Comparative Evaluation of Pyrolyzed Lakatan Banana Peel Fertilizer, Commercial Fertilizer, and Non-Fertilizer Control on the Growth Rate of Tomato *(Solanum lycopersicum)* Plants

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CHAPTER 1

THE PROBLEM

Are fertilizers still important in plant production today, or can crops grow effectively without them? The answer is yes—fertilizers remain essential. They play a crucial role in the agricultural production of fruits and vegetables because they directly influence plant growth, nutrient uptake, and overall crop performance *(Asadu et al., 2024)*. Commercial fertilizers are widely used due to their proven effectiveness in improving plant growth and crop productivity across agricultural systems *(Mertz-Myers, 2025).*

Despite the effectiveness of commercial fertilizers, their rising cost has made them less accessible for many farmers. Moreover, excessive use of commercial fertilizers may contribute to soil degradation, nutrient imbalance, and environmental pollution over time. A study by *Niazi et al. (2023)* reported that long-term dependence on chemical fertilizers can reduce soil fertility and disrupt microbial communities, leading to poorer soil health. These issues emphasize the need for alternative fertilizers that are affordable, sustainable, and environmentally friendly.

One practical solution is the use of organic fertilizers derived from agricultural waste. Organic fertilizers are cost-effective, biodegradable, and beneficial to soil structure, making them suitable for farmers seeking natural ways to improve crop growth. Among these alternatives, Lakatan Banana Peel fertilizer has attracted attention because banana peels are naturally rich in potassium, calcium, phosphorus, and magnesium—nutrients essential for the healthy growth and development of tomato plants. *Ojha et al. (2020)* found that banana peel extract significantly improved seedling growth in several vegetable crops, showing its potential as an organic fertilizer.

This fertilizer improves soil structure, enhances nutrient retention, and supports healthier plant growth. *A study by Haque et al. (2023)* demonstrated that banana peel fertilizer increased soil nutrient availability and improved plant growth performance.

Plant height (cm), stem diameter (mm), and number of leaves (counting) are a reliable indicator of early plant development (*Arshad et al., 2024)*. This study focuses on comparing the height of tomato plants subjected to three treatments: Pyrolyzed Lakatan Banana Peel fertilizer, commercial fertilizer, and non-fertilizer control. While banana peel–based fertilizers have shown potential in improving plant growth, there is limited research directly comparing their effectiveness with commercial fertilizers specifically in terms of tomato plant height (cm), stem diameter, and number of leaves creating a research gap that this study aims to address.

Understanding how these treatments influence plant height may help determine whether this simple, low-cost, eco-friendly, and easy-to-produce organic fertilizer can serve as a sustainable alternative to commercial products. Ultimately, the results of this study may guide farmers, home gardeners, and agricultural practitioners in selecting fertilizer options that promote effective plant growth while supporting economic practicality and environmental sustainability.

Theoretical Framework

This study is based on Liebig's Law of the Minimum states that plant growth is limited by the essential nutrient that is in the shortest supply. Even if other nutrients are sufficient, a deficiency in just one required element restricts overall growth and productivity. In the case of *Tomato (Solanum lycopersicum),* nutrients such as potassium, phosphorus, and calcium are crucial for healthy development and optimal plant height. Since pyrolyzed LBPs naturally contain potassium and other beneficial minerals, they may help to address nutrient shortages in the soil *(Islam et al., 2019; Haque et al., 2023).* Guided by this theory, the present study examines whether pyrolyzed Lakatan peel fertilizer can supply the essential nutrients needed by tomato plants more effectively than commercial fertilizer or nonfertilizer conditions, thus preventing nutrient deficiencies that could restrict plant growth.

In addition, Mitscherlich's Law of Diminishing Returns explains that while increasing nutrient supply can improve plant growth, the rate of growth increase becomes smaller as nutrient levels approach sufficiency. This theory supports the idea that fertilizer effectiveness depends not only on the amount applied but also on how efficiently nutrients are released and absorbed by the plant. Pyrolyzed LBPs fertilizer may release nutrients gradually, allowing tomato plants to utilize them more efficiently compared to commercial fertilizer or no fertilizer.

Furthermore, the Soil Fertility Theory explains that materials such as biochar improve soil physical and chemical properties, including porosity, water-holding capacity, pH balance, and microbial activity. These improvements enhance nutrient availability and root development, which in turn indirectly promotes plant growth, plant height, stem diameter, and number of leaves. Together, these theories provide a strong theoretical framework that explains how Pyrolyzed LBPs fertilizer can influence soil quality, nutrient availability, and the growth performance of *Tomato (Solanum lycopersicum)*.

Conceptual Framework

The dependent variable in this study is the plant height (cm), stem diameter (mm), and number of leaves (counting) of *Tomato (Solanum lycopersicum)* plants, measured. The independent variable is the type of fertilizer used— pyrolyzed LBPs fertilizer, commercial fertilizer, and no fertilizer (control). The relationship between these variables is based on the understanding that fertilizers provide essential nutrients that support plant development *(Asadu Et Al., 2024; Tajer 2024).*

Commercial fertilizer supplies fast-acting nutrients, including a balanced (Nitrogen, Phosphorus, Kotassium (Potassium) NPK formulation such as 4-18-

38, which is recommended for supporting tomato growth *(Tajer, 2024).* While Pyrolyzed LBPs fertilizer provides natural sources of potassium, calcium, phosphorus, and magnesium that contribute to healthy growth. In contrast, plants grown without fertilizer are expected to show slower growth due to limited nutrient availability. Comparing these treatments helps determine which option most effectively improves tomato plant height.

