Pineapple Peel Waste and Water Hyacinth as Liquid Organic Fertilizer for the Growth of Mustard (*Brassica juncea L.*)

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Abstract. Pineapple peel contains substances that allow pineapple as a raw material for making liquid organic fertilizer. The combination of water hyacinth in this liquid organic fertilizer is a nutrient enhancer in liquid organic fertilizer and an effort to overcome the uncontrolled presence of water hyacinth in water bodies. This study aims to utilize pineapple peel waste and water hyacinth as liquid fertilizer applied to mustard plants (*Brassica juncea L.*). This study employs a pure experimental design with a Post Test Only Control Group Design. This study consisted of four experimental groups: one control group and three treatment groups. The treatment groups were exposed to different amounts of organic fertilizer, specifically 4%, 8%, and 12% with 6 repetitions. Measurement of mustard plant growth based on plant height, stem diameter, and wet weight after being given fertilizer. The data analysis was conducted using an ANOVA test to determine whether the generated data had a normal distribution. If it is not normally distributed, the Kruskal-Wallis test is used. The application of pineapple and water hyacinth liquid organic fertilizer to mustard plants (*Brassica juncea L.*) showed significant results on mustard plant growth parameters such as plant height, stem diameter, and wet weight.

Keywords: pineapple peel, water hyacinth, mustard growth.

1 Introduction

Most human activities produce garbage, and uncontrolled waste production may lead to environmental problems [5]. According to the Food Waste Reduction Alliance [9], the largest sector that produces food waste is residential, which is waste generated by households (47%). Subsequently, restaurants account for 37% of the total, while the institutional sector, encompassing hospitals, schools, and hotels, constitutes 11%. Approximately 75% of the environmental consequences associated with food waste, specifically those contributing to global warming, stem from the emission of greenhouse gases during the production phase. Food processing activities provide 6% of emissions related to food waste impacts, while retail and distribution activities contribute 7%. Additionally, food consumption contributes 8%, and food disposal contributes 6% to these impacts. According to Scherhaufer [35],

Fruit peels are one of the contributors to food waste, supported by the tropical climate and fertile soil in Indonesia. Natural products such as fruit have a high production rate, continuously increasing by 5.4% [3]. One of the commodities with the largest production is pineapple, which has experienced an increase in production figures of 17.95%, which previously reached 2.45 million tons to 2.89 tons in 2021. According to data from the Central Bureau of Statistics, 2021 is the year of the highest pineapple production in Indonesia.

Pineapple fruit (Ananas comosus L. Merr) is consumed in various preparations such as juice, jam, syrup, snacks, canned fruit, or fresh fruit. In Kholifah [22], the production of pineapple processing waste is 75-85% in the form of skin, crown, and core, with a percentage of the amount of pineapple skin 30-35%. There are about 596 thousand tons per year of pineapple peel waste that is not processed and wasted. According to Syauqi [41] Pineapple peel waste is usually only used as animal feed, and its utilization is still not optimal.

Based on its nutrient content, pineapple peel contains high carbohydrates and sugar. The pineapple peel contains 81.72% water, 20.87% crude fiber, 17.53% carbohydrate, 4.41% protein, and 13.65% reducing sugar [46]. The utilization of pineapple peel as a raw material for plant nutrition is facilitated by its elevated levels of carbohydrates and sugars. Liquid organic fertilizer from pineapple plant waste could increase ultisol soil fertility, especially on soil pH, %C organic, %N total soil, C/N ratio, and content of P and K elements in the soil [40]. Previous studies have analysed the nutrient composition of liquid organic fertilizers, revealing the presence of many nutrients. These include Phosphate (23.63 parts per million), Potassium (08.25 parts per million), Nitrogen (01.27%), and Calcium (27.55%). The concentrations of various elements in the sample are as follows: magnesium (137.25 ppm), sodium (79.52 ppm), iron (01.27 ppm), manganese (28.75 ppm), copper (00.17 ppm), zinc (00.53 ppm), and organic carbon (03.10%). According to Salim and Sriharti (2008), the carbon-to-nitrogen (C/N) ratio of pineapple trash is 36.05. The utilization of pineapple peel waste as liquid organic fertilizer can enhance soil quality and enrich it with organic matter, hence facilitating the cultivation of crops such as shallots[6]. Applying pineapple peel extract significantly affects the growth of cayenne pepper, namely in leaf count, leaf colour, and plant height [38].

