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The Influence of Doses of Rice Husk (*Biochar*) and Organic Liquid Fertiliser Types on the Growth and Production Yield of Tomatoes (*Lycopersicum esculentum* Mill)

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Keywords

Brass Husk Rice Dose, Liquid Fertilizer Type, Tomato Plant Lycopersicum esculentumn Mill

ABSTRACT

Tomatoes (Lycopersicum esculentum Mill) are essential horticultural crops valued for their high nutritional content and health benefits. With increasing market demand, there is a pressing need to adopt sustainable cultivation practices that enhance soil fertility and crop productivity. This study aims to evaluate the combined effects of rice husk biochar application and different types of liquid fertilizers on tomato yield, with the objective of identifying optimal treatments for improved cultivation. The research employed a Causalized Block Randomized Design (CBRD) with two factors: (1) rice husk application at four levels (0, 1, 2, and 3 tons/ha), and (2) liquid fertilizer type at three levels (no fertilizer, Lof Nachi 500 L/ha, and POC NASA 500 L/ha). Each treatment was replicated three times, resulting in 12 treatment combinations. Data were analyzed using Analysis of Variance (ANOVA). The highest tomato yield (10.76 tons/ha) was observed with the combination of 3 tons/ha rice husk and Lof Nachi 500 L/ha. In contrast, the lowest yield (5.70 tons/ha) occurred in the control treatment without any organic or liquid fertilizer. The results demonstrate a significant interaction between organic matter dosage and liquid fertilizer type in enhancing tomato productivity. This research offers practical implications for sustainable agricultural practices by promoting the integrated use of organic amendments and bio-based fertilizers, which can be particularly beneficial for smallholder farmers seeking cost-effective and eco-friendly production strategies.

INTRODUCTION

Tomato (Lycopersicum esculentum Mill) is a plant in the horticulture sector that has a unique flavor, sweet taste, and is loved by many people, (Ritonga et al., 2019; Rosyidah et al., 2016). The market demand for tomatoes is high year after year. Tomatoes are a fruit vegetable that is important for consumers in Timor-Leste every day, and are used to make fresh salads, sauces, juice, and more. Tomatoes are also rich in nutrients like vitamins and are essential for a healthy and complete diet, (Bachtiar Musthafa, 2022a, 2022b; Nasrulloh et al., 2016; Onggo et al., 2017).

In Timor-Leste, there is a high demand for tomatoes but there are many difficulties that farmers face in cultivating them, such as pests and diseases, and even difficulties in selling the tomatoes in the market, (Pereira, 2019). To respond to market demand, pest and disease problems, and increase productivity, farmers need to use appropriate cultivation techniques, like adding organic materials to the soil, specifically using organic liquid fertilizers from cow manure, and provide adequate nutrition to other crops grown in the same area like maize, cassava, and others. The use of organic materials can enhance the soil quality and productivity of tomatoes, and is an important component for a beautiful environment. In cultivation of tomatoes, environmental factors such as opportune weather, are essential for achieving progress in growth and production (Dwiratna et al., 2018; Fitriani, 2018; Mubarok et al., 2020; Sari & Murtilaksono, 2019).

According to Másimu, Hayati et al. (2012), continued cultivation of tomato plants requires organic material in order to improve the physical characteristics of the soil, especially for clay soil. Osman (1996) states that the success of tomato cultivation production depends on the condition, texture, and structure of the soil. The preferred soil structure for tomato plants is soft and porous, which allows good air and water circulation and optimal nutrient absorption. Rice husk ash can be used as fertilizer, as it contains nutrients that are suitable for tomato plants and can also improve soil pH. Research by Kolo and Rahajo (2016) showed that using 0.5kg of rice husk ash per tomato plant resulted in a total yield of 646g per plant (1.9 t/ha-1).

The use of rice husk ash for tomato cultivation also has the advantage of improving soil characteristics such as porosity and aeration, as well as acting as a nutrient supplement. According to Pereira's (2019) study, the application of rice husk ash is important for the growth and production of tomato plants, especially for the plants' flowers and fruits. A comparison with a control group showed that plants that received no rice husk ash had delayed growth and production. Liquid organic NPK fertilizer and POC NASA fertilizer from Indonesia are also being spread in Timor Leste.