SCHEMATIC DIAGRAM

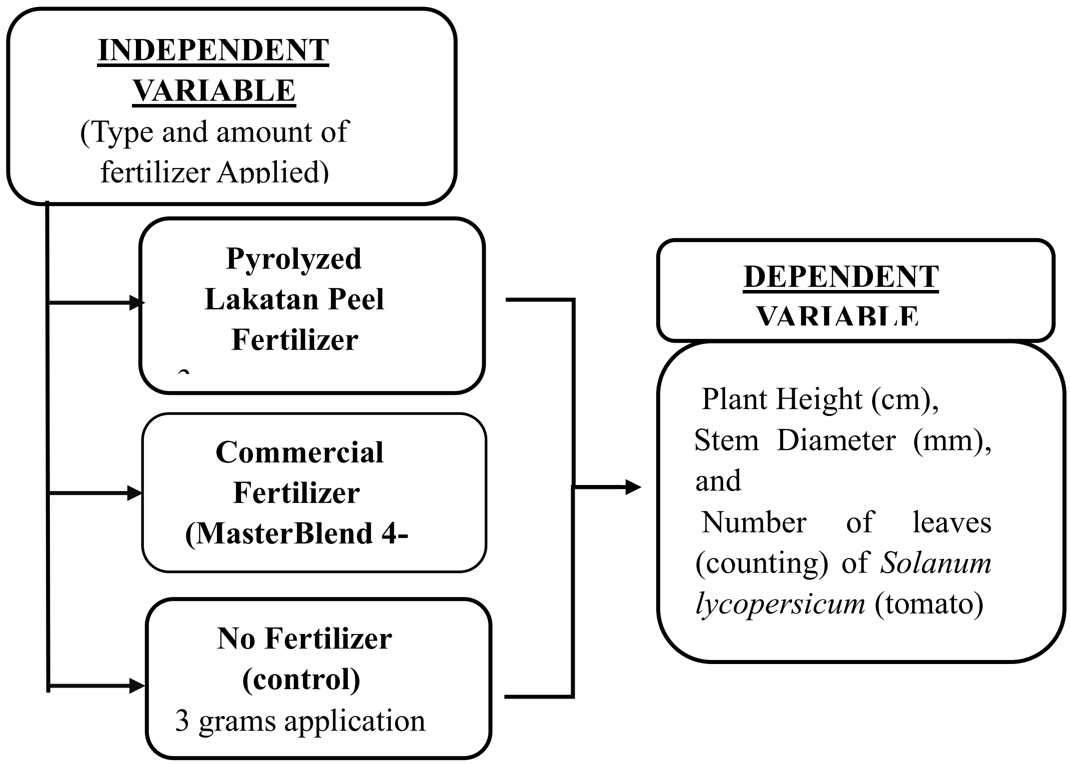

Figure 1. *Conceptual framework shows the relationship between the independent variable and the dependent variable.*

OBJECTIVES

GENERAL OBJECTIVE

To determine the effect of different fertilizer types on the growth performance of *Tomato (Solanum lycopersicum),* specifically their plant height, stem diameter, and number of leaves.

SPECIFIC OBJECTIVES

To determine the difference in plant height (cm), stem diameter (mm), and number of leaves (count) of tomato (solanum lycopersicum) plants treated with pyrolyzed LBP fertilizer, commercial fertilizer (MasterBlend 4-18-38), and no fertilizer.

To determine the effects of different fertilizer treatments on plant height (cm), stem diameter (mm), and number of leaves, in calculating the percentage increase over the control group after the three-week experimental period.

To determine whether there is a statistically significant difference in the mean plant height (cm), stem diameter (mm), and number of leaves (count) among tomato *(Solanum lycopersicum)* plants treated with Pyrolyzed LBPs Fertilizer, Commercial Fertilizer (MasterBlend 4-18-38), and no fertilizer application using appropriate statistical analysis.

The researchers seek to achieve these objectives to better understand how natural and commercial fertilizers influence tomato development. The findings aim to provide practical insights for improving nutrient management, supporting sustainable farming practices, and promoting efficient fertilizer use in tomato production.

Null Hypothesis

H_0: There is no significant difference in the mean plant height (cm), stem diameter (mm), and number of leaves among Tomato *(Solanum lycopersicum)* plants treated with Pyrolyzed LBP fertilizer, Commercial fertilizer (MasterBlend 418-38), and no fertilizer application.

SIGNIFICANCE OF THE STUDY

This study is significant because it examines how different fertilizer treatments—pyrolyzed LBPs fertilizer, MasterBlend 4-18-38 commercial fertilizer, and non-fertilizer—affect the growth of tomato (*Solanum lycopersicum*) plants, particularly in terms of plant height. By determining which fertilizer most effectively promotes growth, the study provides valuable and practical insights that can help improve tomato production using both natural and commercial nutrient sources.

The findings of this research are beneficial to several groups. For the agriculture sector, the study supports sustainable crop production by presenting alternative nutrient sources that may lessen dependence on costly chemical fertilizers while promoting more cost-efficient nutrient management. At the community level, the research encourages proper waste utilization by demonstrating how banana peels can be recycled into useful fertilizers, thereby promoting environmentally friendly farming practices and reducing household and agricultural waste.

Farmers and gardeners may also benefit from this study, as it offers a practical comparison between a commonly used commercial fertilizer and a cheaper, eco-friendly organic option, enabling them to make informed decisions on the most effective and affordable method for enhancing tomato growth. Additionally, students and researchers can use this study as a reference for future investigations on organic fertilizer development, agricultural waste recycling, and innovative approaches to sustainable farming.

This research contributes to the advancement of sustainable agriculture by highlighting the potential of transforming organic waste into a valuable fertilizer while systematically comparing its effectiveness with a widely recommended commercial product.

SCOPE AND DELIMITATIONS OF THE STUDY

This study focuses solely on evaluating the growth response of tomato plants (*Solanum lycopersicum*) under three fertilizer treatments: Pyrolyzed LBP fertilizer, MasterBlend 4-18-38 commercial fertilizer, and no fertilizer (control). The variable measured in this study is plant height (cm), stem diameter (mm), and number of leaves (counting) which serves as the main indicator of the growth performance of *Tomato (Solanum lycopersicum)* plants *(Arshad et al., 2024).*

The experiment is limited to the conditions set by the researchers, including the specific soil type, uniform watering, and a controlled growing environment. External factors such as pests, diseases, climate variations, soil nutrient changes, and other uncontrolled influences are not included. The results are applicable only to the experimental setup used and may not directly generalize to other crops, soil types, environments, or large-scale farming conditions.

DEFINITION OF TERMS

Biochar – a carbon-rich material produced through pyrolysis of organic matter, used in this study to improve soil properties and provide nutrients to tomato plants.

Commercial Fertilizer (MasterBlend 4-18-38) – a water-soluble synthetic fertilizer used in this study as a standard comparison treatment, containing nutrients needed for tomato growth such as nitrogen, phosphorus, and potassium.

Fertilizer Treatment – refers to the specific nutrient application given to the tomato plants in the study, including pyrolyzed banana peel fertilizer, commercial fertilizer, and no fertilizer.

Growth Performance – refers to the development of tomato plants in terms of height increase throughout the experimental period, used to evaluate the effectiveness of each fertilizer treatment.

Non-Fertilizer Control – refers to the treatment group in the study where tomato plants were grown without any fertilizer application, serving as the baseline for comparison.

Nutrient Availability – refers to the amount of essential nutrients present in the soil that can be absorbed by tomato plants, which may vary depending on the fertilizer treatment applied.

Plant Height – the main dependent variable in this study, measured in centimeters (cm) from the soil surface to the tip of the tallest leaf of the tomato plant.

Pyrolysis – the process of heating organic materials like banana peels in a sealed container without oxygen, producing biochar fertilizer used in this study.

Pyrolyzed Lakatan Banana Peel Fertilizer – refers to the fertilizer produced by heating Lakatan banana peels in the absence of oxygen, resulting in a biochar-like substance used in this study to enhance tomato plant growth.

Tomato Plant (Solanum lycopersicum) – the experimental plant used in this study, chosen because it is highly responsive to nutrient changes and commonly grown in agriculture.

CHAPTER 2

RELATED REVIEW LITERATURE AND STUDIES

This chapter presents relevant studies and literature that are related to the present research.

Local Studies

Local research emphasizes the potential of organic fertilizers in improving crop growth in the Philippines. *Conde and De Asis (2021)* examined vermicompost and other organic fertilization mixtures on tomatoes in Sorsogon. They found that organic fertilizers performed comparably—or even better—than commercial fertilizers in fruit weight and nutrient content. However, the study focused on fruit yield rather than plant height, stem diameter, number of leaves, and did not test Pyrolyzed LBPs fertilizer, leaving a gap for research on its effect on tomato height.