Organic fertilizer is fertilizer derived from dead plants, animal waste or animal parts, and other organic waste that has been engineered, in solid or liquid form which is enriched with minerals and microbes that are useful for increasing the nutrient content and organic matter of the soil, as well as improving its physical, chemistry, and soil biology [21]. Liquid organic fertilizer can flow through soil gaps, resulting in plants absorbing it faster than solid fertilizers [29]. Utilizing liquid organic fertilizers can effectively reduce environmental contamination, mainly caused by chemical fertilizers in the soil [26]. Liquid organic fertilizer generally does not damage the soil and plants, even if used as often as possible [13]. Liquid organic fertilizer has the benefit of providing both macronutrients and micronutrients. Furthermore, its hygroscopic characteristics enable it to be easily dissolved, thus minimizing plants' need for a longer absorption interval [45].

Water hyacinth is another type of organic waste that can be utilized as a component in the formulation of liquid organic fertilizer, alongside pineapple peels. Water hyacinth is a species of plant that rapidly spreads through waterways and has a rapid rate of growth; as a result, it is regarded as a weed since it can harm the aquatic environment. Water hyacinth in the waters makes it difficult for sunlight to penetrate them and reduces the water's oxygen content [44]. In addition, water hyacinth also reduces the productivity of water bodies such as taking up space and taking nutrients that are also needed by fish [23]. They also serve as habitats for vectors of diseases. The removal of water hyacinths by chemical and biological control poses risks to the environment and has met limited success. Currently, the most effective control method remains to control excessive nutrients and prevent the spread of this species [30]. Based on the results of research conducted by the North Sumatra Agricultural Technology Assessment Center, the chemical analysis of water hyacinth in its fresh state reveals the presence of various components. These include organic matter at a concentration of 36.59%, organic carbon at 21.23%, total nitrogen at 0.28%, total phosphorus at 0.0011%, and total potassium at 0.016%, and water hyacinth has a C / N ratio of around 75.6% [19]. Liquid organic fertilizers from water hyacinths can increase the growth and production of green mustard plants [1]. The application of liquid organic fertilizer made from water hyacinth can increase the growth and yield of mustard greens at a concentration of liquid organic fertilizer 40 % [20].

According to Kusuma Pramushinta [23], using liquid organic fertilizer on tomato plants and chilli plants with a 12% concentration can increase the number of leaves, plant height, plant weight and root length. Meanwhile, in a study conducted by Amira & Setyawan [2], the effect of applying liquid organic fertilizer from pineapple peel waste and water hyacinth on rubber plants on latex production and soil NPK nutrient levels was significant with the addition of 4% POC concentration.

The green mustard plant is a vegetable that thrives in subtropical climates and is particularly well-adapted to tropical places [8]. Green mustard (Brassica juncea L) is one of the horticultural plant commodities of the vegetable type that is utilized by its young leaves as a vegetable food and has various benefits and uses [28]. Mustard plants are plants that need nitrogen nutrients, so that the addition of liquid organic fertilizer to mustard plants can meet the needs of these elements. This plant grows well in hot and cold weather so that it can be developed in the highlands to lowlands. This plant is also resistant to rainwater so that it can be. It is grown throughout the year. In addition, mustard plants are also easy to flower and produce seeds naturally in Indonesia's tropical climate conditions [32]. Some of these things support that the use of mustard plants in this study will facilitate the monitoring and measurement of growth parameters. This research aims to utilize pineapple peel waste and water hyacinth as liquid fertilizer applied to mustard plants (Brassica juncea L.).

2 Methods

The type of research that will be carried out in this study is pure experimental research with Post Test Only Control Group Design. The subjects in this study were mustard plants aged 14 days after sowing, which had approximately 4 leaves. In this study, there

was 1 control and 3 treatments, namely 4%, 8%, and 12% organic fertilizer concentrations with 6 repetitions. Mustard plant growth is measured by quantifying many parameters, including plant height, stem diameter, and wet weight following fertiliser application. Data analysis is performed using the analysis of variance (ANOVA) test when the acquired data follows a normal distribution. If not normally distributed, the Kruskal-Wallis test was used.

