Borneo Engineering & Advanced Multidisciplinary International Journal (BEAM)
Volume 2, Special Issue (TECHON 2023), September 2023, Pages 116-121

Performance Study of Tea Waste as Nutrient Rich Organic Fertilisers

Full Paper

Article history
Received
24 July 2023
Received in revised form
24 July 2023
Accepted
3 September 2023
Published online
30 September 2023

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Abstract

The amount of tea waste grows rapidly along with the increasing consumption of tea products. Global demand increases led to the increasing of tea waste which normally into the landfill together with other waste. Therefore, there is availability to increase the potential of tea waste utilization into high added value products such as organic fertilizer. The objective of this study is to investigate the performance of tea waste as an organic fertilizer for *Murraya koenigii* plant. The efficiency of tea waste was determined by comparing pH values, plant growth measurement as well as chemical component characterization using Fourier-Transform Infrared (FTIR) analysis. Accordingly, the methodology begins with the preparation of organic fertilizer made from tea waste as well as other organic waste source material of fish waste. Four samples were prepared and pH readings for each sample were recorded. The performance of the tea waste organic fertilizer was observed based on the plant growth measurement. The results show that the additional of tea waste as organic fertilizer towards *Murraya koenigii* plant significantly increased the plant growth. Besides that, additional of other organic material has affected the plant growth performance as well as affecting the soil properties that would interfere the process of plant growth.

Keywords: - Tea waste, organic fertilizers, waste utilisation, Murraya koenigii, FTIR

1. Introduction

Waste from tea bags, waste from tea preparation, or the tea leaves left over after the tea has infused are all examples of spent tea waste. Tea leaves, tea dust, and other organic materials typically make up its composition. Spent tea waste can be used as an organic fertiliser for gardens and crops due to its natural qualities.

However, tea waste increases gradually as the increased production of tea bags due to demand for human usage for tea drinks. The production of tea bags can affect the environment's ecosystem, such as deforestation for tea plantations, alterations of natural water flows, and soil erosion (Yang et al., 2019).

This study aims to use tea waste as an organic fertilizer made from the spent tea waste for home usage. Normally, spent tea waste at kitchen normally discarded as waste together with other kitchen waste which led into increasing of waste and landfill area.

As a result, the use of spent tea leaves as fertiliser has been a topic of investigation for researchers for several years. As stated by Ozdemir et al., (2009), Morikawa & Saigusa (2011) and Eudoxie & Martin (2019), several research have been carried out to establish the efficacy of spent tea waste as a fertiliser and to understand its effects on plant development and soil health.

Organic fertilizers are materials that are derived from natural sources and contain nutrients that can help promote the growth of plants. Organic fertilizers are often used in place of chemical fertilizers since they can provide the same benefits while reducing the risk of environmental contamination (de Corato, 2020).

This study objectives to assess the efficiency of tea waste as an organic fertilizer to replace the use of chemical fertilizers for domestic usage. In addition, the effect of spent tea waste as an organic fertilizer in terms of pH values, chemical components present and plant growth were investigated in this study.

2. Literature Review

Tea waste, also known as tea dregs or tea residues, is the leftover material from brewing tea, and it is considered an organic waste that can have potential benefits in agriculture. The waste contains various organic compounds such as polyphenols, flavonoids, tannins, and caffeine that can have a positive impact on soil properties and plant growth.

Tea waste can be used for two purposes: first, as a reliable supply of biodegradable garbage, and second, as a helpful source of compost. In addition, organic materials such as compost have the potential to serve as an important source of plant-available nutrients such as nitrogen (N), phosphorous (P), potassium (K), sulphur (S), and magnesium (Mg), hence lowering the amount of synthetic fertiliser inputs that are required (Luo et al., 2021).

Several studies have been conducted to investigate the potential use of spent tea waste as a fertilizer. One study conducted by Gupta et al., (2020) showed that tea waste compost can improve the physical and chemical properties of soil, including the pH, organic matter content, and nutrient availability. The authors also reported an increase in the growth of lettuce and tomato plants when tea waste compost was used as a fertilizer.

Another study by Pane et al., (2014) found that spent tea waste extract can promote the productivity of lettuce and kohlrabi. The authors attributed the positive effects of tea waste extract to its high concentration of plant growth-promoting compounds.

In addition to promoting plant growth, spent tea waste can also suppress the growth of plant pathogens. A study by Li-rui (2008) showed that tea waste extract can inhibit the growth of several plant pathogenic fungi, including *Bipolaris maydis, Colletotrichum musae and Fusarium oxysporum.* The author suggested that tea waste extract can be used as a natural alternative to synthetic fungicides.