So and Tan (2018) investigated biochar from LBPs applied to chili pepper and holy basil. They reported that biochar improved soil fertility, moisture retention, nutrient cycling, and cation exchange capacity, enhancing plant growth. While tomatoes were not studied, the results suggest banana peel biochar can serve as an effective soil amendment. The study did not compare biochar with commercial fertilizers or non-fertilizer control on tomatoes, highlighting a gap addressed by this research.

Magbalot-Fernandez and Montifalcon (2019) evaluated organic-based foliar fertilizer on ‘Lakatan’ bananas. Results showed increased leaf production, fruit weight, and overall yield, particularly when combined with NPK. Early plant height did not show significant differences, and the study was limited to foliar applications on bananas. It did not assess soil-applied pyrolyzed banana peel fertilizer on tomatoes or compare it with commercial fertilizers, leaving a gap for this study.

Anuada, Pascual, and Carabio (2021) tested combined organic fertilizers on cherry tomato (*Solanum lycopersicum L.)*. They found that plants treated with organic fertilizers had greater plant height and vegetative growth than those with inorganic fertilizers. Although the study used bat guano and seaweed, it supports the potential of organic fertilizers for tomato growth under Philippine conditions.

Poloyapoy et al. (2024) tested fermented fish entrails and banana stem formulations on tomato plants. Results showed improved shoot length, root growth, and yield. However, their study used liquid fermented fertilizers—not pyrolyzed banana peel biochar—and did not compare treatments with commercial fertilizers or non-fertilizer control in terms of plant height. Together, these studies indicate that organic fertilizers, especially banana peel-based biochar can enhance plant growth. Nevertheless, limited research directly evaluates their effect on tomato plant height compared to commercial fertilizers and control treatments, providing the rationale for this study.

FOREIGN STUDIES

Proper fertilization remains a critical factor in modern agriculture because it directly influences plant height, stem diameter, number of leaves, nutrient absorption, and overall productivity. *Liu (2024)* emphasized that organic fertilizers improve soil fertility, nutrient availability, and water retention, supporting healthy crop growth while reducing the negative effects of excessive chemical fertilizers.

Biochar is one of the most widely studied organic alternatives. *Lehmann et al. (2019)* explained that biochar enhances soil quality by improving nutrient retention, soil aeration, and water-holding capacity, which ultimately supports healthier plant growth. Recent studies also highlight its positive influence on early plant development. *Liu et al. (2020)* found that biochar significantly increased plant height and biomass due to its porous structure and ability to retain potassium and nitrogen—two nutrients necessary for crop growth.

Banana peel biochar is gaining attention as an organic fertilizer because banana peels naturally contain potassium, phosphorus, calcium, and magnesium. *Haque et al. (2023)* demonstrated that banana peel biochar improved soil nutrient availability and significantly enhanced the growth of several vegetable crops. Their findings reinforce banana peel potential as a cost-effective fertilizer alternative.

Tomatoes (Solanum lycopersicum) are highly responsive to nutrient changes, making them ideal for growth evaluation. *Alam et al. (2021)* showed that appropriate fertilizer application— particularly those rich in nitrogen and potassium—leads to noticeable improvements in tomato plant height, leaf count, and fruit production. Although commercial fertilizers remain highly effective, recent studies suggest the need for eco-friendly options.

Another study by *Sikdar et al. (2023)* investigated the effects of banana peel biochar on the growth and yield of tomato *(Solanum lycopersicum)* in acidic soil. Their findings showed that tomato plants treated with different levels of biochar, whether low, medium, or high achieved significantly greater plant height, stem diameter, number of leaves, and yield parameters compared to the control group with no biochar. The researchers also noted that the improvements may be linked to the biochar’s ability to modify soil pH and enhance soil fertility. Despite these positive outcomes, the study did not compare banana peel biochar with commercial fertilizers, leaving a gap that the present research seeks to address.

CHAPTER 3
METHODOLOGY

This chapter presents research design, data collection method, sampling, and data analysis of the study.

RESEARCH DESIGN

This study employs a quantitative experimental research design to determine the causal relationship between different fertilizer applications—pyrolyzed LBPs fertilizer, commercial fertilizer, and non-fertilizer control (independent variables)—and the growth height, stem diameter, number of leaves (dependent variable) of *Tomato (Solanum lycopersicum)* plants. Controlled treatments were established for each fertilizer type to allow systematic comparison of their effects on the given dependent variable. This research design is appropriate because it enables clear testing of the cause-and-effect relationship between the type of fertilizer applied and tomato plant growth. To ensure the validity of the results, environmental factors such as soil type, watering schedule, sunlight exposure, temperature, planting containers, and seed variety were kept constant throughout the experiment.

RESEARCH SETTINGS

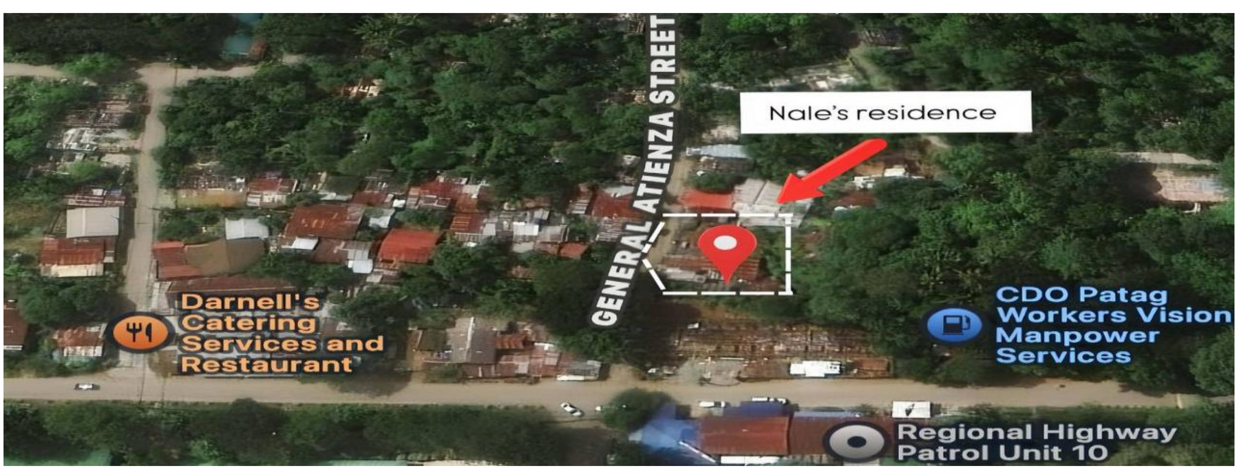

Figure 2. *Map of Zone 6, Patag Camp Evangelista, Cagayan de Oro City, Misamis* Oriental*.*