3 Result and Discussion

The nitrogen, phosphate, and potassium content in liquid organic fertilizer from pineapple peel and water hyacinth was examined after the fermentation process is shown in Table 1.

Table 1. Results of Nitrogen, Phosphate, and Potassium Content in Liquid Organic Fertilizer of Pineapple Peel and Water Hyacinth

Parameter	Test Result	Total $N+P_2O_5+K_2O$	Standard Kepmentan 261/KPTS/SR.310/M/4/2019
Nitrogen	1,19%	1,403%	$N+P_2O_5+K_2O$ Minimum 2-6%
Phosphate	0,127%		
Potassium	0,086%		

The results of the NPK content analysis indicate that the liquid organic fertilizer made from pineapple peel waste and water hyacinth consists of nitrogen, phosphate, and potassium at a concentration of 1.403%. The outcomes of the content assessment continue to fall short of the prescribed criteria as outlined in the Minister of Agriculture's Regulation No. 261 of 2019, which pertains to the minimal technical prerequisites for organic fertilizers, biological fertilizers, and soil conditioners, explicitly requiring a range of 2-6 as a minimum level. Furthermore, subsequent to the completion of the fermentation process, the temperature and pH levels of the liquid organic fertilizer made from pineapple peel waste and water hyacinth are measured. The temperature and pH measurement results of the liquid organic fertilizer were 29°C with a pH of 4.7 which met the requirements of the pH standard of liquid fertilizer by Minister of Agriculture Decree 261 of 2019, which ranges from 4 - 9.

Some factors that may affect the fulfilment of macronutrient content according to applicable regulatory standards include the length of fermentation time and differences in the ratio of EM4 activators used. Adding EM4 solution into the fertilizer ingredients helps accelerate the decomposition of organic materials, resulting in faster and more optimal production of liquid compost [27]. Additional research is needed to investigate the fermentation duration of liquid organic fertilizer derived from pineapple peel and water hyacinth and the optimal quantity of activator used.

According to Meriatna[24], Fermentation time and volume of EM4 bio activator significantly affect the levels of macronutrients (N, P, K). According to Kusuma Pramushinta's study conducted in 2018, the duration of the fermentation process utilized for the production of liquid organic fertilizer from pineapple peel and water hyacinth was four weeks, while Isabella[18] used a fermentation process length of 2 weeks with the same material ratio. Research conducted by Susi[39], namely making liquid organic fertilizer derived from pineapple peel waste with a fermentation process for 1 month. The results of the study revealed that the liquid organic fertilizer made from pineapple peel waste has phosphorus (P) levels of 23.63 parts per million (ppm), potassium (K) levels of 08.25 ppm, and nitrogen (N) levels of 01.27%.

Nitrogen (N), phosphorus (P), and potassium (K) are the primary macronutrients essential for plant growth and development [36]. Nitrogen is an essential element in the process of chlorophyll synthesis [47]. Nitrogen is an important plant nutrient necessary for plant growth and development and is known to increase the yield of Brassica species [37]. The phosphorus supply to plants might have accelerated cell division and plant enlargement, carbohydrate, fat metabolism and respiration[7]. utilized Phosphorus stimulated metabolic processes that facilitated the production of chlorophyll and photosynthesis. Additionally, it promoted the growth of branches through increased microbial activity [31].

3.1 Increase in Stem Diameter of Mustard Plants

Measurement of stem diameter in mustard greens (Brassica juncea L.) was carried out when the 14-day-old mustard greens had been transferred to polybags. Measurements were taken once a week until the mustard was 49 days old. The increase in mustard stem diameter after treatment is shown in Figure 1

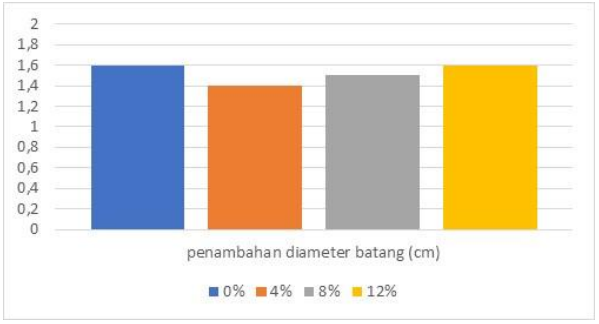

Fig. 1. Increase in stem diameter of mustard plants after treatment with the addition of Pineapple Peel Liquid Organic Fertilizer and Water Hyacinth.