To boost crop yields, an excessive number of chemical fertilisers are being used. On the other hand, if chemical fertilisers are applied in quantities that are beyond a certain threshold, they might damage ecosystems and accumulate in agricultural plants. As a result of this, environmentalists have begun to shift their focus to organic farming, which can be defined as the cultivation of non-polluted crops using biofertilizers and biopesticides. These methods ensure that plants have access to the maximum amount of nutrients while also preventing diseases and controlling pests. It is possible to pollute the air, water, and soil with chemical fertilisers if they are misused or abused. Chemical fertilisers are manufactured in an industrial setting using known quantities of elements such as nitrogen, phosphorus, and potassium (Wazir et al., 2018).

3. Methodology

Accordingly, the methodology was started with the preparation of organic compost fertilizer made from the spent tea waste followed by the compost preparation. Then, it continues with the preparation of *Murraya koenigii* plant samples. The efficiency of spent tea waste acts as organic fertilizer was compared based on plant samples and all results are recorded and analysed.

3.1 Preparation of Spent Tea Waste

The tea bags residue was washed first with distilled water to remove any impurities inside the spent tea waste as shown in Fig. 1. The washing and cleaning steps were repeated several times until there was no longer any coloured solution. It functions also to reduce caffeine contains inside the tea leaves which reduce the growth of plants (Muratova et al., 2020). After that, the spent tea leaves are in a mesh tray and exposed to sunlight during the drying process. which function to remove moisture content as shown in Fig. 2.

Fig. 1. Spent tea bags waste

Fig. 2. Dried of tea waste from tea bags

Next, tea leaves residues were removed from the tea bags after drying process was completed. The materials used for the preparation of organic fertilizer from tea residues were arranged according to the composition determined to ensure the quality of yield and effectiveness of this organic fertilizer.

3.2 Addition of Compost Material

Additional of compost material was used in this study to compare the performance as additional nutrient source for the organic fertilizer. Compost fertilizer is a product that provides helpful nutrients to soil, plants, flowers, and vegetables (Xiao et al., 2022). Fish waste was used as the composting materials. The fish waste consists of fish sediments, bones-rich heads, and fish backbones. In addition, the compost material was used in the study which to investigate the efficiency of spent tea waste organic fertilizer by including together with the tea waste.

The entire composting procedure for fish waste takes two weeks. Due to the emission of methane gas by the composting materials, which has the potential to demolish the container, the container for this medium must be opened at least once every three days.

Besides that, brown sugar is added together with the fish waste in this process. The addition of brown sugar served as a catalyst to accelerate the composting process and a growth promoter for microorganisms (Zhang et al., 2013). In addition, the brown sugar also contains 20 – 30 times more glucose compared to normal fine sugar at market, which glucose function in helping the composting process due to carbon source presence.

3.3 Preparation of Plant Samples

Murraya koenigii plant or often called as curry leaf plant was selected to compare the efficiency of the organic fertilizer performance plants for this study. The availability of this plant on the market was an advantage in this study. Four plant samples were prepared with one plant that acts as the control sample. Meanwhile, other three plant samples were prepared and added with spent tea waste, fish waste compost and combination of spent tea waste and fish waste compost. All samples were placed at an outside control condition and all growth data was recorded.

The duration of plant growth samples recorded for period of two weeks. Four samples were prepared which consists of Sample A (no additional nutrient), Sample B (added with tea waste), Sample C (added with fish waste compost) and Sample D (added with tea waste & fish waste compost). All samples were located at a constant place and kept left outdoor.

3.4 Identification of Functional Group & pH Analysis

The identification of chemical functional group presence in the spent tea waste and fish waste compost were analysed using Fourier transform infrared spectroscopy (FTIR).

Spent tea waste sample was characterised using adsorption mechanism via FTIR device. Based on the study by Ebrahimian Pirbazari (2013), it was expected that binding occurred mostly at hydroxyl (–OH) and ketone (C=O) functional groups of tea waste.

3.5 Process flow chart

Fig. 3 shows the flow chart of the study. The data observation and data recorded for duration of four weeks based on the efficiency of spent tea waste performance as well as additional of compost material together with spent tea waste.

