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Characterization of Poly-organic Fertilizer from *Leucaena leucocephala* (Lam) de Wit (IPIL-IPIL) and Its Application in a Home-grown *Solanum lycopersicum* L. (Tomato) Set-up

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Fertilizers serve as essential supplements in modern agriculture, playing an essential role in supplementing soil fertility and promoting healthy plant growth. The Northern Samar Provincial Agriculture Office reported a 27.94% 5-year percentage change of tomato harvest in the entire province, and this increase in harvest throughout the years were observed with the use of organic

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fertilizers. This study developed an organic fertilizer from *Leucaena leucocephala* (Lam) de Wit (Ipil-ipil) with Polyvinyl Alcohol to be used in a home-grown *Solanum lycopersicum* L. (Tomato). Functional groups were investigated using FTIR. The soil physicochemical properties were analyzed to determine the soil's texture, pH, and macronutrient content. Tomato plant growth parameters such as plant weight and number of fruits were also identified. Test of significant relationship among the fertilizer treatments and the parameters were assessed with the use of Analysis of Variance. The functional group present in the Ipil-ipil leaf powder were hydroxyl, alkyl, amino, and carbonyl groups. The results revealed that the soil has silty clay texture, has a weakly acidic pH level, and contains varying macronutrients level. Tomato plants with Ipil-ipil organic fertilizer and PVA-containing Ipil-ipil fertilizer were the same in terms of the weight in kilograms. In terms of number of fruits, Ipil-ipil fertilizer with PVA has the greatest number of fruits among the other different fertilizer treatments. Use of the other parts of Ipil-ipil plant for fertilizer, implementing the fertilizer for different soil types and climatic conditions for plant, and exploring various application methods and dosage levels of fertilizers were recommended.

Keywords Fertilizer; soil physicochemical properties; polyvinyl alcohol; Leucaena leucocephala (Lam) de Wit; Solanum lycopersicum L.

1. INTRODUCTION

The adoption of sustainable and environmentally friendly agricultural practices has become crucial due to concerns about soil health and environmental degradation caused by traditional farming methods. Intensive use of chemical fertilizers and pesticides in conventional agriculture has led to soil depletion, reduced biodiversity, and ecological imbalances. As a result, organic farming, which emphasizes natural or organic inputs to enhance soil fertility and promote healthy plant growth, has gained popularity. Utilizing locally crafted organic fertilizers not only provides sustainable alternative but also reduces the carbon footprint associated with synthetic fertilizers. This shift towards sustainable agriculture is driven by the need to meet the growing global demand for nutritious, responsibly cultivated products while maintaining soil health and environmental integrity.

Agricultural statistics integrates advanced technology with traditional farming to provide comprehensive framework for collecting, analyzing, and interpreting agricultural data, enhancing productivity and sustainability [1, 2]. The use of organic fertilizers, such as animal manures, has notably improved the growth and nutritional content of tomatoes, contributing to a 27.94% increase in tomato harvests in Northern Samar from 2018 to 2022. Unlike conventional fertilizers, which can cause environmental harm through soil acidification and water contamination, organic fertilizers offer environmental benefits due to their slow-release nature and reliance on natural materials [2]. These fertilizers are economically advantageous for local farmer, reducing dependence on costly imports and opening new market opportunities for organically grown produce. Additionally, the organic fertilizer industry presents substantial growth potential, driving sustainable agricultural practices, fostering innovation, and enhancing corporate social responsibility, ultimately contributing to economic growth and job creation.

Leucaena leucocephala (Lam) de Wit, commonly known as Ipil-ipil plant, is renowned for its nitrogen-fixing ability and high biomass production making it a potential source of organic fertilizers [3,4]. However, systematic assessments of Ipil-ipil-based fertilizers on crops like tomatoes are limited. Hasan *et al.,* (2015) found that Ipil-ipil green leaf biomass significantly enhances essential nutrients crucial for crop yield [5]. The incorporation of polyvinyl alcohol (PVA) into organic fertilizer, a synthetic polymer that improves physical properties and nutrient retention, further enhances their effectiveness and sustainability [4,6,7]. Tomatoes, being a nutritious and economically important crop, benefit significantly from enhanced nutrient availability [8]. This study aims to evaluate the impact of Ipil-ipil-based organic fertilizers on the growth, yield, and quality of home-grown tomatoes, providing evidence for its potential a sustainable alternative to commercial fertilizers.