The study is conducted at *Zone 6, Patag Camp Evangelista, Cagayan de Oro City, Misamis Oriental* (Nale's resident), a residential area with warm temperatures and sufficient sunlight suitable for tomato plant growth. The location was selected for its accessibility and convenience, allowing close and consistent monitoring of the experimental plants throughout the study period. All tomato plants are grown in identical pots using the same loamy soil and maintained under uniform conditions in terms of watering, sunlight exposure, and care to ensure that environmental factors do not influence plant height, stem diameter, and number of leaves. This controlled setting allows the study to focus solely on the effects of the different fertilizer treatments—pyrolyzed LBPs fertilizer, commercial fertilizer, and no fertilizer—on the height of tomato (*Solanum lycopersicum)* plants*.*

DURATION AND FREQUENCY OF THE STUDY

The experiment be conducted over a period of three weeks, starting on *February 2, 2026*, and ending on *February 20, 2026*. Throughout the experimental period, the researchers regularly observe and record the plant height, stem diameter, and number of leaves of the tomato plants twice a week to monitor growth progression under each fertilizer treatment *(Torres-Osorio, Villa-Carmona, & Zamorano-Montanez, 2024).*

Data collection is carried out at fixed and consistent intervals to ensure accurate and reliable measurement of plant height, stem diameter, and number of leaves to clearly assess the influence of each fertilizer treatment over time. In addition, the researchers conduct daily follow-up monitoring of the tomato plants to document any additional observations or changes throughout the experimental period.

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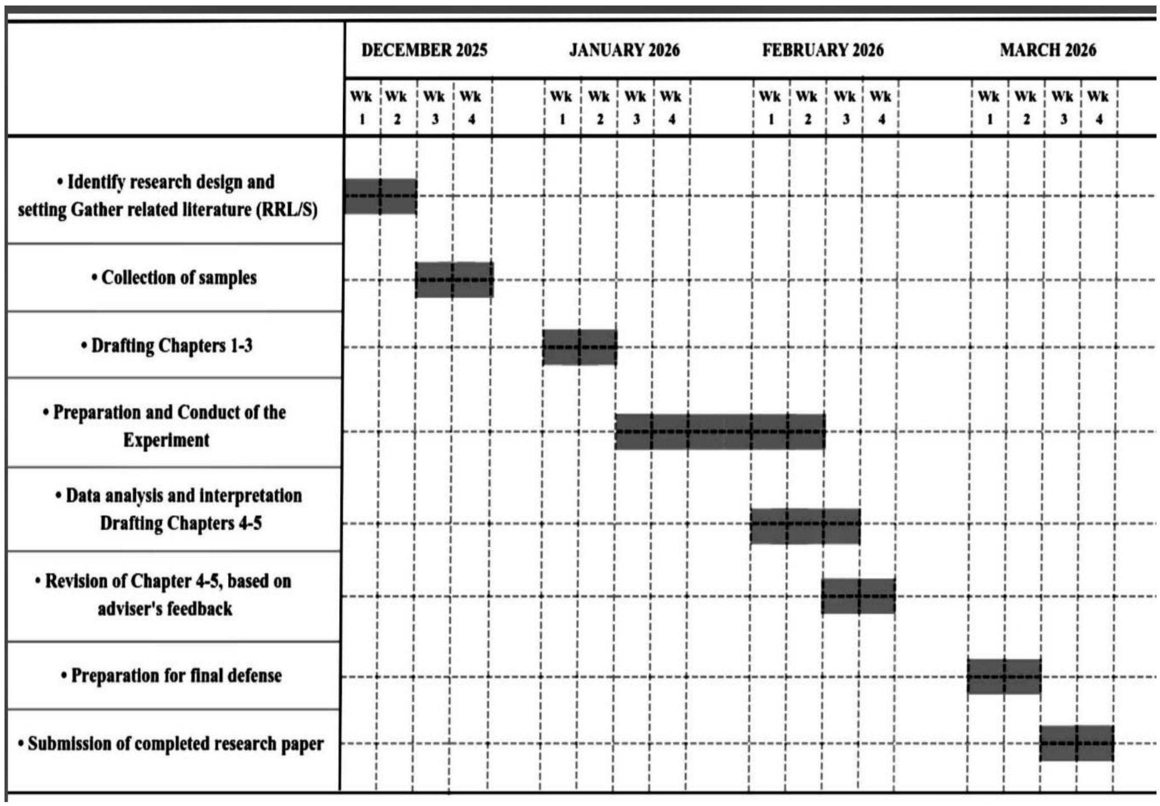

Figure 3*. Gantt chart showing the timeline of research activities from preparation to final defense.*

DATA GATHERING INSTRUMENTS AND PROCEDURES

A. PREPARATORY ACTIVITIES

COLLECTION OF SAMPLES

LBPs were collected from one of the researchers' farms in Buenasuerte, Lukuran, Zamboanga del Sur. Soil was collected from Nale's place (Zone 6, Patag, Camp Evangelista) to ensure that its texture, nutrient content, and organic matter were similar and could be measured and analyzed for the study. By adding fertilizer, the effect of the applied fertilizer on the soil could be observed. Planting pots and tomato *(Solanum lycopersicum)* seeds (EAST-WEST SEED Diamante Max F1, Batch #PH0002850) were purchased from a local gardening store at *Osmeña-Hayes St., Barangay 37, Cagayan de Oro City, Philippines*. Commercial fertilizer (MasterBlend 4-18-38) was ordered online from a verified supplier to ensure consistency among all experimental plants. To make sure that differences in plant growth were due only to the type of fertilizer, environmental factors, including sunlight exposure, watering schedule, and growth duration, were kept constant throughout the experiment.

(Note: Since this study focuses on tomato plant height, stem diameter, number of leaves and the effects of different fertilizer applications, loamy soil was chosen to standardize the growing medium. This ensures that variations in plant growth are due to the independent variable (fertilizer type) rather than soil related environmental factors, providing fair and reliable treatment comparisons.

PREPARATION OF SAMPLES

In this experiment, the researchers first thoroughly washed the LBPs to remove surface impurities. The peels were finely chopped into small pieces and placed in an aluminum container. Pyrolysis was conducted by heating 400 and 600°C until it becomes charcoal-like *(Jiang et al.,2023)* and sealed in an aluminum container for one hour in the absence of oxygen. After cooling, the resulting residue was crushed into a fine powder and stored in a clean, airtight container for safe handling and preservation of its quality, producing the Pyrolyzed LBPs fertilizer.

The collected loamy soil was prepared and divided into equal portions of 4.5 kg each, which were then placed into identical pots assigned to the different treatment groups: Pyrolyzed LBPs fertilizer, commercial fertilizer (MasterBlend 4-18-38), and no-fertilizer control. Fertilizer treatments were applied at a designated dosage of 3 grams per pot. Tomato seedlings were transplanted into the prepared pots after the soil preparation and fertilizer application were completed.

EXPERIMENTAL SETUP

The experiment consists of three treatment groups to evaluate the effect of different fertilizer applications on the growth of *Tomato (Solanum lycopersicum)* plants:

Treatment 1 (T1): Pyrolyzed LBP fertilizer

Treatment 2 (T2): Commercial fertilizer (MasterBlend 4-18-38)

Treatment 3 (T3 – Control): No fertilizer application

For Treatments 1 and 2, a uniform dosage of 3 grams per pot is applied. The control group (T3) receives no fertilizer. All tomato plants are grown in identical pots containing equal amounts of loamy soil (4.5 kg) to ensure uniform growing conditions. Tomato seedlings of the same variety and age are transplanted into each pot following fertilizer application.