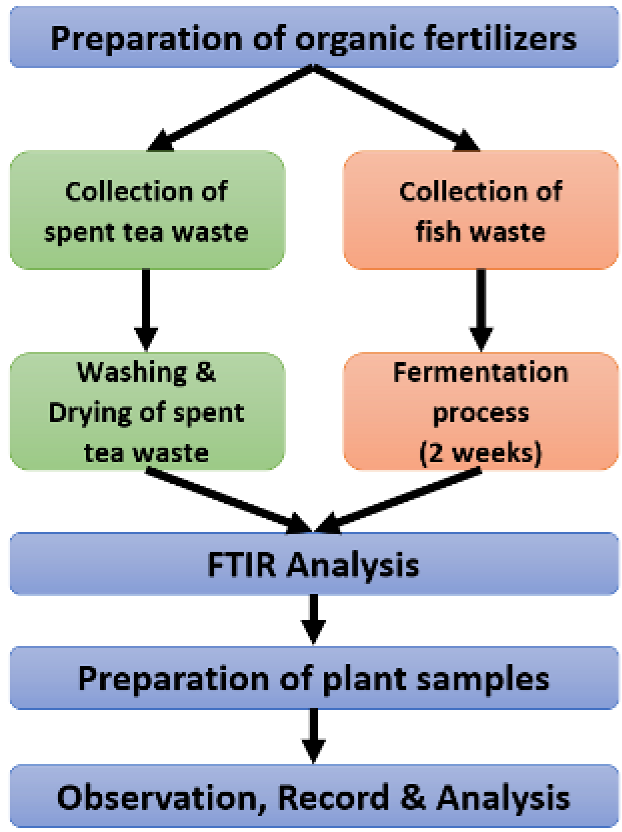

Fig. 3. Overall research workflow chart

4. Finding and Analysis

4.1 Identification of Functional Group using FTIR & pH Analysis

Three solution samples were prepared in this analysis, consists of: i) Tea Waste, ii) Fish Waste and iii) Combination Tea and Compost Fish Waste. Fig. 4 shows the FTIR analysis results.

Fig. 4. FTIR spectrum of tea waste

The functional groups of tea waste were identified by the FTIR analysis. Based on the FTIR analysis of all samples, it shows almost similar FTIR spectrum of all together. Fig. 4 shown the absorption band at 3280 cm^{-1} refers to the hydroxyl (-OH) group.

It had been expected that the majority of the solution would be made up of water in its liquid state. In addition to this, the frequency range of 2840-2920 cm^{-1} was where the C-H bond transmission was at its peak. This can be confirmed by referring to another research done by Ebrahimian Pirbazari (2013) and Syed Draman et al., (2015). In addition, the presence of an alkene functional group can be determined from the absorption band located at 1640 cm^{-1}.

All three samples also undergo pH analysis to understand the effect of pH towards plant growth. Fig. 5 shows the pH analysis work for all sample.

Fig. 5. pH analysis procedure

All result of pH analysis was tabulated in Table 1 which consists of 3 different samples that include tea waste as well as fish waste compost.

Table 1. pH reading for all sample

Sample	pH Reading
Tea waste	5.32
Fish waste compost	3.25
Tea + Fish waste compost	2.80

Based on Table 1, all results show the pH reading towards acidic environment. The tea waste shows pH reading at 5.32 which varies on the optimum soil pH readings for plant growth well between pH range 5.5 to 6.5 (Bolan et al., 2005). The fish waste was expectedly to get pH readings in alkaline or base readings with pH between 8.0 to 11.0 (Shenbagavalli et al., 2020).

However, the pH reading of the sample that turned into an acidic solution was thought to have been affected by the brown sugar added to the compost material. Organic acids were produced as a result of the fish waste compost's initial stage's rapid rate of decomposition, which was caused by the addition of brown sugar. Additionally, one of the causes that caused the fish waste compost samples to be in an acidic solution was the oxygen restriction in the confined container.

4.2 Plant Growth (Height of Plant & Size of Leaf)

The duration of the plant growth observation was recorded for a period of two weeks. All samples plant growth results are tabulated in Table 2.

Table 2. Comparison in terms of height measurement of the *Murraya koenigii* tree

Date / Sample	Day 1	Day 4	Day 7	Day 10	Day 13	Day 16
A (No Additional Nutrients)	15 cm	15.7 cm	16.2 cm	16.7 cm	16.5 cm	16.5 cm
B (Tea Waste Fertilizer)	15 cm	15 cm	15 cm	14.9 cm	14 cm	14 cm
C (Fish Waste Fertilizer)	15 cm	16 cm	16 cm	13 cm	18.5 cm	19.6 cm
D (Tea + Fish Fertilizer)	15 cm	13 cm	14.3 cm	14.5 cm	13 cm	13.1 cm

In comparison to the other samples, Sample C displays the highest plant height as measured based on Table 2. The nutrient-rich content of fish compost waste was thought to be a more concentrated supply of nutrients and may therefore have a greater impact on plant growth.