This research aimed to develop an organic fertilizer from *Leucaena leucocephala* (Lam) de Wit (Ipil-ipil) combined with Polyvinyl Alcohol (PVA) for use in home-grown tomatoes (*Solanum lycopersicum* L.). It sought to identify the functional groups in Ipil-ipil leaves using FTIR, evaluate the soil's pH and texture, and analyze the soil's macronutrient content (nitrogen, phosphorus, and potassium) when treated with different fertilizers. The study also compared the effects of no fertilizer Ipil-ipil organic fertilizer, Ipil-ipil with PVA, and commercial fertilizer on tomato plant growth, including plant weight and number of fruits, and investigated the significant relationships between these treatments and the plant growth parameters.

2. METHODOLOGY

The *Leucaena leucocephala* (Lam) de Wit (Ipil-ipil) leaves used in this study were collected at Barangay Bonifacio, Lope de Vega, Northern Samar. The soil physicochemical test except for identification of macronutrients (Nitrogen, Phosphorus and Potassium) was conducted at the Chemistry Laboratory, College of Science, University of Eastern Philippines, University Town, Catarman, Northern Samar. Soil Analysis for identification of macronutrients took place at the Technological Innovation Center located at the University of Eastern Philippines – Main Campus using the Soil Test Kits bought from Department of Agriculture – Bureau of Soil and Water Management. The determination of the plant growth of *Solanum lycopersicum* (Tomato) took place at Barangay Bonifacio, Lope de Vega, Northern Samar.

2.1 Preparation of Treatment

The tomato seeds were planted in an improvised seedling tray and when a sprout was observed, it was transferred in an improvised plant pot that served as experimental pots and was placed in a well-ventilated area. Watering was done regularly. Various fertilizer treatment will be applied to the soil in each pot. Insects were monitored closely, and if any, it was removed manually.
The following treatments were used:

Control Variable: No treatment (Without Ipil-ipil organic fertilizer and commercial fertilizer).

Experimental Variable:

Treatment 1: Ipil-ipil organic fertilizer without PVA per pot
Treatment 2: Ipil-ipil organic fertilizer with PVA per pot
Treatment 3: Commercial fertilizer per pot

2.2 Organic Fertilizer Formulation

The *Leucaena leucocephala* (Lam) de Wit (Ipil-ipil) leaves were collected from Barangay Bonifacio, Lope de Vega, Northern Samar. The leaves were washed thoroughly with distilled water to remove impurities and were dried in the dehydrator. Once dried, the leaves were grinded into a fine powder using an electrically powered grinding machine.

2.3 Poly-Organic Fertilizer Formulation

For the preparation of poly-organic fertilizer from *Leucaena leucocephala* (Lam) de Wit (Ipil-ipil) leaves, another set ipil-ipil leaves were collected and chopped finely. The finely chopped leaves were mixed with distilled water in a ratio of 1:2 (Ipil-ipil leaves in mg to water in mL) and fermented for about two weeks in a covered container and was stirred occasionally. After fermentation, the mixture was strained to separate the liquid extract. The ipil-ipil leaf extract was then combined with the polyvinyl alcohol solution in a ratio of 1:1.

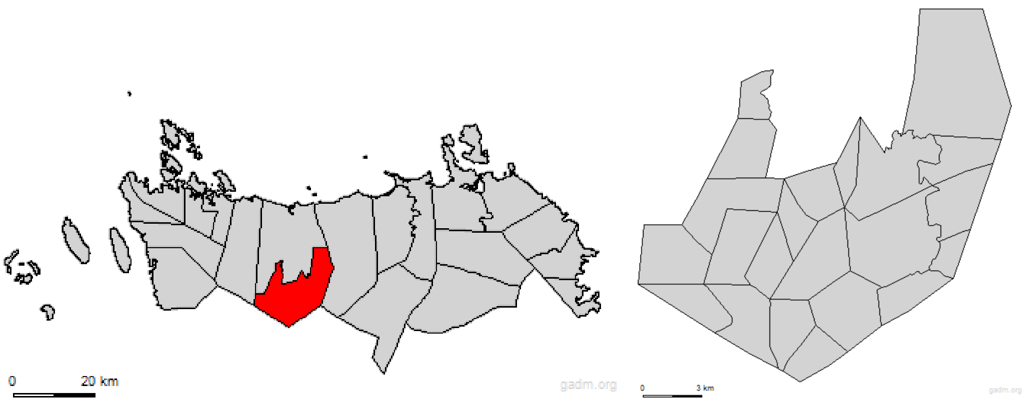

Fig. 1. Map of Northern Samar and Lope de Vega [9]

2.4 Characterization of Ipil-ipil Starch without Polyvinyl Alcohol

For Ipil-ipil characterization, the researcher used the Perken Elmer Spectrum IR – Spectrum 2 (Version 10.7.2) machine, available at the University of Eastern Philippines, to determine the functional groups that are present in the ipil-ipil powder.