The experimental pots are placed in the same location and maintained under uniform environmental conditions, including a consistent watering schedule, uniform sunlight exposure, stable temperature, and growth duration, to minimize external variability. Plant height is measured two times per week at fixed and consistent intervals throughout the three-week experimental period, following methods adapted from similar studies on tomato growth measurement *(TorresOsorio, Villa-Carmona, & Zamorano-Montanez, 2024).*

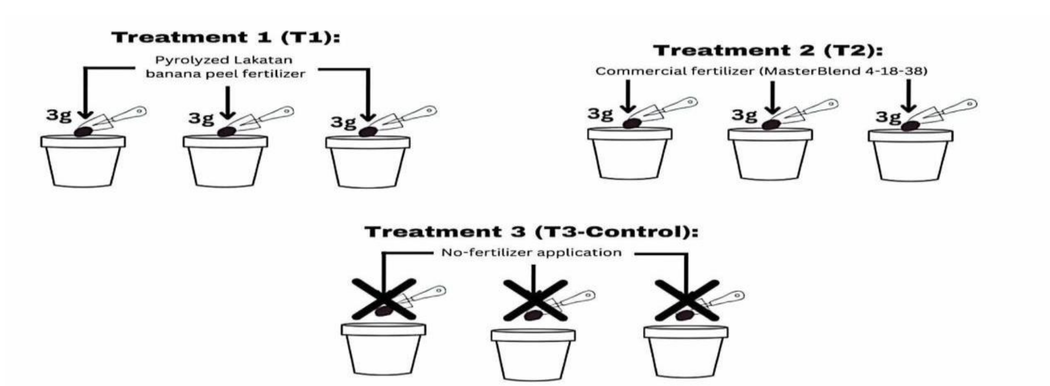

Figure 4: *Three fertilizer treatments be applied to tomato plants: T1 – pyrolyzed LBP fertilizer, T2 – commercial fertilizer (MasterBlend 4-18-38), and T3 – control with no fertilizer. For T1 and T2, fertilizers are applied 3g per pot*.

B. APPLICATION OF TREATMENT

The experiment follows controlled factors to ensure uniformity, including using identical pots filled with equal amounts of loamy soil. Three fertilizer treatments be applied to tomato plants: T1 – pyrolyzed LBP fertilizer, T2 – commercial fertilizer (MasterBlend 4-18-38), and T3 – control with no fertilizer. For T1 and T2, fertilizers are applied 3g per pot. The 3 g dose follows the manufacturer's recommended rate for tomatoes *(Tajer, 2024).*

Tomato seedlings be transplanted into treated pots and watered immediately after fertilizer application, then maintained at once every day to keep the soil consistently moist, ensuring uniform nutrient uptake. This watering schedule follows recommended practices for potted tomatoes *(Gillette, 2025).*

C. COLLECTION OF DATA

The researchers collected data on the growth of tomato *(Solanum lycopersicum)* by measuring plant height in centimeters (cm), stem diameter (mm), and number of leaves (counting) which served as the dependent variable of the study. Plant height was measured from the soil surface to the tip of the highest leaf using a measuring tape, following the standardized procedure described by *Zhu et al. (2025).* Stem diameter was measured at the base of the plant using a vernier caliper, and the total number of leaves per plant was determined by counting all fully expanded leaves *(Arshad et al., 2024).* Measurements were taken twice a week, consistent with the method used by *Torres-Osorio, Villa-Carmona, and Zamorano-Montanez (2024),* throughout the three-week experimental period. This measurement frequency was sufficient to monitor tomato growth, detect differences among fertilizer treatments, and maintain measurement accuracy while minimizing workload.

All measurements were systematically recorded using prepared data sheets for each pot and treatment group to ensure consistency and accurate comparison across treatments. Measurements were conducted at the same time of day to minimize variations caused by environmental factors such as temperature and sunlight intensity.

D. RESEARCH INSTRUMENTS

The research instruments used in this study were selected to ensure accuracy, reliability, and consistency in data collection. These instruments were used to evaluate the effects of different fertilizer treatments on the height of Solanum lycopersicum (tomato), namely pyrolyzed LBPs fertilizer (T1), commercial fertilizer MasterBlend 4-18-38 (T2), and non-fertilizer control (T3).

Digital Weighing Scale (*Cost way 66Lbs Digital Weight Scale Price Computing Retail Count*

Scale Food Meat Scales - A digital weighing scale was used to accurately measure the fertilizer dosage applied to each treatment pot. For Treatments 1 and 2, a uniform amount of 3 grams of fertilizer was weighed per pot to ensure consistent fertilizer application.

Measuring Tape - A measuring tape was used to measure tomato plant height in centimeters (cm) from the soil surface to the tip of the highest leaf, following the standardized procedure described by *Zhu et al. (2025).* Measurements were taken twice a week at fixed intervals throughout the experimental period.

Vernier Caliper – A vernier caliper was used to measure the stem diameter of tomato plants in millimeters (mm) at the base near the soil surface.

Observation Checklist - An observation checklist was used to record visual observations related to plant growth and condition, including general vigor and visible abnormalities such as wilting or discoloration. This supported systematic monitoring and ensured that external factors did not influence the interpretation of plant height data.

Data Recording Sheet (Spreadsheet or Logbook) - A prepared data recording sheet, maintained as a spreadsheet or manual logbook, was used to systematically document plant height (cm), stem diameter (mm), and number of leaves (counting) measurements for each treatment group during every observation period. The data sheet included the date of observation, treatment type (T1, T2, or T3). This facilitated organized data compilation and preparation for statistical analysis using the mean, standard deviation, and one-way ANOVA.

These research instruments enabled consistent monitoring of tomato plant height and allowed the researchers to accurately evaluate the effects of pyrolyzed LBP fertilizer, commercial fertilizer, and no fertilizer application on plant growth.

DATA ANALYSIS INSTRUMENT AND PROCEDURE

The data collected on the height of tomato (*Solanum lycopersicum)* plants are analyzed using descriptive and inferential statistical tools: mean, standard deviation, And One-way ANOVA (Welch's). These determine if significant Differences exist among different fertilizer treatments.

Plant height (cm), stem diameter (mm), and number of leaves (count) were systematically recorded for each treatment group at fixed intervals throughout the experimental period. Each treatment consisted of three pots with a single tomato plant each, and repeated measurements over time served as observations for analysis.

Mean (x̄)

The mean determines the average plant height for each fertilizer treatment.

Formula**:**

$$\bar{x} = \frac{\sum x}{n}$$

Where**:**

- x^{-}= mean plant height
- $\sum x$= plant measurements
- nn= number of observations

Standard Deviation (SD)

The standard deviation measures the variability or dispersion of plant height

Measurements within each treatment group.

Formula**:**

$$SD = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$

Where:

- SD= standard deviation
- x= individual plant height measurement
- $\bar{x}$= mean plant height
- n= number of observations

One-Way Analysis of Variance (ANOVA)

One-way ANOVA determines if there is a statistically significant difference in mean.

