

Innovation in Liquid Potassium Fertilizer Made from Seawater and Coconut Husk (*Cocos nucifera*)

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Abstract

Article history:

Received: 13-12-2025

Accepted: 18-01-2026

Published: 13-03-2026

Keywords:

coconut husk;
liquid potassium fertilizer;
maceration;
production;
seawater.

This study innovates a liquid potassium fertilizer utilizing seawater and coconut coir as sustainable and economical alternatives to inorganic fertilizers. The research aimed to investigate the effects of varying maceration times (4, 8, 12, 16, and 20 days) and coconut coir weights (10, 15, 20, 25, and 30 grams) on the characteristics of the resulting fertilizer, specifically its pH, Total Dissolved Solids (TDS), and K₂O content. The production process involved seawater collection and filtration, followed by coconut coir preparation (soaking, drying, size reduction, and weighing). Maceration was then performed using seawater and varied coconut coir weights over different time periods. The liquid fertilizer underwent pH, TDS, and K₂O analyses. Key findings indicate that pH decreased with increased coir weight and maceration time, ranging from 8.47 to 7.33, remaining safe for plants. TDS increased with longer maceration and higher coir amounts, reaching 6000 ppm after 20 days with 30 grams of coir, signifying enhanced dissolved compound extraction. The highest K₂O content of 0.132% was achieved at 16 days of maceration with 30 grams of coconut coir, indicating optimal potassium dissolution. This suggests that a combination of seawater and coconut coir can produce a liquid potassium fertilizer with promising characteristics, offering an eco-friendly and cost-effective agricultural solution.

1. Introduction

Fertilizer is one of the important factors in agriculture that directly affects crop productivity. One of the essential elements required by plants in significant quantities is potassium. Due to its dynamic nature, this ion is easily leached by low pH and sandy soils[1, 2]. Potassium fertilizer is one of the most essential fertilizers for plants as it enhances disease resistance, strengthens stems, and supports the photosynthesis process.

Currently, the most commonly used potassium fertilizer in Indonesia is KCl (potassium chloride) with a 60% K₂O content. Other potassium fertilizers include potassium nitrate (KNO₃), potassium sulfate, and potassium magnesium sulfate (K₂SO₄.MgSO₄). Compared to K₂SO₄, KCl fertilizer is relatively cheaper[3, 4]. On the other hand, the use of organic waste has become the primary option for fertilizer production, as fertilizer prices have risen due to the removal of subsidies and the reduction in the amount of raw materials that must be imported.

Utilizing Indonesia's abundant natural resources, such as seawater and coconut husk waste, can be a more sustainable option and an alternative to reduce the use of inorganic fertilizers and lower costs. Seawater has great

potential as a fertilizer base. This is because most of the macro and micro minerals needed for healthy plant growth are found in seawater, including potassium, magnesium, and calcium[5, 6]. The use of seawater can also reduce dependence on chemical fertilizers, while also being an economical alternative.

Coconut husks are organic waste that, if not properly utilized, can become environmentally harmful waste. Coconut husks contain many useful components, one of which is as fertilizer. Potassium-based coconut husk fertilizer can reduce waste and also lower fertilization costs. Additionally, potassium (K), calcium (Ca), magnesium (Mg), sodium (Na), and phosphorus—all natural elements required by plants—are also found in coconut husks[7, 8].

Potassium was extracted from coconut husk waste using water as a solvent (study of the effects of temperature and time variations). The temperature variations used were 60, 70, and 80°C, and the time variations were 50, 60, and 70 minutes. The stirring speed was 250 rpm. From this study, the highest potassium percentage at 80°C and 70 minutes was obtained with a concentration of 1.53 N and a potassium percentage of 21.54%. The longer the

maceration time, the higher the percentage of potassium produced [9, 10].

Based on the above study, this research will innovate liquid potassium fertilizer from a combination of seawater and coconut husk waste with varying weights of coconut husks macerated for 4-20 days. The tests to be conducted include pH value, Total Dissolved Solids (TDS) value, and K₂O content using the Inductively Coupled Plasma (ICP) method. The resulting liquid potassium fertilizer will be applied to spinach plants to observe their growth response. This study will compare the growth of spinach plants sprayed with liquid potassium fertilizer with those not treated with fertilizer, without treating the spinach plants as an independent variable.