2.5 Soil Texture Analysis

Sift the soil through a mesh sieve or colander to remove debris, rocks, and large organic matter. Fill one-third of a jar with the sifted soil and the rest with clean water, leaving some space at the top. Add one tablespoon of powdered dishwashing detergent, cap the jar, and shake until the soil forms a uniform slurry. Let it sit for one minute and mark the coarse sand layer on the jar. After two hours, mark the top of the settled silt layer. After 48 hours, mark the top of the clay layer. Measure and record the height of each layer and the total height [10]. Percentage of silt, clay, and sand present were computed using this formula:

% SAND= (sand height)/ (total height) x 100 =___________ % SAND
% SILT= (silt height)/ (total height) x 100 =___________ % SILT
% CLAY= (clay height)/ (total height) x 100 =___________ % SILT

2.6 Soil Analysis

A sample of the soil in Barangay Bonifacio, Lope de Vega, Northern Samar was taken for the soil analysis. The pH was identified by using the soil pH-moisture meter available at the Technology Innovation Center, University of Eastern Philippines. The identification of macronutrients (N, P and K) was done using the soil test kit bough from the Department of Agriculture – Bureau of Soil and Water Management.

2.7 Determination of Tomato Plant Growth Parameters

Observations on the plant weight variable was conducted forty-five days since the first bud was observed. While the collection of the variable amounts, number of the fruits, was done after harvesting the sample plants [10].

2.8 Test of Significance

To evaluate the impact of different fertilization treatments on tomato plant growth, the researcher used Analysis of Variance (ANOVA) to compare the effects of no fertilizer, ipil-ipil-based organic fertilizer, poly-organic fertilizer from ipil-ipil, and commercially available fertilizer on growth metrics like plant weight, height, leaf count, fruit weight, and fruit count. Utilizing IBM's SPSS software for data analysis, if ANOVA indicated significant differences, Tukey's Honest Significant Difference (HSD) test was employed for post hoc analysis to identify specific differences between treatments while controlling the Type I error rate, ensuring reliable and easily interpretable results [11].

3. RESULTS

Fig. 2 shows that the Ipil-ipil sample registered an IR spectrum of normal polymeric -OH stretch at 3280.74 cm-1, methylene C-H symmetrical stretch at 2918.09 cm-1, C=O primary amine, NH bend at 1630.04 cm-1, and primary amine C-O stretch at 1035.98 cm-1. This corresponded to the study of Kulkarni & Sethi (2023). Their study revealed that *Leucaena leucocephala* (Lam) de Wit or Ipil-ipil lead contains *Mimosine* – which have shown to have cleaning properties.

This is in consonance to the result gained by Widaad et al. (2022). Their findings revealed that *Leucaena leucocephala* extract contains Mimosine – a compound that could be used as a potent anthelmintic agent. Numerous biological activities of mimosine, including its antiviral, antibacterial, and antitumor effects, have been demonstrated. Mimosine has been demonstrated to have some beneficial effects on soil fertility and plant growth, suggesting a potential use in a biofertilizer setup [12]. For instance, some research has shown that adding mimosine to soil can boost the activity of good microorganisms like bacteria that fix nitrogen, which can enhance soil fertility and plant growth [13].

Table 1 shows the summary of the soil physicochemical properties conducted. The soil analysis indicates a composition of 45.21% clay and 54.79% silt, with a neutral pH of 6.8, ideal for tomato cultivation. The result suggests that the soil provides an ideal environment for tomato cultivation, while the neutral pH level ensures optimal nutrient ability for plant growth. Therefore, these results indicate a foundation for good tomato cultivation, leading to healthy plant growth and abundant yields [14].

