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The quality of liquid organic fertilizer made from moringa leaf stems as influenced by the concentration of microbes and the duration of fermentation

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***Abstract*- Liquid organic fertilizer from moringa leaf stems was produced through a fermentation process. In this study, moringa leaf stems were utilized by adding banana stems and EM4. The use of moringa leaf stems and banana stems in liquid organic fertilizer was expected to enhance macro-nutrients in the soil, such as nitrogen, phosphorus, and pH. The objective of the research was to determine the optimum conditions for producing liquid organic fertilizer. The experimental variables included adding EM4 starter concentrations of 1%, 3%, and 5% (v/v) to the fermentation substrate and fermenting it for 7, 14, and 21 days. The analysis results indicated that the nitrogen, phosphorus, and pH content of the liquid organic fertilizer met the standards. The optimum conditions were achieved during a 14-day fermentation period with a 5% concentration of EM4, resulting in nitrogen content of 10.06%, phosphorus content of 2.05%, and pH level of 7.5.**

Keywords—moringa leaf stems; liquid organic fertilizer; fermentation; EM4

I. Introduction

Moringa leaves hold significant importance as a widely consumed food among various communities. They are recognized for their nutritional value and health benefits [1], making them a popular choice in many cuisines and traditional dishes. During food processing, the moringa leaves are separated from their stems because they may not be as palatable or suitable for consumption.

The discarded moringa stems pose a challenge as they become waste, often overlooked and underutilized. Despite containing potentially valuable components, these stems are typically left unused, leading to missed opportunities for alternative applications and potential benefits.

Efforts to find creative and sustainable ways to utilize moringa stems could lead to various possibilities. For instance, they could be explored for their potential in animal feed, composting, or even for producing natural fibers. Furthermore, their use in the production of organic fertilizers or other agricultural applications could contribute to reducing waste and promoting environmental sustainability.

Therefore, the aim of this research was to utilize the moringa leaf stems and formulate it into a liquid organic fertilizer to meet the quality standards of fertilizer. Main consideration in this study was research specifically focusing on the Moringa oleifera stems is limited. While extensive research has been conducted on various parts of the Moringa oleifera plant, the leaves, in particular, have been the subject of thorough investigation and are widely recognized for their rich abundance of vitamins, minerals, and antioxidants [1].

Having known that the minerals present in Moringa oleifera are calcium, potassium, magnesium, iron, zinc, and sodium [2,3]. The stems then are, therefore, pose a huge potential as organic liquid fertilizer. In this study, we added banana corms and bio-activator EM4.

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The banana corms are rich in nutrients, includes carbohydrates (66%), protein, water, and essential minerals such as calcium, iron and phosphor [4]. The carbohydrate is a potential source of organic material for bacteria growth. The EM4, on the other hand, is a combination of different beneficial microorganisms, including photosynthetic bacteria, lactic acid bacteria, yeast, Actinomycetes, Lactobacillus, Saccharomyces, and filamentous fungi [5]. These microorganisms are essential in maintaining the balance of Carbon and Nitrogen, which is crucial for accelerating the maturity of organic fertilizer production [6]. Besides expediting the fermentation of waste and organic materials, EM4 also plays a role in inhibiting the growth of soil pathogens, leading to improved nutrient availability and accessibility of organic compounds for plants [5]. Therefore, the research was expected to produce high quality liquid organic fertilizer which met the national standard.

II. Research Methodology

A. Materials

The equipment used in this research includes a knife, spatula, porcelain dish, analytical balance, stove, furnace, AAS equipment, measuring flask, Whatman 40 filter paper, Erlenmeyer flask, dropping pipette, volumetric pipette, measuring pipette, digestion tube, clamp, measuring flask, distillation apparatus, round-bottom flask, tissue, pH meter, UV-Vis Spectrophotometer, label, shaker, spray flask, bulb, wooden board, blender, hotplate, centrifuge, and titration equipment.

The materials used in this research are moringa leaf stems, banana blossoms, EM4, granulated sugar, distilled water, $K_2Cr_2O_7$ 1N, H_2SO_4 98%, HCl 37%, HNO_3, ammonium molybdate-vanadate, $SnCl_2$, KH_2PO_4, CuSO4, $NaSO_4$, NaOH 30%, H_3BO_3 2%, mixed indicator, and HCl 0.1N.