Based on Figure 1, Each treatment of liquid organic fertilizer showed a varying increase in diameter. This indicates that the application of liquid organic fertilizer made from pineapple peel and water hyacinth affects the diameter of the mustard plant stem. The stem diameter of plants that continue to grow shows cell division and enlargement. Nutrients, especially macronutrients, can influence stem diameter because

nitrogen nutrients can accelerate and increase stem diameter growth. The most significant diameter increase is in the treatment of organic fertilizer with a concentration of 12%, which is 1.6 cm. High nitrogen and temperature increase stem height comparable to diameter ratios, but elevated carbon dioxide (CO_2) decreases stem height relative to diameter ratio [43].

3.2 Plant Wet Weight Measurement.

The wet weight of *Brassica juncea L.* mustard greens was measured at 49 days of growth. The measurements were conducted by determining the weight of the harvested mustard greens after pulling the roots and thoroughly cleaning any residual soil from the roots. Detail of the Measurement of wet weight of mustard plants after treatment can be seen in Figure 2

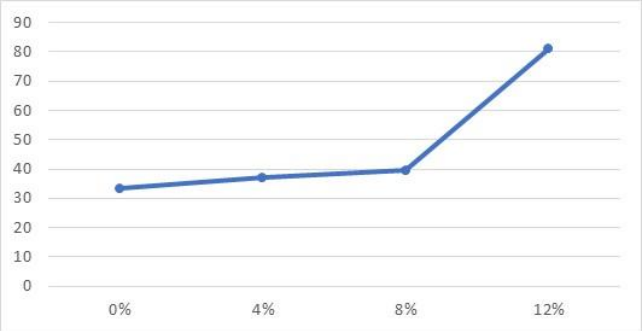

Fig. 2. Measurement of the wet weight of mustard plants after treatment with the addition of Pineapple Peel Liquid Organic Fertilizer and Water Hyacinth.

The highest average wet weight is in applying liquid organic fertilizer from pineapple peel waste and water hyacinth at a concentration of 12%, which is 80.80 grams. Plant wet weight is the weight of the plant when the plant is still alive and weighed directly after harvest, before the plant withers due to water loss. Measurement of plant wet weight aims to obtain an overall picture of plant growth biomass [42]. Based on the wet weight results obtained, each treatment showed a different average wet weight. The result suggests that the application of liquid organic fertilizer made from pineapple peel and water hyacinth impacts the wet weight of mustard plants.

Both internal and external factors influence the growth of plants. Internal factors include the rate of photosynthesis, respiration, differentiation, and the impact of genes. On the other hand, external factors consist of light, temperature, water, organic matter, and nutrient availability [4]. The wet weight per plant measurement is influenced by the availability of nutrients, leading to an increase in the wet weight of mustard plants. This rise in weight is attributed to enhanced cellular development, resulting in both an increase in cell number and size. Optimal plant growth is a supporting factor for plants to carry out photosynthesis and produce a lot of carbohydrates [34].

3.3 Plant Height Increase

Measurement of plant height in mustard greens (Brassica juncea L.) was carried out when the 14-day-old mustard greens had been transferred to polybags. Measurements were taken once a week until the mustard was 49 days old. Measurements are taken from the bottom of the lower stem to the top of the highest leaf. The increase in mustard plant height after treatment is shown in Figure 3

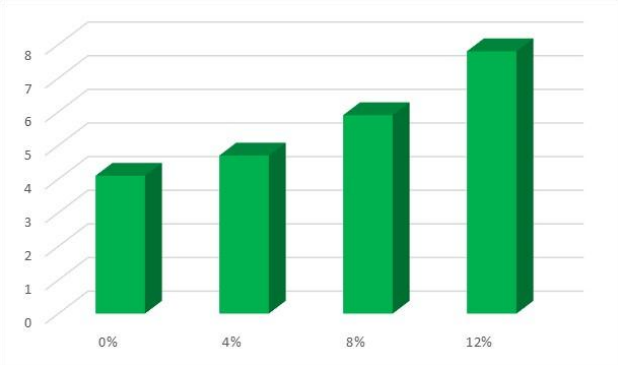

Fig. 3. Increase mustard plant height after treatment by adding Pineapple Peel Liquid Organic Fertilizer and Water Hyacinth.