The innovation of liquid potassium fertilizer made from seawater and coconut husks is an interesting new solution to be developed because it has never been done before. This combination has the potential to provide high potassium content, be environmentally friendly, and efficient, as well as having the potential for commercial production. Variations in maceration time and coconut husk size significantly affect the properties of the resulting liquid potassium fertilizer, namely pH value, TDS value, and K₂O content. Specifically, longer maceration times and greater amounts of coconut husk are expected to increase potassium availability (K₂O), affect acidity levels (pH), and increase Total Dissolved Solids (TDS) in the liquid potassium fertilizer. This study not only focuses on the technical aspects of fertilizer production but also considers environmental and economic aspects. By utilizing local resources, it is hoped that innovative solutions can be provided to meet fertilizer needs in the agricultural sector [11, 12].

2. Method

This research employed a factorial design to investigate the effects of varying maceration times and coconut coir weights on the characteristics of liquid potassium fertilizer. The fixed variable was seawater volume at 500 mL. Independent variables included maceration times set at 4, 8, 12, 16, and 20 days, and coconut coir weights at 10, 15, 20, 25, and 30 grams. The dependent variables measured were pH, Total Dissolved Solids (TDS), and K₂O content. Key materials used included seawater, aquades, coconut coir, and HCl (Hydrochloric acid).

Equipment comprised sample bottles, scissors, basins, a pH meter, a TDS meter, an Inductively Coupled Plasma (ICP) set, 500 mL beaker glasses, volume pipettes, and ball pipettes.

2.1 Production and Analytical Procedures

The production process began with preparing raw materials: 12.5 liters of seawater were collected from Kuala Meuraksa and filtered to remove insoluble particles. Coconut coir was pre-treated by soaking in clean water for 2x24 hours until no foam appeared, dried under sunlight, crushed, and weighed according to the experimental variations. Maceration involved placing the varied weights of coconut coir into sample bottles, adding 500 mL of seawater, and allowing it to macerate for the specified time periods. After maceration, the liquid extract (fertilizer) was separated from the coir using filter paper.

2.2 Data Analysis and Measurements

The resulting liquid fertilizer underwent several analyses. pH and TDS measurements were performed on days 4, 8, 12, 16, and 20. pH was measured using a digital pH meter by immersing the cathode into the sample until a stable reading was obtained. TDS was measured to quantify total dissolved substances, indicating nutrient availability. K₂O content was analyzed using Inductively Coupled Plasma (ICP) on samples with the highest TDS values. For K₂O analysis, 5 mg of the liquid fertilizer sample was diluted in a 100 mL volumetric flask with 5 mL of concentrated HNO₃ and aquades, then analyzed by ICP-OES. The K₂O percentage was calculated using the formula:

$$K_2O (\%) = \frac{K (ppm) \times FP \times 1.205}{w} \times 100\% \quad (1)$$

The parameter K (ppm) represents the potassium concentration obtained from measurements using Inductively Coupled Plasma (ICP) analysis. This value is subsequently adjusted by the FP (dilution factor), which accounts for the dilution applied to the sample during the preparation process prior to analysis. Furthermore, a conversion factor of 1.205 is employed to convert potassium oxide (K₂O) into elemental potassium (K), ensuring that the calculated results are expressed in the appropriate chemical form. The variable w (sample weight) denotes the mass of the sample used in the analysis and plays a crucial role in

ensuring the accuracy and reliability of the determined potassium content.

3. Result and Discussion

In this study, the tests include pH value, TDS, and K₂O content to determine the variation of maceration time and weight of coconut fiber.

3.1 Effect of Coconut Fiber Weight on pH Value at Different Maceration Times

Based on the analysis results, the pH value tends to decrease as the weight of coconut husk and maceration time increase as shown in Figure 1. The highest value was found in the treatment of 10 grams of coconut husk with a maceration time of 4 days, with a pH value of 8.44, while the lowest value was found in the treatment of 30 grams of coconut husk with a maceration time of 20 days, with a pH value of 7.33.

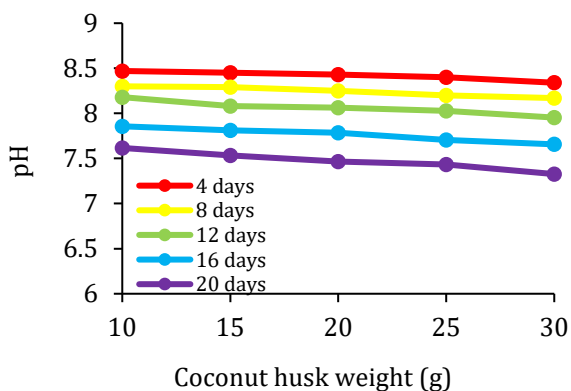


Figure 1. Effect of coconut fiber weight on pH value at different maceration times

The decrease in pH in this study occurred due to the accumulation of acidic compounds as a result of maceration. The longer the soaking time and the greater the amount of coconut fiber used, the higher the concentration of acidic compounds formed. Although the pH value decreased, the range was still within the neutral to slightly alkaline range, so it remained safe for plant growth and did not interfere with soil microorganism activity.

