.6^{a}	4.8±0.5^{a}
T3	1.5±0.2	3.8±0.5^{a}	4.8±0.4^{a}	3.8±0.3^{a}	4.8±0.2^{a}	4.8±0.1^{a}
T4	1.5±0.2	3.7±0.7^{a}	4.7±0.3^{a}	3.8±0.3^{a}	4.8±0.1^{a}	4.8±0.2^{a}
P-VALUES	0.7636	0.0100	0.0001	0.0001	0.0000	0.0001
LSD	0.66	1.41	1.14	0.78	1.07	1.11
CV (%)	31.04	29.2	18.86	15.94	17.34	17.94

Means in the column accompanied by the same letter (s) are not significantly difference at (P≤ 0.05%) using Least Significance Difference (LSD), where CV=Coefficient of Variation, WAP=Weeks After Planting

Mean Stem diameter (mm)

The mean stem diameter of okra plant as affected by the different treatments at the end of the experiment is shown in Figure 03. Stem diameter of okra followed the same pattern to plant height where there was a significant difference between the treatment means throughout the experimentation, ($p < 0.05$) ($p= 0.0000$, F=23.17, DF=3, CV=37.06, LSD=0.70). The biggest stem diameter was recoded in T3 (3.88 mm) which did not differ significantly from T4 (3.87 mm) and T2 (3.85 mm) but they were significantly different from T1 which recorded the smallest stem diameter (1.48 mm) with a percentage difference of 89.55%.

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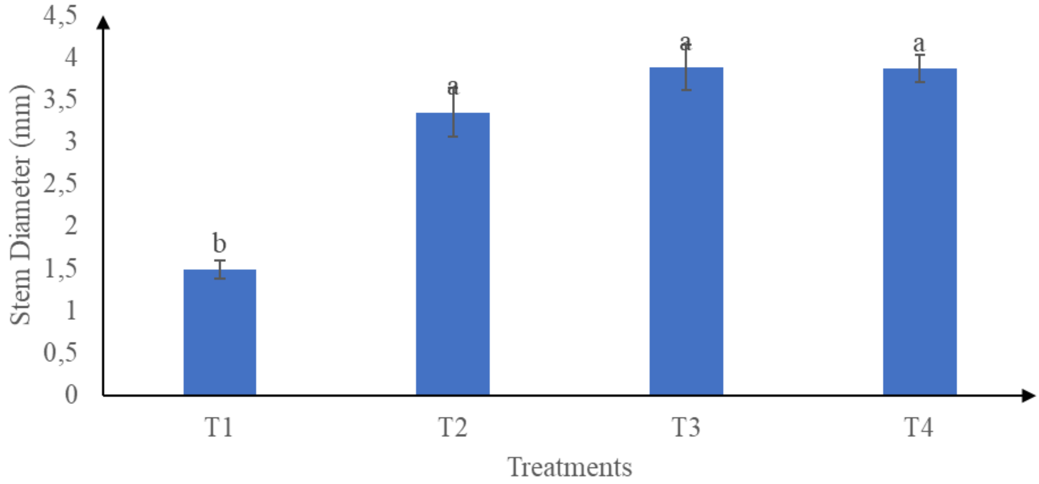

T1= Control / T2= 0.4254 kg of *A. lebbeck* / T3= 0.2932 kg of *A. zygia* / T4= 0.2127 kg of *A. lebbeck* + 0.1466 kg of *A. zygia*
Figure 03 - Effect of *Albizia lebbeck* and *Albizia zygia* leafy biomass on the Stem diameter (mm) of okra

Effect of *Albizia lebbeck* and *Albizia zygia* leafy biomass on the Yield of okra at harvest

Fruit yield/ha

The effect of different levels of *A. lebbeck* and *A. zygia* leafy biomass application regimes on the fruit yield/ha component of okra at harvest. There was a significant difference between treatment means, ($p < 0.05$) ($p= 0.0214$, $F=4.71$, $DF=3$, $CV=32.71$, $LSD=77143$). Mean values of okra fruit yield during the period of experimentation indicated that, T4 biomass application regime recorded the maximum number of fruits (184852) followed by T3 (179037), T2 (176667), and the minimum number of fruit yield/ha was recorded in fertilizer application regime of T1 (71742) with a percentage difference between T4 and T1 being 88.16%.There was no significant difference between T2, T3 and T4, but they differed significantly from T1 (Figure 04).