Timor's agriculture is an important sector to apply in the field to reduce the cost of accessing NASA POC (Shepherd & Palmer, 2015). One such liquid fertilizer is NPK, as well as other complementary liquid fertilizers, which provide effective nutrition for healthy and productive tomato plants. The low nitrogen content in liquid fertilizers stimulates the growth process. Liquid fertilizer, especially NPK, contains important macro-nutrients such as nitrogen, phosphorus, potassium and organic carbon, which are needed in large quantities for plants. Organic fertilizers are made from decomposed materials. Liquid organic fertilizers contain nutrients, such as nitrogen, phosphorus, and potassium, which are essential for tomato plants, providing complete nutrition. NPK organic liquid fertilizer is also a complementary fertilizer, which contains nitrogen nutrients in the form of Nitrate-nitrogen (NO_3) that are specifically prepared for tomatoes. The combination of these two fertilizers provides ample nitrogen supply, resulting in abundant tomato yields. NPK organic liquid fertilizer plays an important role in retaining and supplementing the nutrients in the soil and preventing the loss of evaporated nutrients or harmful substances to tomato plants. It also helps prevent erosion of nutrients in muscly, healthy soil (Imansyah et al., 2023; Luka et al., 2023; Sara et al., 2021; Sulistiyanto et al., 2022).

Previous studies have demonstrated the positive effects of rice husk biochar and organic fertilizers on tomato plant growth and yield. For instance, Adebajo et al. (2019) found that applying rice husk biochar at 40 t/ha significantly improved tomato growth parameters and fruit yield. Similarly, a meta-analysis by Zhang et al. (2021) indicated that organic fertilizers could enhance tomato yield by up to 42.18%, along with improvements in fruit quality attributes such as soluble solids and vitamin C content. However, these studies primarily focused on the individual effects of either biochar or organic fertilizers.

The primary objective of this study is to evaluate the combined effects of rice husk biochar application rates and types of liquid fertilizers on the growth and yield of tomato plants (Lycopersicum esculentum Mill). Specifically, it aims to determine the optimal combination that maximizes yield and improves soil fertility. The benefits of this research include providing farmers with evidence-based recommendations for sustainable fertilization practices, enhancing tomato production efficiency, and contributing to environmental conservation by promoting the use of organic amendments.

METHOD

This research employs an experimental quantitative approach using a Randomized Complete Block Design (RCBD) with a factorial pattern of 4 × 3. The study was conducted from June to December 2023 in Sukaer Laran Village, Hera Tribe, Cristo Rei Administrative Post, Dili Municipality, situated at an altitude of 10 meters above sea level. The population in this study includes all tomato plants cultivated under various combinations of rice husk dosage and liquid fertilizer treatments. The sample consisted of 36 experimental plots, each assigned one of the 12 treatment combinations and replicated three times. Sampling technique was purposive, based on predefined treatment combinations to ensure consistency and comparability in the experimental setup.

The research instruments included a measuring tape for plant height, a digital scale for fruit weight, and manual counters for the number of fruits per plant. To ensure instrument validity, measurements followed standardized agricultural procedures, and tools were calibrated prior to use. Reliability was enhanced through repeated observations and measurement verification across replications. Data collection techniques comprised direct field observations and measurements during key growth stages, from flowering to harvest. Data such as yield per plot (converted to tons per hectare), plant height, and fruit count were documented in structured data sheets prepared using Microsoft Excel.

For data analysis, recorded data were imported into Genstat 18th Edition software. The analysis began with Analysis of Variance (ANOVA) to determine the significance of main effects and interactions between rice husk dosage and types of liquid fertilizer. If a significant effect was detected, a post-hoc test using the Least Significant Difference (LSD) at a 5% significance level was performed to compare treatment means. This method ensured the robustness of statistical conclusions and provided empirical support for recommending optimal treatment combinations in sustainable tomato farming.

RESULTS AND DISCUSSION

Table 1. The Variables Observed

Rice husk (*Biochar*) dosage	Plant Height 3 WAP (cm)	Plant Height 5 WAP (cm)	Plant stem diameter 3 WAP (mm)	Plant stem diameter 5 WAP (mm)	Number of leaves 3 WAP	Number of leaves 5 WAP	Number of stems 5 WAP
0 Ton/ha	12.63	30.56	3.31	6.23	5.41	11.26	4.00
1 Ton/ha	12.63	27.96	3.22	5.88	5.52	9.63	4.33
2 Ton/ha	13.63	30.81	3.53	6.48	5.89	11.11	6.04
3 Ton/ha	12.19	30.56	3.40	6.35	5.63	10.59	4.67
F.prob	**0.621**	**0.395**	**0.708**	**0.553**	**0.521**	**0.151**	**0.118**
LSD,p,<.05	**Ls**	**Ls**	**Ls**	**Ls**	**Ls**	**Ls**	**Ls**
% CV	**12.5**	**13.2**	**17.2**	**14.6**	**12.5**	**14.9**	**38.1**

NB: F.prob = Frequency probability : LSD = Least significant different : CV = Coefficient variation : LS = Not significant

Table 1 shows that there is no significant influence of the twelve levels of shading on all growth components, according to the analysis of variation with a specific difference indicator of 5%.