Plant height among three fertilizer treatments: pyrolyzed LBP fertilizer, commercial fertilizer

(MasterBlend 4-18-38), and no fertilizer (control). The F-value is computed as:

$$F = \frac{MS_{between}}{MS_{within}}$$

Where:

- $MS_{between}$= mean square between treatments
- MS_{within}= mean square within treatments

Mean squares are obtained using:

$$MS_{between} = \frac{SS_{between}}{df_{between}}$$

$$MS_{within} = \frac{SS_{within}}{df_{within}}$$

Where:

- $SS_{between}$= sum of squares between treatments
- SS_{within}= sum of squares within treatments
- $df_{between} = k - 1$(k = number of treatments)
- $df_{within} = N - k$ (N = total number of observations)

Decision Rule

The computed F-value is compared with the critical F-value at a 5% level of significance

(alpha = 0.05) and 95% confidence level.

- If computed F-value > critical F-value, the null hypothesis be rejected.
- If computed F-value ≤ critical F-value, the null hypothesis is not rejected.

This statistical procedure allows researchers to determine if fertilizer type significantly affects tomato *(Solanum lycopersicum)* height, consistent with approaches used in similar Fertilizer and biochar studies (Alam et al., 2021).

CHAPTER 4

RESULT AND DISCUSSION

This chapter presents the results of the study on the effect of Pyrolyzed LBPs Fertilizer, Commercial Fertilizer (MasterBlend 4-18-38), and no fertilizer on the growth of tomato plants. The study measured three dependent variables: plant height (cm), stem diameter (mm), and number of leaves (count) over a three-week period, with measurements taken twice a week.

A. SPECIFIC OBJECTIVE 1

To determine the difference in plant height (cm), stem diameter (mm), and number of leaves (count) of tomato (*solanum lycopersicum*) plants treated with pyrolyzed LBPs fertilizer, commercial fertilizer (MasterBlend 4-18-38), and no fertilizer.

Table 1. Mean Plant Height (cm) of Tomato Plants Across Treatments from Day 1 to Day 6

Treatment	Pot 1 (Mean)	Pot 2 (Mean)	Pot 3 (Mean)	Treatment Mean
T1 – Pyrolyzed LBP Fertilizer	15.08	10.10	12.95	12.71
T2 – Commercial Fertilizer (Masterblend 4-18-38)	12.02	10.12	10.08	10.74
T3 – No Fertilizer (Control Group)	8.38	8.37	7.73	8.16

Discussion:

The data presented in Table 1 demonstrate notable differences in plant height among the three treatment groups throughout the experimental period. Tomato plants treated with T1 (pyrolyzed LBP fertilizer) achieved the greatest mean height, reaching a final value of 12.95 cm. Plants in T2 (commercial fertilizer, MasterBlend 4-18-38) exhibited intermediate growth with a mean height of 10.74 cm, whereas the control group (T3, no fertilizer) recorded the lowest mean height of 8.16 cm.

The superior growth performance of T1 indicates that the biochar-based fertilizer effectively supplied essential nutrients necessary for vegetative development. This outcome aligns with prior research reporting that organic fertilizers derived from agricultural waste enhance plant height by improving soil nutrient availability and microbial activity *(Zainal et al., 2019).* Pyrolysis-treated organic materials are known to release nutrients gradually, enabling sustained nutrient uptake and prolonged growth support *(Hassan et al., 2021)*. The slow-release characteristic of biochar likely contributed to the consistent growth advantages observed in T1.

The consistent superiority of T1 over T2 suggests that the organic amendment may have provided a more balanced nutrient profile or improved soil conditions conducive to growth. While commercial fertilizers such as MasterBlend 4-18-38 deliver concentrated amounts of nitrogen, phosphorus, and potassium, organic amendments additionally enhance soil structure, water retention, and microbial populations *(Tajer, 2024)*. These secondary benefits may have facilitated improved root development and nutrient absorption, thereby explaining the enhanced growth performance of T1 despite the commercial fertilizer's immediate nutrient availability.

Plants in T3 exhibited the slowest growth, with a final mean height of 8.16 cm, representing a substantially lower increment compared to T1 and T2. This finding highlights the importance of fertilizer applications in optimizing plant development. The unfertilized control group relied solely on the limited nutrients present in the potting medium, which restricted cellular division and elongation *(Akbar et al., 2020).*

Table 2. Mean Stem Diameter (mm) of Tomato Plants Across Treatments from Day 1 to Day 6

Treatment	Pot 1 (Mean)	Pot 2 (Mean)	Pot 3 (Mean)	Treatment Mean
T1 – Pyrolyzed LBP Fertilizer	2.93	2.70	3.04	2.89
T2 – Commercial Fertilizer (MasterBlend 4-18-38)	2.90	2.46	2.92	2.76
T3 – No Fertilizer (Control Group)	2.11	1.93	2.03	2.02

Discussion:

Table 2 presents the stem diameter measurements across all treatment groups. Initially, plants in T1 exhibited the greatest mean stem diameter (2.89 mm), followed by T2 (2.76 mm) and T3 (2.02 mm). The superior stem thickness observed in T1 during the early growth stage suggests that organic fertilizer facilitate enhanced structural development. This finding aligns with the hypothesis that organic amendments improve vascular tissue formation, which is essential for efficient water and nutrient transport within plants (*Islam et al., 2019; Lehmann et al., 2019).*

Treatment 3 exhibited the lowest stem diameter record (2.02 mm), reflecting the absence of fertilizer supplementation. Plants in this group relied solely on the limited nutrients available in the potting medium, which restricted cell division and tissue expansion. Such nutrient limitations consequently inhibited stem diameter development. A phenomenon consistent with the findings of *Akbar et al. (2020),* who emphasized that insufficient nutrient availability constrains vegetative growth and structural advancement.

Comparative analysis between T1 and T2 reveals that organic treatment produced marginally thicker stems during the early growth phase. This advantage may be attributed to the additional benefits of organic matter on soil physical properties, including improved aeration, moisture retention, and microbial activity. *Sikdar et al. (2023)* reported that biochar application at varying rates consistently enhanced tomato growth, demonstrating that organic amendments can improve plant performance without detrimental effects across different application levels.

These results underscore the potential of organic fertilizers as viable alternatives to commercial synthetic inputs. While commercial fertilizers deliver concentrated and immediately available nutrients, organic amendments (pyrolyzed LBP fertilizers) provide secondary benefits that support long-term soil health and structural development based on the data collected. The findings support the proposition that agricultural waste-derived fertilizers can effectively contribute to sustainable crop production by improving both plant growth and soil quality.

Table 3. Mean Number of Leaves of Tomato (Solanum Lycopersicum) Plants Across Treatments from Day 1 to Day 6

Treatment	Pot 1 (Mean)	Pot 2 (Mean)	Pot 3 (Mean)	Treatment Mean
T1 – Pyrolyzed LBP Fertilizer	8.83	7.5	7.8	8.04
T2 – Commercial Fertilizer (MasterBlend 4-18-38)	8.6	8	7.3	7.96
T3 – No Fertilizer (Control Group)	6.1	6.6	5.3	6

Discussion:

The data on leaf numbers presented in Table 3 demonstrate clear treatment effects on foliar development. Throughout the experimental period, both fertilized treatments (T1 and T2) consistently produced more leaves than the unfertilized control (T3). T1 achieved an overall mean leaf count of 8.04, while T2 recorded 7.96; both values exceeded the mean of 6.00 leaves observed in T3.