Fish compost waste is a rich source of nitrogen, phosphorus, and other micronutrients, making it an ideal fertilizer for promoting healthy plant growth. Nitrogen is essential to produce chlorophyll and for promoting overall plant growth. Phosphorus is also important for plant growth, particularly for the development of healthy roots, stems, flowers, and fruit.

Additionally, fish compost waste contains a substantial number of micronutrients such as iron, manganese, and zinc, which are essential for plant growth and development. These micronutrients are typically present in smaller amounts in other types of organic fertilizers in the tea waste. Fig. 6 shows the *Murraya koenigii* plant of Sample C that added with fish waste compost.

Fig. 6. Differences in terms of height of sample C

Sample A also demonstrates an overall increase in plant height with just a 1 cm variation from the 15 cm base height. The overall height measurement is decreasing in samples B and D. It was thought that the addition of composted tea waste and fish waste as fertiliser in sample D resulted in excessive soil nutrient levels, which were harmful to plant growth and the environment. However, the *Murraya koenigii* plant leaf of sample B shows among highest and widest leaf measurement as shown in Fig. 7.

Fig. 7. The *Murraya koenigii* plant leaf of sample B

In addition, all sample results in terms of leaf measurement are tabulated in Table 3.

Table 3. Comparison in terms of leaf measurement of the *Murraya koenigii* tree

Sample \ Date	Day 1	Day 4	Day 7	Day 10	Day 13	Day 16
A (No Additional Nutrients)	2.9 cm	2.7 cm	2.9 cm	2.8 cm	2.8 cm	2.8 cm
B (Tea Waste Fertilizer)	3.0 cm	3.3 cm	3.7 cm	3.6 cm	3.9 cm	3.9 cm
C (Fish Waste Fertilizer)	2.7 cm	2.7 cm	2.7 cm	2.9 cm	2.6 cm	2.8 cm
D (Tea + Fish Waste Fertilizer)	3.1 cm	3.3 cm	3.9 cm	3.4 cm	3.3 cm	3.4 cm

According to Table 3, sample B has the longest leaf measurement out of all the samples that were observed and measured. Samples A and C, on the other hand, display the lowest leaf measurements ever recorded since the first day of observations. The nitrogen in tea waste was thought to be a rich supply of the nutrient necessary for plant growth and a part of the chlorophyll molecule, which is responsible for photosynthesis. The production of chlorophyll tends to increase when plants have enough nitrogen, which can result in leaves that are bigger and greener (Zou et al., 2023).

The plant leaf measurement offers an infinite amount of information. This process also known as calculating leaf surface area gives vital information about the growth and development of plants as well as how they interact with their surroundings by measuring the surface area of the leaves (Pandey & Singh, 2011). This knowledge can be applied to increase crop output, create environmentally friendly farming methods, and comprehend how ecosystems work.

In addition, the tea waste used in this project already decomposed in order ensure that the nutrients are available to the plants and that the tea waste will not attract pests or cause disease. Tea waste leaves also contain other beneficial compounds such as antioxidants, flavonoids, and tannins, which can have positive effects on plant growth and health.

The effect of tea waste on plant growth can vary depending on the specific type of plant and the soil conditions. In some cases, the use of tea waste may result in a more balanced growth of both leaves and stem, leading to an overall increase in plant height. However, the *Murraya koenigii* plant that used in this study shows different results in terms of plant height and differ in the size of the plant leaves especially as shown in Sample C. It is possible that a number of mistakes were made during this research, or that the way fish waste interacts with the plant, could have an effect on it. To better understand how fish waste affects plant growth, more in-depth research investigations are required.

5. Conclusion

The performance study and analysis of tea waste as organic fertilizer has been successfully performed. This study evaluated the feasibility of using spent tea waste as a valuable resource natural fertilizer for plant growth, for personal or household use. pH value of 5.32 in the spent tea waste solution significantly improve the growth of *Murraya koenigii* plant.

However, the effect on plant height can vary depending on the specific type of plant and soil conditions, which reflect to the plant performance as shown in Sample C. The performance results using tea waste can be particularly beneficial for promoting leaf growth due to its high nitrogen content, as shown in Sample B.

It can be concluded that, the efficacy of tea waste as a natural fertiliser can promote plant growth and provides an eco-friendly and sustainable solution.

Acknowledgement

The authors would like to thank the Department of Petrochemical Engineering at Politeknik Kuching Sarawak, as well as the students, staff, and lecturer from the tea waste project for their participation and assistance in data collection, progress works, and other aspects of this study.

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