The variables observed from the table above are the low height of the tomato plant, stem diameter, number of branches, and amount of fruit per observation of tomato plants in weeks 3 and 5 after shading. The result was better in treatment with 2 tons/ha of organic matter Biochar because the organic matter can normalize the soil condition and make it more compact in the soil. The tomato plants can also effectively photosynthesize and absorb nutrients from the soil, which increases the overall plant growth. This is supported by the research from Soo Kim *et a*l. (2015) that using organic matter (biochar) shade levels with 1, 2, or 3 tons/ha can improve the physical and chemical properties of the soil, resulting in an improved tomato plant growth as well. Reinforcement from Husen (2013) states that applying rice plant ash (biochar) even if incomplete in nutrients can support the growth of planted trees and enrich the soil. In the observation of tomato plant growth, its diameter, fruit count, and branch quantity in the third and fifth week after planting showed a decline in treatments of 0, 1, and 3 tons per hectare. This happened because tomato plants have the ability to adapt to climate conditions with high heat, allowing them to absorb nutrients and organic matter with a minimum, despite the harsh conditions. This supports Fischer's (1996) statement that tomato plants with different genetic characteristics can adapt to the environment. However, the type of genetic characteristics affects the growth and production of plants.

Table 2. Organic liquid types for observation of tomato seedling growth

Dosage of liquid organic fertilizer types	Plant Height 3 WAP (cm)	Plant Height 5 WAP (cm)	Plant stem diameter 3 WAP (mm)	Plant stem diameter 5 WAP (mm)	number of leaves 3 WAP	number of leaves 5 WAP	number of stems 5 WAP
Control	11.81**a**	27,92**a**	3.11	5.8	5.42	10.08	3.53**a**
ALN (Lof Nachi)	13.75**b**	32.19**b**	3.61	6.58	5.83	11.03	6.14**b**
APN (Poc Nasa)	12.42**ab**	29.81**ab**	3.37	6.32	5.58	10.83	4.61**ab**
F.prob	**0.02**	**0.047**	**0.13**	**0.128**	**0.361**	**0.323**	**0.007**
LSD,p,<.05	**1.341**	**3.352**	**Ls**	**Ls**	**Ls**	**Ls**	**1.535**
% CV	**12.5**	**13.2**	**17.2**	**14.6**	**12.5**	**14.9**	**38.1**

Table 2 shows that there is no significant influence of organic liquid type on growth components, but there is a significant difference in the parameters of branch sprout at 3 WAP, 5 WAP, and 5 WAP twig counting according to variation analysis with a specific 5% concrete difference indicator.The observations on tomato branch sprout growth show that the observations on tomato branch sprout growth in the parameters of 3 WAP, 5 WAP and 5 WAP twig counting are significantly affected by the type of organic fertilizer used, which has an impact on improving soil structure and making it easier for the branches to absorb nutrients for the growth of tomato branch sprouts. We consider that the nutrition from Poc Nasa and Lof Nachi organic liquid fertilizers is sufficient for the process of tomato morphology formation, and Nitrogen element itself has a stimulating effect on the growth of tomato branch sprouts in general, but specifically on branch sprouts, twigs, and sprouts. The type of organic liquid fertilizer does not have a significant influence on the stem diameter at 3 WAP, 5 WAP, and 3/5 WAP twig counting, even though all values are low for the Lof Nachi organic liquid fertilizer, such as stem diameter 3 WAP with a value of 3.61cm, stem diameter 5 WAP with a value of 6.58cm, twig counting 3 WAP with a value of 5.83 and twig counting 5 WAP with a value of 11.03. This happens because the effective liquid fertilizer provides nutrients and creates favorable conditions for tomato branch sprouts.

Production parameters and components of tomato tree

production The analysis of variations showed an interaction between the factors of rice dose, ash, and type of organic liquid for productivity (ton/ha).