The most significant increase in plant height in the treatment of liquid organic fertilizer concentrations made from pineapple peel and water hyacinth was as much as 12% in mustard plants, which ranged from 7.8 cm per week. The measurement results show the height of mustard plants (*Brassica juncea L.*) The measurement findings reveal that the height of mustard plants (*Brassica juncea L.*) increases differently in each treatment. This demonstrates that applying a liquid organic fertilizer produced from pineapple peel and water hyacinth influences the height of mustard plants. The age of the plant and the nutrient availability in the soil are a few factors that influence the growth of plant cell size[15]. The high growth of the plant is strongly related to the availability of macronutrients, especially Nitrogen (N). Element N promotes plant vegetative growth, explicitly contributing to increased plant height. [10]
According to Moi[25], the more N elements received by mustard plants through liquid organic fertilizer, the higher the height of mustard plants. This is because microorganisms have broken down the organic matter in water hyacinth and pineapple, allowing organic elements in liquid organic fertilizer to feed plants with nitrogen [11]. As a result, the more concentrated the liquid organic fertilizer, the more significant the rise in mustard plant height.

Based on the growth of mustard plants (*Brassica juncea L.*) when a liquid organic fertilizer produced from pineapple peel and water hyacinth was applied, it is in line with some previous research results such as the application of pineapple peel liquid organic fertilizer which can have a significant effect on the morphology of oil palm seedlings[17]. In addition, using pineapple peel liquid organic fertilizer can increase

plant height, stem diameter, number of fruits per sample, fruit length per sample, production weight per sample and production weight per cucumber plot [16].

3.4 The Most Optimal Concentration in the Grrowth of Mustard Plants (*Brassica juncea L.*)

Liquid organic fertilizer concentration for mustard plants must be considered for optimal results. Regularly determining the frequency of liquid organic fertilizer application is necessary to ensure that the mustard plants grow and produce optimal results. [12, 14]. Based on the results obtained from the increase in each growth parameter of mustard plants (*Brassica juncea L.*) which includes plant height, stem diameter, and wet weight, it shows that the provision of liquid organic fertilizer made from pineapple peel waste and water hyacinth is most optimal at a concentration of 12%. This is in line with previous research conducted by Kusuma Pramushinta[23] which used a 12% concentration of liquid organic fertilizer on tomato plants and chili plants to get significant results, besides that other studies use a lower concentration of 50ml/L or 5% POC which brings the best results in shallot growth and the use of the highest concentration, namely 150ml/L or 15% POC, does not show significantly different results [18]. The difference in the use of liquid organic fertilizer concentrations must be adjusted to the nutrient needs of each plant.

Table 2. Statistical Test Results of the Effect of Liquid Organic Fertilizer of Pineapple Peel and Water Hyacinth on Plant Growth

Treatment	Significant Value		
	Plant Height	Wet Weight	Plant Diameter
Concentration 4%	0,000	0,000	0,008
Concentration 8%			
Concentration 12 %			

Based on Table 2, The significance value of the *ANOVA* and *Kruskal Wallis* test results shows that applying liquid organic fertilizer of pineapple peel waste and water hyacinth affects the growth of mustard plants (*Brassica juncea L.*). This is in line with the research of Rosita & Regar [33] from the provision of pineapple peel liquid organic fertilizer, water hyacinth liquid organic fertilizer, and the combination of pineapple peel and water hyacinth showed that liquid organic fertilizer has the most effect on the growth and yield of land kale plants, namely liquid organic fertilizer with pineapple peel and water hyacinth. This is supported by the macronutrient content contained in pineapple peel and water hyacinth liquid organic fertilizer which is higher than water hyacinth liquid organic fertilizer containing N, P and K respectively 0.52%, 0.002% and 0.098% [48].

4 Conclusion

Utilization of pineapple peel and water hyacinth as liquid organic fertilizer affects the growth of mustard plants (Brassica juncea L.). The most optimal concentration of liquid organic fertilizer from pineapple peel and water hyacinth waste in mustard plant growth is at a concentration of 12%. The macronutrient content (N, P, and K content) in organic fertilizer still does not meet the Minister of Agriculture Number 261 of 2019 standard. Further research is needed to determine the appropriate levels of bioactivators and lenght of fermentation in making organic fertilizer.

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