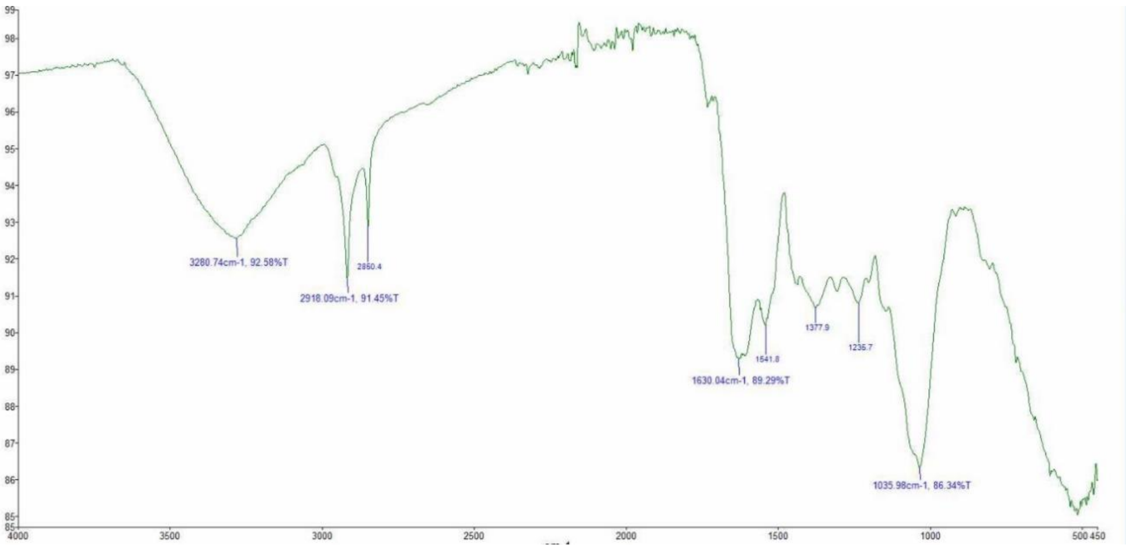

Fig. 2. FTIR Spectra of Ipil-ipil starch

Table 1. Summary of soil physicochemical properties

Soil Physicochemical Properties	Value
Soil Texture	Silty Clay
Clay	45.21%
Silt	54.79%
pH	6.8

Table 2. Soil macronutrient (NPK) content

Treatments	Macronutrient		
	Nitrogen (N)	Phosphorus (P)	Potassium (K)
No Fertilizer	Low	Very High	Sufficient
Ipil-ipil Fertilizer	Low	Very High	Sufficient +
Ipil-ipil Fertilizer with PVA	Low	Very High	Sufficient ++
Commercial Fertilizer	Low	Very High	Sufficient +

Table 2 reveals the soil macronutrient content tested using the soil test kit bought from Department of Agriculture – Bureau of Soil and Water Management. Results show that in control soil, nitrogen is low, phosphorus is very high, and potassium is sufficient. Fertilizer treatments, including Ipil-ipil and PVA-containing Ipil-ipil, consistently show low nitrogen, very high phosphorus, and varying sufficiency in potassium levels, with the PVA-containing fertilizer providing the highest potassium enrichment. This suggests that while all fertilizers increase phosphorus, PVA-containing Ipil-ipil is most effective in boosting potassium, which is crucial for plant growth, health, and yield improvement according to Marschner [15,4].

Fig. 3 shows the summary of tomato plant weight on different fertilizer treatments. The researcher identified the plant weight to observe the efficacy of the treatments. The results indicated that tomato plants with ipil-ipil fertilizer have the same weight as that of the plant with poly-organic fertilizer. This suggests that Ipil-ipil fertilizer can be as effective as poly-organic fertilizer in promoting plant growth. This finding is significant as it indicates the potential of Ipil-ipil fertilizer as a sustainable alternative for enhancing plant productivity [16,1].

Table 3 shows the number of fruits of *Solanum lycopersicum* L. (Tomato) plant with different fertilizer treatments. The number of fruits were also identified as it is one of the indicators of good plant growth. There were no fruits produced on a plant with no fertilizer. Tomato plant with commercial fertilizers produced 2 fruits, plant with Ipil-Ipil fertilizer produced 4 fruits, and plant with poly-organic fertilizer produced the greatest number of fruits which is 6. The absence of fruit production on the unfertilized plant suggests the necessity of fertilizer for optimal growth and yield. The results indicate that different fertilizers have varying effects in fruit production, with PVA-containing Ipil-ipil organic fertilizer resulting in the highest yield. This highlights the importance of selecting appropriate fertilizers for maximizing crop production. Studies such as those by Chaudhary *et al.* (2017) and Sharma *et al.* (2019) have similarly demonstrated the significant impact of fertilizer type on fruit yield in various crops, supporting the findings of this experiment [17-20].