Table 3. Tomato production and production components.

Treatments	Prod (t/ha)	Density per unit area (m2)	Number of fruits per plant	Total weight of each fruit (gr)
H0A0	**5.70**	3.0	4.84	40.2
H0ALN	7.19	3.5	4.83	43.3
H0APN	7.40	3.2	4.49	52.4
H1A0	6.91	3.5	4.51	45.0
H1ALN	6.74	2.7	7.36	35.5
H1APN	6.65	3.3	5.02	42.1
H2A0	5.60	3.7	4.52	33.9
H2ALN	8.90	2.8	7.89	40.8
H2APN	8.15	3.2	5.18	50.8
H3A0	6.70	3.3	5.52	37.1
H3ALN	**10.76**	3.6	6.81	44.6
H3APN	7.35	3.2	5.51	43.1
F.prob	**<.001**	**0.135**	**0.175**	**0.149**
LSD, p<.05	**1.129**	**Ls**	**Ls**	**Ls**
% CV	**9.1**	**15**	**19.1**	**16**

Table 3 shows that the combination of rice husk treatment and organic liquid fertilizer type has an interaction on the production of tons/ha. We know that the combination of rice husk treatment of 3 t/ha with Lof Nachi liquid fertilizer of 500 Ltr/ha (H3ALN) has an excellent value of 10.76 tons/ha because this combination has a very positive impact on the growth and production of tomato plants. The rice husk that we applied during the planting season did not improve the microorganisms' place in the soil, but it was available to increase the soil's fertility. This is due to the circulation of organic material in the soil and Lofnachi liquid fertilizer's nutrients and growth regulator substances that can stimulate the vegetative and generative phases of optimal fruit production. With sufficient nutrition, photosynthesis can produce assimilates as an optimal output for plant growth. Assimilates refer to the products that are used to grow the plant, and when the optimal growth stage is reached, the tomatoes' fruit will be affected by the assimilates. In the combination of rice husk treatment of 0 t/ha with no organic fertilizer or control (H0A0), the minimum value of 5.70 ton/ha was achieved because it could not respond to the essential nutrients and hormones that the tomato plant needed to distribute and optimize assimilation. This resulted in a decrease in fruit production. In Ayu's (2017) research, he stated that the final growth stage of a tomato plant's fruit includes cell growth, carbohydrate accumulation, and amino acids resulting from the effects of nutrition and declining fertility in the initial pollination process. The density per square meter, the number of fruits per tomato plant, and the weight per fruit did not have a significant effect on the combination of treatment factors. The density per square meter increased significantly in the combination of treatments (H2A0), with a value of 3.7, and decreased in the combination of treatments (H2ALN), with a value of 2.8.

Table 4. Effect of ash dosage on rice production and tomato production components.

Rice husk dose (*Biochar*) (ton/ha)	Prod (t/ha)	density per plant (m2)	Number of fruits per tree	Fruit weight per plant (gr)
0 ton/ha	6.76**a**	3.247	4.72	40.3
1 ton/ha	6.77**a**	3.173	5.63	40.9
2 ton/ha	7.**55ab**	3.222	5.86	45.3
3 ton/ha	8.27**b**	3.358	5.95	41.6
F.prob	**<.001**	**0.872**	**0.081**	**0.526**
LSD, p<.05	**0.652**	**Ls**	**Ls**	**Ls**
% CV	**9.1**	**15**	**19.1**	**16**

Table 4 shows a significant influence of rice dosage and ash on the productivity of tomato plants, but there is no significant difference in density per square meter or the amount of fruit per tree, based on analysis of a small variation within a 5% difference indicator.

Table 4 above shows that the observation for tomato production yields in terms of productivity has a significant influence due to the dosage factor of unhusked rice skin for productivity (t/ha). Despite the fact that the productivity of tomato yields showed a high result in the treatment that was given a biochar dosage of 3 tons/ha with a value of 8.27t/ha, the yield was lower in the treatment without biochar (0t/ha) with a value of 6.76t/ha. This observation occurred because the application of biochar to the soil can improve the soil's characteristics, increase its fertility, and have the capacity to activate micro-organisms in the soil, thereby improving the growth and production of tomato fruits and flowers significantly.