These results indicate that the pH of coconut shell liquid fertilizer decreases due to the accumulation of dissolved compounds during the soaking process [9]. In addition, seawater helps maintain pH stability because it contains buffer ions such as Mg²⁺ and Na⁺ that can neutralize pH fluctuations [5]. This pH level continues to support plant growth and microbial activity in the soil, as it complies with the

provisions of Minister of Agriculture Regulation No. 261/Kpts/SR.310/4/2019.

3.2 Effect of Coconut Fiber Weight on TDS (Total Dissolved Solids) Value at Different Maceration Times

Based on the analysis results, there was an increase in TDS along with the increase in maceration time and the amount of coconut husk as shown in Figure 2. The highest TDS value was found in the treatment of 30 grams of coconut husk with a maceration time of 20 days, which was 6000 ppm. On the other hand, the lowest TDS value was observed in the treatment with 10 grams of coconut husk and a maceration time of 4 days, at 4,453.33 ppm.

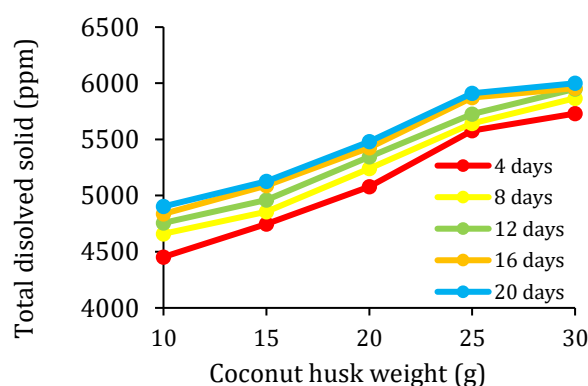


Figure 1. Effect of coconut fiber weight on TDS (Total Dissolved Solids) value at different maceration times

The increase in TDS indicates that the longer the immersion time and the more coconut husks, the greater the amount of soluble compounds extracted. Coconut husks contain nutrients such as K, Mg, and Ca, which gradually dissolve into seawater. Seawater also supports the release of these ions through a charge exchange process.

These results indicate that seawater-based liquid fertilizer has a higher TDS value than regular water [5]. An increase in organic matter weight has a significant effect on the final TDS value [13]. Based on this study, nutrient dissolution and diffusion are more optimal with longer immersion times, resulting in fertilizer with higher nutrient content.

3.3 Effect of Coconut Fiber Weight on K₂O Content Value at Different Maceration Times

Based on the analysis results, test using the Inductively Coupled Plasma (ICP) method on

the K_2O content of the maceration treatment using 30 grams of coconut husk with a maceration time of 4 to 20 days showed a range of values between 0.111% and 0.132%. The highest value was recorded on day 16 at 0.132%, while the lowest value was observed on day 4 at 0.111%. In general, the K_2O content increased up to day 16, then decreased again on day 20 to 0.129% as shown in Figure 3.

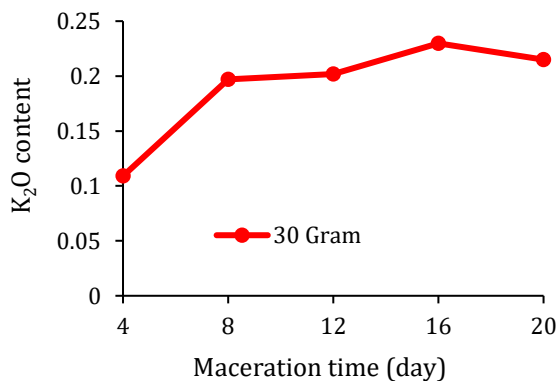


Figure 2. Effect of coconut fiber weight on K_2O content value at different maceration times

It was concluded that the Vitamin C content in red guava jam was the best for adding pectin levels in sample 3 with a pectin content of 0.1 gram, stirring for 20 minutes with a heating temperature of $80^{\circ}C$ obtained a percentage of 23.23% Vitamin C content.

Coconut husks are lignocellulosic waste containing potassium in the form of complex compounds such as potassium silicate and organic potassium, which can dissolve during the maceration process [7]. The hemicellulose fraction in coconut husk tissue is the main site of potassium binding. During soaking, this structure undergoes softening and degradation, allowing K^+ ions to be released into the solution [14].

