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Empowering Sustainable Agriculture: Pineapple Leaf as an Eco-Friendly Growth Medium

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Abstract. This study aims to evaluate the potential of pineapple leaf powder as an organic additive in the development of sustainable plant media. Fresh pineapple leaves were dried, ground into powder, and mixed with soil at three different ratios (90:10, 70:30, and 50:50). Various ratios of soil and pineapple leaf powder were tested to evaluate their effects on soil pH and seedling height. Mustard seed were grown under controlled conditions for twelve days. Soil pH and seedling height were recorded and statistically analyzed using one-way analysis of variance (ANOVA). The results showed that the mixture containing 70% soil and 30% pineapple leaf powder produced the highest seedling growth, with statistically significant differences observed among treatments ($p < 0.05$). This shows that the reuse of pineapple leaf waste not only improves plant development but also contributes to sustainable innovation in the production of agricultural media. The study reflects a resilient scientific approach to addressing global sustainability challenges through the integration of agricultural waste management and green technologies.

Keywords: Pineapple Leaf, Agriculture Waste, Planting Medium, Sustainable Agriculture

1. INTRODUCTION

Sustainable agriculture is increasingly important in addressing issues of food safety, environmental pollution, and waste management. In Malaysia, pineapple is one of the main commodities, with extensive cultivation areas in Johor, Pahang and several other states. However, pineapple leaves are often considered agricultural waste that has no commercial value. If this waste is not managed properly, it can contribute to environmental problems [1].

In a global context, agricultural waste management has long been discussed as an important strategy in sustainable agriculture. Various agricultural by-products such as rice husk, coconut husk, corn stalk, and sugarcane bagasse have been used to improve soil structure and increase fertility [2]. Despite that, the potential of pineapple leaf powder as a soil additive is still underexplored [3].

With its fibrous nature and good organic matter content, pineapple leaves are very suitable as a natural additive to agricultural soil. However, this pineapple leaf mixture must be well optimized, as excessive mixing can change the acidity of the soil and disrupt the nutrient content [4]. Pineapple leaves, often discarded as agricultural waste, promise as an environmentally friendly recycling alternative in agriculture. Therefore, this study examined the effects of

different ratios of pineapple leaf powder and soil on the growth of mustard seedlings, to identify the most suitable mixture that can balance the growth rate of the plant.

2. LITERATURE REVIEW

Previous studies have found that agricultural by-products have great potential in improving soil fertility and crop productivity. Rice husk is widely used as a soil conditioner due to its ability to improve soil aeration and retain moisture [5]. Similarly, coconut coir is used as an alternative planting medium due to its high water retention capacity [6].

Most previous research for pineapple leaves has focused on the use of its fibers in the textile and composite industries. [7]. Pineapple leaf fiber is reported to have high tensile strength and good biodegradability, making it suitable as a reinforcing material in polymer composites. In addition, there are also studies focusing on its use in the production of paper pulp and biofuels [3, 8].

However, research on the direct use of pineapple leaf powder as a soil additive is still limited. Adding organic matter to the soil can indeed improve soil nutrients and structure, but if used excessively it can cause acidity and nutrient imbalance [4]. Therefore, this study sought to fill the knowledge gap by evaluating the effects of various ratios of pineapple leaf powder on the growth of mustard seedlings.

3. METHODOLOGY

Fresh pineapple leaves were collected from a plantation in Pahang, Malaysia. The leaves were washed, air dried, and subsequently oven dried at 65°C for eight hours to remove residual moisture as shown in Figure 1. The dried leaves were ground into fine powder using a mechanical grinder. Three soil pineapple leaf powder mixtures were prepared as shown in Table 1.