Leaf number is a critical growth parameter because it directly influences photosynthetic capacity and overall plant productivity *(Li et al., 2025).* The higher leaf counts observed in T1 indicate that fertilizer application substantially enhanced vegetative growth by supplying nitrogen and other essential nutrients necessary for chlorophyll synthesis and leaf tissue development.

A notable observation is that T2 slightly outperformed by T1 in mean leaf production (8.04 vs 7.96). Although the difference is minimal, this finding suggests that the nutrient composition of the pyrolyzed LBP fertilizer, particularly its potassium content, may have contributed to enhanced leaf formation during later growth stages. This interpretation is supported by *Lehmann et al. (2019)*, who emphasized that biochar-based amendments enhance soil porosity, water-holding capacity, and microbial activity, ensuring that plants receive a steady supply of nutrients needed for continuous leaf formation and stronger overall growth.

In contrast, plants in T3 relied solely on the limited nutrients available in the potting medium, resulting in reduced leaf initiation and expansion. These findings align with *Liebig's Law of the Minimum,* which posits that plant growth is constrained by the essential nutrient present in the lowest supply. In this case, insufficient nitrogen availability in unfertilized treatment is likely limited leaf development, as nitrogen is fundamental to chlorophyll production, cell division, and tissue growth in tomato plants.

B. SPECIFIC OBJECTIVE 2

To determine the effects of different fertilizer treatments on plant height (cm), stem diameter (mm), and number of leaves, calculating the percentage increase over the control group after the three-week experimental period.

Data was collected twice weekly for six days, and treatment means were obtained by averaging measurements from the three pots per observation day. Final mean values of plant height, stem diameter, and number of leaves were used to assess treatment effects. Treatment performance was compared with the control group, and percentage increase was calculated following methods used in previous bell pepper fertilizer studies *(Balkrishna et al., 2024).*

Table 4. Percentage Increase in Plant Height Over the Control Group After Three Weeks

Treatment	Final Mean	Percentage Increase Over Control (%)
T1 – Pyrolyzed LBP Fertilizer	12.71	55.76%
T2 – Commercial Fertilizer (Masterblend 4-18-38)	10.74	31.62%
T3 – No Fertilizer (Control)	8.16	Baseline

Discussion:

Table 4 shows clear differences in plant height among treatments after the three-week experimental period. T1 recorded the highest percentage increase over the control group (55.76%), followed by T2 (31.62%), while T3 served as the baseline (0%). These results indicate that the pyrolyzed LBP fertilizer produced greater plant height compared to both the commercial fertilizer and the unfertilized control.

The superior performance of T1 may be explained by *Liebig's Law of the Minimum*, which states that plant growth is limited by the nutrient in the shortest supply. The pyrolyzed LBP fertilizer contains essential macronutrients such as potassium, calcium, phosphorus, and magnesium, which are important for stem elongation and vegetative development in tomato plants *(Haque et al., 2023).* Although Masterblend 4-18-38 provides balanced nutrients for general growth, the nutrient composition of the LBP fertilizer may have better met the specific nutrient demands required for enhanced stem elongation. This likely contributed to the higher percentage increase observed in T1.

Similarly*, Balkrishna et al. (2024)* reported a significant percentage increase over control in plant height of bell pepper treated with organic fertilizers, emphasizing the positive impact of nutrient-rich organic amendments on vegetative growth. Their findings support the present results, suggesting that organic-based fertilizers can effectively enhance plant height when compared to unfertilized controls. This parallel strengthens the validity of the observed growth response in tomatoes and indicates that organic fertilizers consistently promote stem elongation across different vegetable crops.

The controlled experimental conditions strengthen the conclusion that differences in growth were primarily due to fertilizer treatment. However, the three-week duration limits the findings to early vegetative growth and does not reflect potential long-term effects on yield or soil properties. The lower performance of the control group further confirms that insufficient nutrient supply restricts plant development.

Table 5. Percentage Increase in Stem Diameter Over the Control Group After Three Weeks

Treatment	Final mean	Percentage Increase Over Control (%)
T1 – Pyrolyzed LBP Fertilizer	2.89	43.07%
T2 – Commercial Fertilizer (Masterblend 4-18-38)	2.64	30.69%
T3 – No Fertilizer (Control)	2.02	Baseline

Discussion:

Table 5 shows that stem diameter varied across treatments after the three-week experimental period. T1 (pyrolyzed LBP fertilizer) recorded the highest percentage increase over the control group (43.07%), followed by T2 (30.69%), while T3 served as the baseline (0%). These findings indicate that T1 promoted superior stem development compared to commercial fertilizer and unfertilized control.

The improved performance of T1 may be attributed to its nutrient composition, including potassium, calcium, and phosphorus, as well as the soil-enhancing properties of biochar *(Islam et al., 2019; Haque et al., 2023).* According to *Liebig's Law of the Minimum*, plant growth is constrained by nutrients in short supply. The pyrolyzed LBP fertilizer may have provided a more sustained nutrient release and improved nutrient retention, supporting greater stem thickening. In contrast, commercial fertilizers may release nutrients more rapidly, potentially reducing long-term utilization efficiency, consistent with *Mitscherlich's Law of Diminishing Returns.*

Balkrishna et al. (2024) likewise observed enhanced structural growth parameters in Capsicum under organic fertilizer treatments, reporting improved plant vigor and sustained growth compared to control plots. Their findings reinforce the concept that organic fertilizers not only supply nutrients but also improve soil conditions that contribute to stronger vegetative structures. This supports the present observation that biochar-based LBP fertilizer enhanced stem diameter development in tomatoes.

These results highlight the potential of pyrolyzed LBP fertilizer as a sustainable alternative in tomato production. The relevance of *Balkrishna et al. (2024)* lies in demonstrating that organic fertilizers derived from alternative waste materials can be transformed into productive agricultural inputs, supporting both crop productivity and environmental sustainability. The lower stem diameter observed in the control group further confirms that adequate nutrient supply is essential for proper vegetative development.

Table 6. Percentage Increase in Number of Leaves Over the Control Group After Three Weeks

Treatment	**Final mean**	**Percentage Increase Over Control (%)**
T1 – Pyrolyzed LBP Fertilizer	8.04	34.00%
T2 – Commercial Fertilizer (Masterblend 4-18-38)	7.86	31.00%
T3 – No Fertilizer (Control)	6.00	Baseline

Discussion:

Table 6 shows differences in leaf production among treatments after the three-week experimental period. T1 (pyrolyzed LBP fertilizer) recorded the highest percentage increase over the control group (34%), followed closely by T2 (31%), while T3 served as the baseline (0%). These findings indicate that fertilizer application enhanced foliar development compared to the unfertilized control *(Sikdar et al., 2023).*

The comparable performance of T1 and T2 suggests that both fertilizers supplied essential nutrients required for leaf formation. Leaf production in tomato plants is strongly influenced by nitrogen and potassium availability, which are vital for cell division and chlorophyll synthesis *(Alam et al., 2021; Anuada et al., 2021).* Although both treatments improved leaf count, T1 showed slightly greater enhancement of 4% compared to T2.