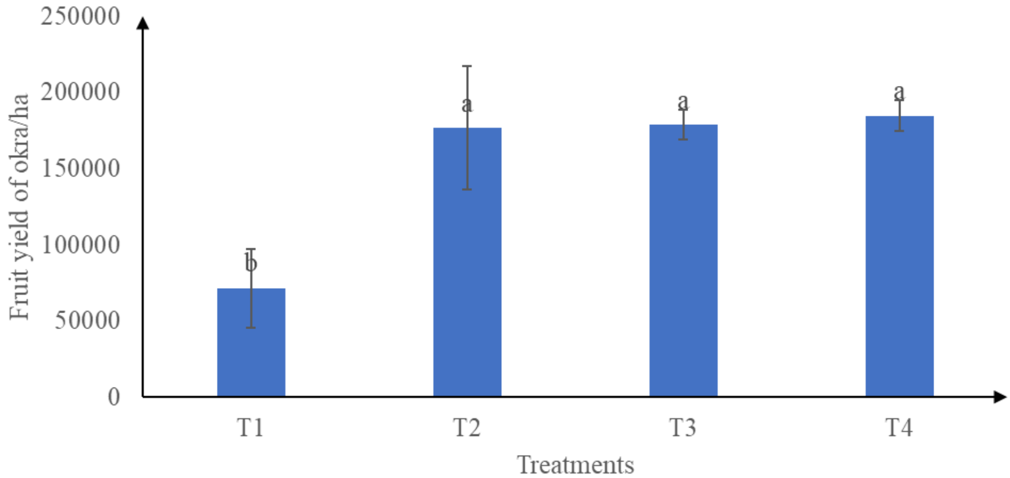

Figure 04 - Effect of *Albizia lebbeck* and *Albizia zygia* leafy biomass on the Yield/ha of okra. T1= Control; T2= 0.4254 kg of *A. lebbeck*; T3= 0.2932 kg of *A. zygia*; and T4= 0.2127 kg of *A. lebbeck* + 0.1466 kg of *A. zygia*.

Dry weight kg/ha

Figure 05 shows the effect of different biomass application regimes on the dry weight component of fruits at harvest. There was a significant difference between treatment means, with the maximum dry weight of fruits recorded in T4 (338.89 kg/ha) followed by T3 (338.41 kg/ha), T2 (334.26 kg/ha) and the minimum dry weight was recorded in T1 (169.11 kg/ha). There were significant differences between T2, T3 and T4, but they were significantly different from the control treatment (T1). The percentage difference between T4 and T1 is 66.73%.

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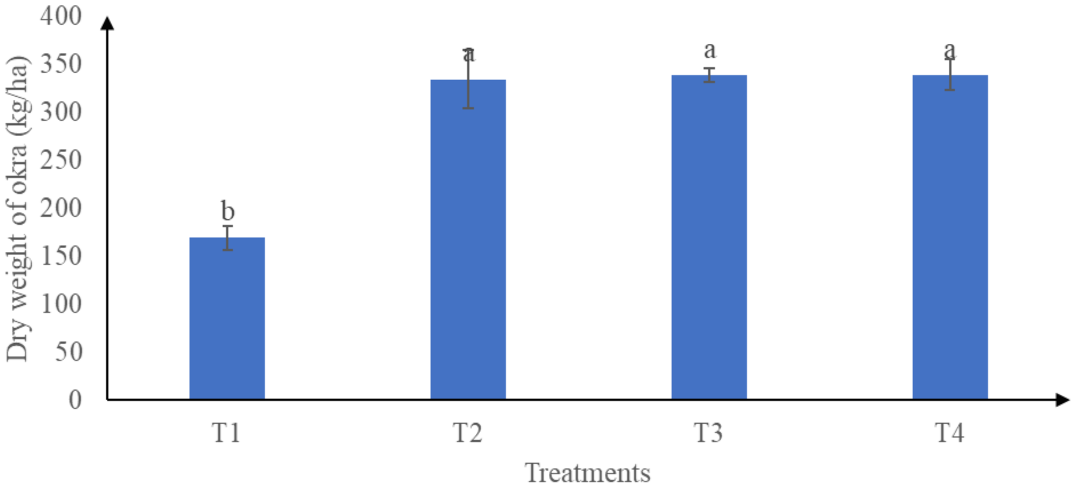

Figure 05 - Effect of *Albizia lebbeck* and *Albizia zygia* leafy biomass on the Dry weight kg/ha of okra T1= Control; T2= 0.4254 kg of *A. lebbeck*; T3= 0.2932 kg of *A. zygia*; and T4= 0.2127 kg of *A. lebbeck* + 0.1466 kg of *A. zygia*.

DISCUSSION

Effect of *Albizia lebbeck* and *Albizia zygia* leafy biomass on the morphological growth and yield

The utilization of *A. lebbeck* and *A. zygia* leafy biomass has demonstrated a positive impact on the morphological growth and yield of plants. These organic materials contribute to enhanced plant development and increased yield, showcasing their potential as beneficial amendments in agricultural practices. According to Muzamil et al. (2021) and Rao et al. 2022), enhancing soil fertility is bolstered through the incorporation of natural materials, enriching soil organic content. The practice of modifying soil aims to enhance its structure and physical attributes, like its ability to retain water, permeability, water penetration, drainage, aeration, all conducive to fostering optimal conditions for root development (Franzluebbers, 2023; Shakywal et al., 2023).

The results from the study have shown that okra demonstrated significantly greater growth when tree legume leafy residues were applied compared to the control (okra without manure). This observation highlights the improved growth performance of okra when organic residues are added to enhance soil nutrients. This result confirms the findings of Sun et al. (2020) and Zhao et al. (2020) whom reported that the utilization of organic matter can enhance soil nutrients, ultimately boosting crop productivity. Additionally, *A. zygia* and *A. lebbeck* leafy biomasses are rich in nutrients, including nitrogen, phosphorus, potassium, and other essential minerals. This could be that when incorporated into the soil as organic amendments, they release these nutrients during decomposition (Magingo, 2017).