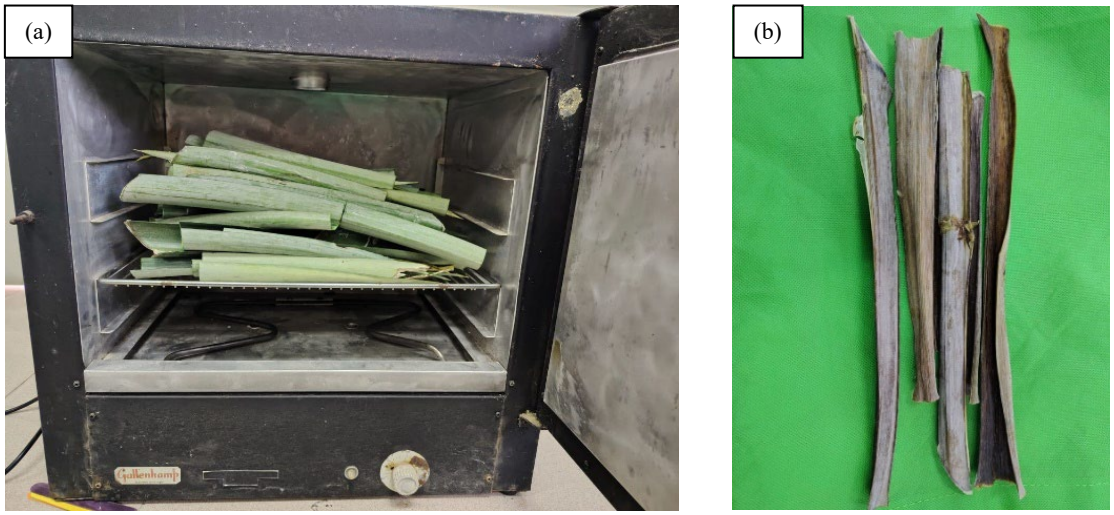

Figure 1. Drying process of pineapple leaves: (a) Pineapple leaves placed in the oven for the drying process, (b) Pineapple leaves after being dried in the oven

Table 1. Sample preparation

Sampel	Soil (%)	Pineapple leaf powder (%)
T1	90	10
T2	70	30
T3	50	50

The experiment involved three compositions of soil and pineapple leaf powder as shown in Figure 2. The samples were designated as (T1) for the mixture of 90% soil and 10% pineapple leaf powder, (T2) for the mixture of 70% soil and 30% pineapple leaf powder, and (T3) for the mixture of 50% soil and 50% pineapple leaf powder. Mustard seeds (*Brassica juncea*) were planted in each planting medium with three replications per treatment. The experiment was conducted under controlled conditions for twelve days. Seedling height and soil pH were measured daily to evaluate plant growth performance.

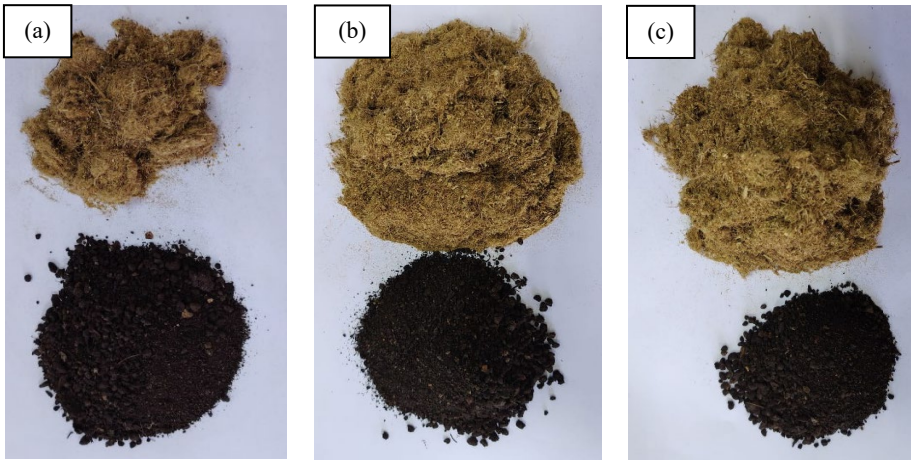

Figure 2. Composition of soil and pineapple leaf powder mixtures: (a) 90% soil and 10% pineapple leaf powder, (b) 70% soil and 30% pineapple leaf powder, and (c) 50% soil and 50% pineapple leaf powder.