Density per square meter does not have a significant influence, but the data shows that the treatment with a biochar dosage of 3t/ha had a higher value (3.353 m2) compared to the treatment without biochar with a value of 3.173 m2. This occurred because unhusked rice has the ability to improve soil fertility, normalize nutrition, and also improve and balance the hydrogen potential of the soil. Thus, if the application of biochar to the soil is increased with the sufficient quantity needed, the nutrition in the soil can be absorbed effectively according to its need. The quantity of fruit per tomato plant does not have a significant influence, but the treatment that was given a biochar dosage of 3 tons/ha had a higher result with a value of 5.95 compared to the treatment without biochar at 0 ton/ha with a value of 4.72. The quantity of fruit per tomato plant increased significantly in the treatment that was given biochar with a sufficient quantity because biochar can improve soil characteristics, including its chemistry and biology. Biochar can also improve drainage and aeration in the soil, providing a suitable place for micro-organisms to live. This study shows that the dosage of biochar has a significant impact on the production and productivity of tomato plants.

Table 5. Influence of organic liquid type on tomato production and production components.

Organic Liquid Type	Prod (t/ha)	Plant density (m2)	Number of fruits per plant	Weight per fruit (gr)
Control	6.23**a**	3.161	4.85**a**	39.0**a**
ALN (LOF NACHI)	8.40**c**	3.222	6.72**b**	41.0**a**
APN (POC NASA)	7.39**b**	3.645	5.05**a**	47.1**b**
F.prob	**<.001**	**0.608**	**<.001**	**0.021**
LSD, p<.05	**0.564**	**Ls**	**0.896**	**5.73**

Organic Liquid Type	Prod (t/ha)	Plant density (m2)	Number of fruits per plant	Weight per fruit (gr)
% CV	**9.1**	**15.0**	**19.1**	**16.0**

Table 5 shows a significant influence of the type of organic liquid on tomato production and yield components. Productivity (ton/ha), fruit quantity per ai-horis and fruit weight per todan (grams) were indicated. However, density did not have a significant influence, according to the analysis of variation with a small difference indicator of 5%.

Table 5 above shows that the observation of organic liquid type for tomato production and its components significantly influences productivity (ton/ha). The table above shows that the highest result was obtained from the treatment using Lofnachi liquid fertilizer, with a value of 8.40 ton/ha, while the lowest resulted from the treatment that did not use liquid fertilizer (Control) with a value of 6.23. This happened because the Lofnachi liquid fertilizer given to the tomato plants at the appropriate concentration can enhance the production results. The density per square meter did not significantly influence the result, but the utilization of the organic liquid type had a significant influence on the quantity of fruit per rice plant, with the highest result obtained from the treatment using Lofnachi liquid fertilizer with the value of 6.72, while the lowest was from the treatment that did not use liquid fertilizer or control with a value of 4.85. Furthermore, the utilization of organic liquid fertilizer also significantly influenced the weight of each fruit produced. The highest value was from the treatment that used Poc Nasa liquid fertilizer with a value of 47.1 gr, while the lowest was from the treatment that did not use organic liquid fertilizer, with a value of 39.0 gr. The result was influenced by the concentration, time, and method of work, as well as the proper fertilization that can be easily absorbed and prevent damages to property's physical and chemical aspects. According to Sarief (2003), Poc Nasa organic liquid fertilizer is made of natural substances such as animal protein, bones, and materials from the plants that can produce a mixed nutrition that can be absorbed easily by the plants and enhance the condition of the property.

CONCLUSION

This research demonstrates that the combination of rice husk biochar and organic liquid fertilizer has a significant impact on the productivity of tomato plants. The highest yield was obtained from the treatment of 3 tons/ha rice husk combined with 500 L/ha of Lof Nachi liquid fertilizer, resulting in a productivity of 10.76 tons/ha. The use of biochar at higher doses improved soil fertility, moisture retention, and microbial activity, which in turn enhanced vegetative and generative growth phases of tomato plants. Similarly, organic liquid fertilizers, particularly Lof Nachi and Poc Nasa, provided essential nutrients and growth stimulants that contributed to increased fruit count and fruit weight. While plant growth characteristics such as height, leaf count, and stem diameter were not significantly influenced, production parameters showed notable improvement due to the integrated treatment. These findings confirm that sustainable agricultural practices using organic inputs can enhance crop yield effectively. Future research is recommended to explore the long-term effects of biochar and organic fertilizers on soil health, assess economic feasibility for smallholder farmers, and compare these results with other horticultural crops under different agroecological zones to broaden the applicability and impact of such treatments. Additionally, combining these organic inputs with precision agriculture tools may further optimize nutrient use efficiency and crop performance.

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