The findings support similar studies by Mukhopadhyay & Masto (2022) and Singh & Kumar (2022) whom reported that the use of *A. lebbeck* and other *Albizia* species could increase nutrient availability in the soil providing a favorable environment for enhanced plant growth, as evidenced in taller and bigger okra plants.

Furthermore, organic amendments play a vital role in enhancing soil fertility and promoting healthy crop yields. By adding organic matter such as compost or manure to the soil, essential nutrients are released slowly over time, improving soil structure, water retention, and microbial activity. This not only boosts nutrient availability for plants but also contributes to sustainable agricultural practices, reducing reliance on synthetic fertilizers and fostering long-term soil health. According to Essling (2020), Hombegowda et al. (2022) and Murugaragavan et al. (2022), organic matter from the leafy biomasses might have improved soil structure by enhancing aggregation, aeration, and water-holding capacity. Mitra et al. (2023), Sharma & Kumar (2023) and Zvinavashe et al. (2021) reported that better soil structure could facilitate root penetration, nutrient uptake, and water absorption, promoting healthy root development and overall plant growth. Vigorous height and stem diameter growth in the *Albizia* species amended plots compared to the unamended plots might be attributed to the presence of organic matter from *A. zygia* and *A. lebbeck* leafy biomasses which could have encouraged beneficial microbial activity in the soil. This agrees with Edwards & Arancon (2022), Soumare et al. (2023), Turp et al. (2023), and Younas et al. (2022) whom indicated that the presence of microorganisms in the soil could break down organic matter, thereby converting it into plant-available nutrients.

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These symbiotic relationships between plants and soil microbes can significantly boost plant growth and yield (Diagne et al., 2020; Khaliq et al., 2022).

The addition of *A. zygia* and *A. lebbeck* leafy biomasses like other organic amendments could have helped reduced soil erosion by improving the soil's ability to retain moisture and withstand heavy rainfall. This, in turn, maintained a stable growing environment for the okra plants, enabling them to grow better with higher fruit yield. This supports previous research by Mohammed et al. (2022) whom stated that the application of *Leucaena leococephala* leafy biomass as soil amendment could bind loosed soil particles together thereby preventing them from leaching and run-off which could provide favorable conditions for optimum okra growth and yield compared to the control. More so, organic matter in the soil acts like a sponge, retaining moisture in the soil for longer periods (Li et al., 2022; Pradhan et al., 2023). This increased water availability might have ensured a consistent water supply to the okra plants, preventing stress and promoting continuous growth, which is reflected in increased plant growth and yield. Similar results were reported by Mohammed et al. (2023) when *Gliricidia sepium* leafy biomass significantly improved the growth and yield of tomato plants compared to the control. In addition, leafy biomasses from *A. zygia* and *A. lebbeck* are known to contain bioactive compounds that can stimulate plant growth. Leafy biomasses from *A. zygia* and *A. lebbeck* are recognized for their content of bioactive compounds that possess the capability to stimulate plant growth. These compounds contribute to the overall health and vigor of plants, promoting robust growth and development. According to Iqbal et al. (2023), and Mekonnen & Kibret (2021), these compounds, through various mechanisms, might have promoted cell elongation and division, leading to increased height, stem diameter, fruit yield, and fruit dry weight in okra plants. This finding confirms the suggestion by Aggangan (2019) that the higher availability of nutrients increases succulent growth of plants. It might have therefore been for this reason that plant height, stem diameter, fruit yield/ha and dry weight of fruits (kg/ha) increased slowly through the experimental period than in the unamended soils (control). Organic amendments like *A. lebbeck* and *A. zygia* leafy biomasses can possess natural weed-suppressive and pest-repelling properties (Bamboriya et al., 2022). By minimizing weed competition and deterring pests, the okra plants have reduced stress and can allocate more energy and nutrients towards growth and fruit production, resulting in increased fruit yield and dry weight (Chauhan et al., 2023).

In the control (T1) there is a lower nutrient content in the soil compared to the other treatments which might have attributed to the lowest growth and yield performance. Nutrient deficient soils result in retarded growth and lower yields of plants (Elavarasan & Premalatha, 2019; Füllgrabe et al., 2022; Narayan et al., 2022; Yadav et al., 2021). Also, plants that received amendments at T2, T3 and T4 were not significantly different in height, stem diameter, fruit yield/ha and dry weight (kg/ha). This might imply that, plants with amendment at T2 and T3 received enough nitrogen for growth; hence the excess in nitrogen received by plants with amendment at T4 did not result in significant difference in the growth and yield of the okra.

CONCLUSIONS

The use of *A. lebbeck* and *A. zygia* leafy biomass increases the growth in height and stem diameter of okra plants. Furthermore, it increases the production and dry weight of okra fruits. However, it is important that research is conducted to determine the most effective and efficient application rates of *A. lebbeck* and *A. zygia* leafy biomass to optimize growth and improve okra yield.

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