The passive extraction process of potassium from biomass is highly dependent on the duration of immersion and the quality of the solvent[15]. In this case, the use of seawater as a solvent supports the diffusion of potassium ions due to its high ionic properties.

The increase in K_2O levels from day 4 to day 16 occurred due to the progressive decomposition of coconut husks. The peak occurred on day 16, with a highest value of 0.132%, reflecting optimal conditions for the dissolution of potassium from the lignocellulose structure.

The decrease on the 20th day is likely due to several factors, namely the precipitation of potassium compounds such as K_2CO_3 or K_2SO_4 due to saturated solutions, ionic interactions in seawater that may cause precipitation or reabsorption of some K ions, or a decrease in chemical degradation activity because most of the dissolved compounds have reached saturation point.

These findings are consistent with the results of studies that state that the optimal soaking time for potassium dissolution from coconut shells is between 14 and 16 days, after which the effectiveness of dissolution tends to decrease or stagnate [9]. The use of seawater as a solvent can increase the efficiency of nutrient dissolution because it contains ions such as Na^+ and Mg^{2+} , which function as supporting ions in the diffusion process [5].

A maseration time of 16 days with a coconut husk weight of 30 grams is the most optimal combination for producing liquid fertilizer with the highest K_2O content of 0.132%. All values obtained do not meet the minimum limit of 2% as stipulated in Minister of Agriculture Regulation No. 261/Kpts/SR.310/4/2019, so this liquid fertilizer product is not yet suitable in terms of macro nutrient content.

The research indicates that the lowest pH value observed was 7.33, occurring with 30 grams of coconut coir after 20 days of maceration. In contrast, the highest Total Dissolved Solids (TDS) value reached 6000 ppm, achieved with 30 grams of coconut coir after 20 days of maceration. For potassium content, the K_2O concentration peaked at 0.132% under conditions of 30 grams of coconut coir and 16 days of maceration, which was identified as the optimal condition for potassium extraction from the coir's lignocellulose structure. The test results for pH, Total Dissolved Solids, and K_2O content are presented in Table 1.

In summary, the study demonstrates that increasing coconut fiber weight and maceration time generally leads to a decrease in pH, an increase in TDS, and an initial increase followed by a slight decrease in K_2O content. The optimal conditions for K_2O extraction were found at 16 days of maceration with 30 grams of coconut coir.

Table 1. The test results for pH, total dissolved solids, and K₂O content

Maceration time (day),	pH	TDS (ppm)	K ₂ O (%)
4	8,34	5730	0,111
8	8,17	5866,67	0,125
12	7,95	5950	0,128
16	7,66	5956,67	0,132
20	7,33	6000	0,129

3.4 Comparison of Spinach Plant Growth between C₀ and C₁

Spinach (*Amaranthus* spp.) is a popular and fast-growing leafy vegetable. It is rich in vitamins A and C, as well as other important minerals. The availability of nutrients, especially potassium, which is important for physiological functions and tissue formation in plants, has a significant impact on its growth.

These findings indicate that spinach plants can grow better vegetatively when liquid potassium fertilizer is applied. In plants, potassium improves nutrient distribution, accelerates photosynthesis, and strengthens stems. Previous studies have shown that the use of liquid potassium fertilizer can accelerate growth and increase the yield of horticultural crops[16].



Figure 3 Comparison of spinach plant growth between C₀ and C₁

Table 2. Comparison of spinach plant growth between C₀ and C₁

Parameters	Week 1 (C ₀)	Week 1 (C ₁)	Week 2 (C ₀)	Week 2 (C ₁)
Plant Height (cm)	6,2	8,5	8,4	10,8
Number of Leaves (Sheets)	5	7	7	10

4. Conclusion

This study investigated the influence of maceration time and coconut coir weight on the

characteristics of liquid potassium fertilizer, specifically pH, total dissolved solids (TDS), and K₂O content. The findings confirm that both maceration time and coconut coir weight significantly affect the chemical properties of the fertilizer, directly addressing the research objectives and problem formulation.

The pH values decreased with increased coir weight and maceration time, ranging from 8.47 (10g coir, 4 days) to 7.33 (30g coir, 20 days). Conversely, TDS values increased, reaching a maximum of 6000 ppm (30g coir, 20 days), indicating enhanced extraction of soluble compounds. The K₂O content peaked at 0.132% with 30 grams of coconut coir after 16 days of maceration, suggesting this as the optimal condition for potassium extraction.

Acknowledgment

The research team extends its gratitude and appreciation to all parties who have contributed to this study. Special thanks to Politeknik Negeri Lhokseumawe and the Department of Chemical Engineering for providing the necessary facilities for this research.

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