4. RESULTS

The results of the study that was carried out using three soil and pineapple leaf powder mixture ratios, namely T1 (90% soil and 10% pineapple leaf powder), T2 (70% soil and 30% pineapple leaf powder), and T3 (50% soil and 50% pineapple leaf powder), showed differences in terms of mustard seedling growth for all three plant media mixtures. Referring to table 1, for sample T1 (90% soil and 10% pineapple powder), mustard seedling growth was at a good level. Where the soil maintains pH stability and provided sufficient nutrient support. For sample T2 (70% soil and 30% pineapple powder), it showed the best growth rate where growth was faster than other mixtures. This mixture balanced the organic matter content and soil structure. While for sample T3 (50% soil and 50% pineapple powder), it showed a rather slow growth rate. This is because the soil was found to be more acidic, while the soil texture became too loose, thus interfering with nutrient absorption. Figure 3 shows the growth rate of mustard seedlings for twelve days. A one-way ANOVA was performed to evaluate the statistical significance of differences in seedling height among the treatments. The analysis revealed statistically significant differences ($p < 0.05$), indicating that the ratio of pineapple leaf powder in the planting medium had a significant effect on plant growth.

Table 2. Growth performance of mustard seedlings based on pineapple leaf powder and soil mixtures

Sample	Soil (%)	Pineapple Leaf Powder (%)	Growth Rate	Soil Mixture pH
T1	90	10	Good growth	6.4
T2	70	30	Best growth	6.2
T3	50	50	Slow growth	5.8

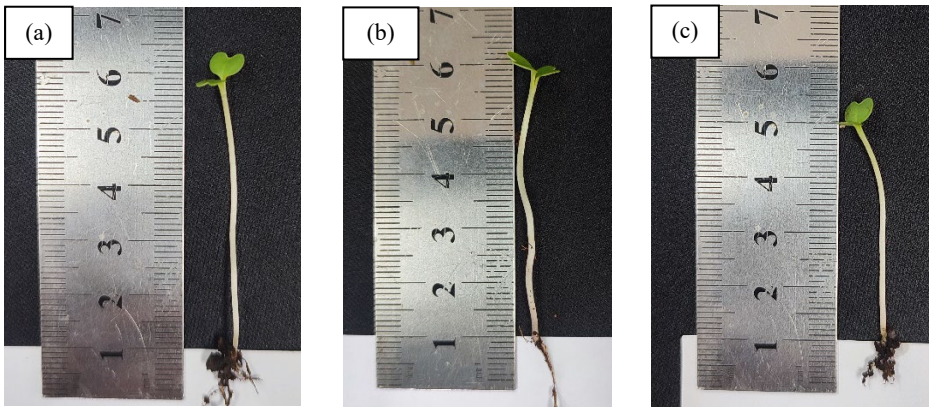

Figure 3. Growth rate of mustard seedlings with (a) A mixture of 90% soil and 10% pineapple leaf powder, (b) A mixture of 70% soil and 30% pineapple leaf powder, and (c) a mixture of 50% soil and 50% pineapple leaf powder.

5. DISCUSSION

The results of the study showed that the T2 mixture (70% soil and 30% pineapple leaf powder) was the most optimal for the growth of mustard seedlings. This ratio was found to be able to improve soil aeration, water retention, and provide suitable organic matter to support plant growth. Sample T1 (90% soil and 10% pineapple leaf powder) also showed good performance in terms of mustard seedling height, but not as high as T2 seedlings because the small amount of pineapple powder had a limited effect on improving soil properties. On the other hand, sample T3 (50% soil and 50% pineapple leaf powder) caused stunted growth. This is likely due to the high pineapple powder content, which increases soil acidity and reduces the content of essential nutrients for growth [9]. This finding is consistent with previous studies which state that moderate use of organic matter provides optimal benefits to crops, but excessive use can affect soil quality [10]. The study therefore reinforces the need for optimized ratios when repurposing agricultural waste for soil improvement.

6. CONCLUSION

This study proves that pineapple leaf powder has the potential to be an environmentally friendly growth medium. The optimal ratio is 30% pineapple leaf powder and 70% soil, which results in the best growth of mustard seedlings. This study not only contributes to sustainable agriculture, but also offers innovative solutions in agricultural waste management.

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