Fig. 4 revealed the result of a test of significance between different fertilizer treatments and plant growth parameters such as *Solanum lycopersicum* L. (Tomato) plant weight and the corresponding post-hoc test results. There was a statistically significant difference between treatments as demonstrated by one-way ANOVA ($F = 27.4$, $p = <0.001$). A Tukey-post hoc test revealed that the control treatment and experimental treatment B (Ipil-ipil fertilizer with PVA) were statistically significant to the plant weight of tomato with $p = 0.001$. Ipil-ipil fertilizer treatment and commercial fertilizer showed no statistically significant difference towards the plant weight of tomato. These findings suggest that the experimental treatment B (Ipil-ipil fertilizer with PVA) could be a promising alternative to traditional and commercial fertilizers in enhancing tomato growth.

Fig. 5 revealed the result of a test of significance between different fertilizer treatments and the *Solanum lycopersicum* L. (Tomato) plant's number of fruits yield. Based on the one-way ANOVA result, all the fertilizer treatments have no significant effect on the number of fruits of *Solanum lycopersicum* L. (tomato) plant since the *p-values* gained were greater than the significant value 0.05. This result implies that within the parameters of this study, the choice of fertilizer did not significantly influence fruit yield. However, it's crucial to consider the limitations of this study such as specific environmental conditions and plant variability which could affect the outcomes [21].

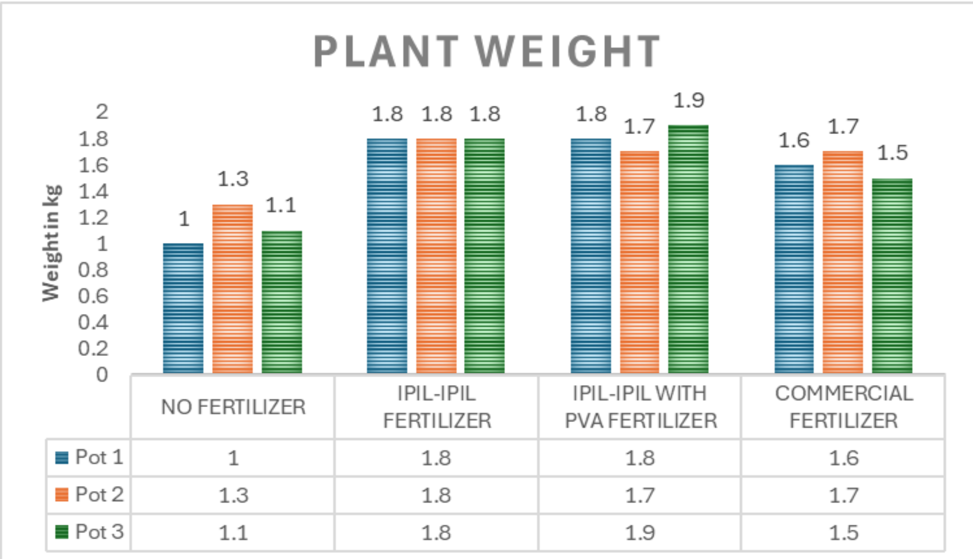

Fig. 3. Plant Weight of tomato with different fertilizer treatments

Table 3. Tomato fruit yield in different fertilizer treatments.