Consistent with the present findings, *Balkrishna et al. (2024)* reported a significant percentage increase over control in leaf-related growth parameters under organic fertilizer treatments. Their results indicate that organic nutrient sources enhance photosynthetic surface area, which is critical for overall plant productivity. This similarity suggests that the positive effect of organic fertilizers on leaf development may be consistent across different vegetable crops, including tomato and bell pepper.

The application of 3g of pyrolyzed LBP fertilizer per plant aligns with *Tajer (2024). Sikdar et al. (2023)* also reported that biochar application enhanced tomato growth across different rates, indicating that pyrolyzed LBP fertilizer can promote growth even at varying application levels. Furthermore, *Balkrishna et al. (2024)* emphasized that organic fertilizers improve vegetative growth and support sustainable nutrient management. These findings reinforce the potential of pyrolyzed LBP fertilizer as an environmentally sustainable alternative to commercial fertilizers.

Leaf counts in this study were limited to fully expanded leaves to ensure measurement consistency with established methodological standards *(Conde et al., 2021).* This standardization enhances reliability and comparability across treatments. However, it may not fully capture early leaf emergence, which could influence total foliar development. Despite this limitation, the approach strengthens the validity of treatment comparisons.

C. SPECIFIC OBJECTIVE 3

To determine whether there is a statistically significant difference in the mean plant height (cm), stem diameter (mm), and number of leaves (count) among tomato *(Solanum lycopersicum)* plants treated with Pyrolyzed LBP Fertilizer, Commercial Fertilizer (MasterBlend 4-18-38), and no fertilizer application using appropriate statistical analysis.

Table 7: One-Way ANOVA (Welch's) Results for Plant Growth Parameters

One-Way ANOVA (Welch's)				
	F	**df1**	**df2**	**p**
Plant Height	10.14	2	2.92	0.048
Stem Diameter	29.83	2	3.41	0.007
Number of Leaves	7.86	2	4.00	0.041

Discussion:

The One-Way ANOVA (Welch's) was conducted to determine whether fertilizer type significantly affects the growth of tomato plants in terms of plant height, stem diameter, and number of leaves. The results presented in Table 7 indicate statistically significant differences among the three treatments for all growth parameters. Plant height showed $F(2,2.92) = 10.14$, $p = 0.048$, stem diameter $F(2,3.41) = 29.83$, $p = 0.007$, and number of leaves $F(2,4.00) = 7.86$, $p = 0.041$. Since all p-values are below the 0.05 significance level, the null hypothesis is rejected, indicating that fertilizer type has a significant effect on tomato growth *(Haque et al., 2023; Sikdar et al., 2023; Liu et al., 2020).*

Analysis of the means revealed that tomato *(Solanum Lycopersicum)* plants treated with pyrolyzed LBP fertilizer consistently exhibited the highest growth performance across all measured variables. Plants treated with commercial fertilizer (MasterBlend 4-18-38) showed intermediate growth, while the unfertilized control group recorded the lowest growth values. These findings suggest that the biochar-based organic fertilizer effectively supplied essential nutrients such as nitrogen, potassium, calcium, and phosphorus, which are necessary for stem elongation, structural development, and leaf production *(Lehmann et al., 2019; Sikdar et al., 2023).*

The implications of these results are significant for sustainable agriculture. First, the pyrolyzed LBPs fertilizer can serve as an effective alternative to commercial fertilizers, reducing reliance on synthetic inputs while supporting optimal plant growth *(So and Tan, 2018)*. Second, according to Soil fertility Theory, organic amendments such as biochar improve soil structure, water retention, and microbial activity, which can enhance soil health and long-term productivity. Third, utilizing agricultural waste like banana peels promotes environmental sustainability by reducing organic waste and preventing potential soil and water pollution from chemical fertilizers *(Balkrishna et al. (2024))*.

In conclusion, the type of fertilizer has a statistically significant impact on the vegetative growth of tomato plants, specifically affecting plant height, stem diameter, and number of leaves. The results directly support Specific Objective 3, confirming that pyrolyzed LBP fertilizer is not only effective but also a sustainable option for enhancing tomato growth, demonstrating that locally available organic resources can provide comparable or superior outcomes to commercial fertilizer *Lehmann et al. (2019).*

CHAPTER 5

Summary, Conclusion and Recommendation

Summary

This study determined the effect of Pyrolyzed LBP fertilizer, commercial fertilizer, and no fertilizer on the growth performance of tomato plants. A quantitative experimental design was utilized over three weeks with treatments applied at three grams per pot. Growth measurements were recorded twice weekly and analyzed using mean, percentage increase, and One-Way ANOVA (Welch's). The results indicated significant differences among the three treatments regarding plant height, stem diameter, and number of leaves. Plants treated with pyrolyzed LBP fertilizer recorded the highest mean values across all parameters compared to the commercial fertilizer and control groups. Percentage increase calculations revealed that the LBP fertilizer improved plant height by 55.76%, stem diameter by 43.07%, and number of leaves by 34% over the control group. Statistical analysis confirmed that these differences were significant at the 0.05 level, leading to the rejection of the null hypothesis. These findings highlight the potential of agricultural waste as a viable organic fertilizer alternative.

Conclusion

The general objective of this research was to evaluate the significant difference in the growth performance of tomato plants treated with pyrolyzed Lakatan banana peel fertilizer versus commercial fertilizer and no fertilizer. The data confirmed that fertilizer type significantly influenced plant height, stem diameter, and leaf count. Pyrolyzed LBP fertilizer consistently outperformed the commercial fertilizer and the control group, demonstrating superior efficacy in promoting early vegetative growth. Consequently, the null hypothesis was rejected in favor of the alternative hypothesis.

Pyrolyzed LBPs fertilizer serves as an effective and sustainable alternative to commercial fertilizers for tomato cultivation. These findings suggest that transforming agricultural waste into organic fertilizer can enhance plant growth while supporting environmental sustainability and cost-efficient farming practices. This study validates the practical application of waste valorization in agriculture.

Recommendations

Based on the study's findings, it is recommended that pyrolyzed LBPs fertilizer be adopted by schools, small-scale backyard gardeners, and farmers as a cost-effective and environmentally sound alternative to commercial fertilizers. This practice not only supports sustainable agricultural practices but also aids in reducing organic waste. However, to further optimize its application, it is recommended that the pyrolyzed LBPs fertilizer undergo additional analysis and refinement to maximize its effectiveness. Future researchers are encouraged to experiment with varying application rates, combine the pyrolyzed LBPs with other organic materials, or extend the observation period to evaluate long-term growth and yield potential. Furthermore, subsequent studies should expand the scope of variables beyond plant height, stem diameter, and leaf count to include leaf size, root development, fruit yield, and soil nutrient levels. Increasing the sample size and duration of the experiment would also contribute to the reliability and generalizability of the results.

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