Treatment	POT 1	POT 2	POT 3	Total
No fertilizer	0	0	0	0
With Ipil-ipil Fertilizer	2	1	1	4
Ipil-ipil Fertilizer with PVA	3	1	2	6
Commercial Fertilizer	0	2	0	2

ANOVA

PLANTWEIGHT

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.890	3	.297	27.385	<.001
Within Groups	.087	8	.011		
Total	.977	11			

Multiple Comparisons

Dependent Variable: PLANTWEIGHT
Tukey HSD

(I) TREATMENTS	(J) TREATMENTS	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
NO FERTILIZER	IPIL-IPIL FERTILIZER	-.6667*	.0850	<.001	-.939	-.395
	IPIL-IPIL WITH PVA	-.6667*	.0850	<.001	-.939	-.395
	COMMERCIAL FERTILIZER	-.4667*	.0850	.003	-.739	-.195
IPIL-IPIL FERTILIZER	NO FERTILIZER	.6667*	.0850	<.001	.395	.939
	IPIL-IPIL WITH PVA	.0000	.0850	1.000	-.272	.272
	COMMERCIAL FERTILIZER	.2000	.0850	.165	-.072	.472
IPIL-IPIL WITH PVA	NO FERTILIZER	.6667*	.0850	<.001	.395	.939
	IPIL-IPIL FERTILIZER	.0000	.0850	1.000	-.272	.272
	COMMERCIAL FERTILIZER	.2000	.0850	.165	-.072	.472
COMMERCIAL FERTILIZER	NO FERTILIZER	.4667*	.0850	.003	.195	.739
	IPIL-IPIL FERTILIZER	-.2000	.0850	.165	-.472	.072
	IPIL-IPIL WITH PVA	-.2000	.0850	.165	-.472	.072

*. The mean difference is significant at the 0.05 level.

Fig. 4. Analysis of Variance (ANOVA) result for plant weight and its corresponding post-hoc test

ANOVA

NO.OFFRUITS

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	6.667	3	2.222	3.333	.077
Within Groups	5.333	8	.667		
Total	12.000	11			

Fig. 5. Analysis of Variance (ANOVA) result for the number of plants

4. CONCLUSION

The main objective of this thesis was to develop an organic fertilizer from *Leucaena leucocephala* (Lam) de Wit (Ipil-ipil) leaves with polyvinyl alcohol. The pulverized ipil-ipil leaves was characterized by Fourier-Transform Infrared Spectroscopy (FTIR). The ipil-ipil leaves powder was isolated in the Technology Innovation Center, University of Eastern Philippines and the result that was obtained indicated that this sample register an IR spectrum of -OH stretch at 3280.74 cm-1, methylene C-H symmetrical stretch at 2918.09 cm-1, C=O primary amine, NH bend at 1630.04 cm-1, and primary amine C-O stretch at 1035.98 cm-1. The findings revealed that the ipil-ipil powder contained mimosine.

The soil physicochemical properties indicated that the soil sample that was used subjected for plant growth has a silty clay texture having 54.79% silt and 45.21% clay. Soil pH and macronutrient analysis of the four fertilizer treatments (no fertilizer, Ipil-ipil fertilizer, Ipil-ipil fertilizer with PVA, and commercial) were also assessed. Nitrogen presence in the soil samples with all the different fertilizer treatments were found to be low. However, there is a very high presence of phosphorus in all the soil samples with all the different fertilizer. Potassium content varies among the soil samples depending on its fertilizer treatment, soil sample without fertilizer appeared to have sufficient potassium content, soil samples with Ipil-ipil fertilizer and commercial fertilizer has a sufficiency level greater than that of the soil sample without fertilizer, while the soil sample containing Ipil-ipil with PVA fertilizer has the greatest potassium sufficiency content among others.

The *Solanum lycopersicum* L. (Tomato) plant growth was also determined. Plant growth parameters such as plant weight and number of fruits were uncovered. For the plant weight, the results indicated that tomato plants with Ipil-ipil fertilizer have the same weight as that of the plant with poly-organic fertilizer. PVA-containing Ipil-ipil fertilizer also recorded the greatest number of fruits among the other treatments.

The study examined the impact of various fertilizer treatments on different growth parameters of tomato plants. Analysis of Variance (ANOVA) was employed to assess the relationships among the treatments. Significant differences were found in plant weight, with the Tukey's Honest Significant Difference (HSD) test identifying specific variations. However, the number of fruits showed no significant difference across the fertilizer treatments. While the study revealed significant variations in plant weight among the different fertilizer treatments, further investigations into factors influencing fruit number are warranted to comprehensively understand the nuances of tomato plant growth under varying fertilizer treatments.

This study presents a sustainable and cost-effective alternative to synthetic fertilizers. By integrating traditional farming knowledge with modern techniques, it addressed the need for sustainable agriculture while promoting economic growth and environmental conservation. Adopting eco-friendly fertilization methods could result in healthier crops, improved soil health, and a greener future for agriculture.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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