B. Methods

The 215 g moringa leaf stems and 215 g banana blossoms were weighed, chopped, and then blended with 1 liter of water. The mixture was placed in a fermentation container, and EM4 was added in concentrations of 1%, 3%, and 5%, along with 20 grams of granulated sugar. The mixture was stirred during the fermentation period, which varied between 7, 14, and 21 days. Subsequently, a filtration process was conducted for separation. The obtained filtrate underwent analysis for phosphorus using UV-Vis spectrophotometer, nitrogen analysis using the Kjeldahl method, and pH analysis.

Phosphoros analysis-a precise 2g sample was weighed and placed in a 100 ml glass beaker. The composition was then dissolved with 1 ml of concentrated HCl and 3 ml of concentrated HNO_3. The mixture was heated on a hotplate at 30°C, producing white smoke for 5 minutes. After cooling, the solution was transferred into a 100 ml measuring flask. Subsequently, water was added to the flask until reaching the mark, and the mixture was vigorously shaken for homogenization. The solution was then filtered using Whatman 40 filter paper into an Erlenmeyer flask. Next, 1 ml of the filtered solution was pipetted into a 50 ml measuring flask, diluted with 50 ml of water, and then 2 ml of ammonium molybdate-vanadate reagent and 5 drops of $SnCl_2$ were added. The flask was filled with water until reaching the mark and shaken. For comparison, standard solutions of P_2O_5 (potassium dihydrogen phosphate) with concentrations of 5, 10, 15, 20, and 25 ppm, totaling 100 ml, were prepared and treated similarly to the composition solution, along with blank preparation. After 10 minutes of color development, the intensity of color was read at a wavelength (ג) of 750 nm, and the absorbance readings were recorded.

Kjeldahl method- briefly divided into 3 stages. First, sample preparation, 1 gram of liquid fertilizer was weighed and mixed with 7 grams of a catalyst blend (CuSO4 and NaSO4) along with 25 ml of concentrated H2SO4. The mixture was placed in a digestion tube, and a blank solution was prepared similarly. Next, digestion, the tube was assembled on a heating device and heated until the solution turned clear green. Subsequently, the sample solution was transferred to a 100 ml volumetric flask and diluted with water to the

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mark. Moving to distillation, the setup involved a distillation apparatus, and the sample solution was poured into a 500 ml round-bottom flask. Then, 75 ml of 30% NaOH was added until the solution turned brown, and 100 ml of 2% Boric acid was added to an Erlenmeyer flask to collect the distillate, with 3 drops of mixed indicator for color indication. The distillation process was initiated and stopped after 150 ml of distillate and boric acid were collected. Finally, for titration, the distillation sample was titrated with 0.1 N HCl solution until a pinkish-red color change occurred, and the volume of titrant used was recorded.

$$Nitrogen=((V1-V2) \times N \times 14.08)/(G\ sample) \times 100\%$$

Note: V1 = Volume of titrant solution (HCl) used for the sample (ml); V2 = Volume of titrant solution (HCl) used for the blank (ml); N = Normality of the titrant solution (HCl) (mgrek/ml); 14.08 = Equivalent weight of nitrogen (mg/mgrek); G = Weight of the sample (mg).

III. Results and Discussion

A. Phosphor content

The research findings revealed a notable pattern in the phosphorus content over time for all treatments. Specifically, there was a consistent increase in phosphorus content until day 14 of fermentation, followed by a subsequent decrease after day 21. During the 7-day fermentation period with varying EM4 concentrations (1%, 3%, and 5%), the phosphorus content was measured at 2.011%, 2.021%, and 2.032%, respectively. This initial phase of microbial growth observed during the first week of fermentation could be attributed to the adaptation period when the microbial inoculation was introduced to the medium. Interestingly, in this early phase, the changes in cell mass occurred without any significant alteration in the overall cell count.

Moving to the 14-day fermentation period with the same EM4 concentrations (1%, 3%, and 5%), the phosphorus content displayed a further increase, reaching 2.040%, 2.048%, and 2.050%, respectively. This upward trend in phosphorus content suggests a shift in microbial growth towards the exponential phase. During this phase, the microorganisms experience rapid proliferation, leading to a substantial change in the total cell count and, consequently, a rise in the phosphorus content. These observations underscore the significance of fermentation time and EM4 concentration in influencing the phosphorus levels in the liquid organic fertilizer. Further analysis of the fermentation process can provide valuable insights into optimizing the production of nutrient-rich organic fertilizer for agricultural applications.

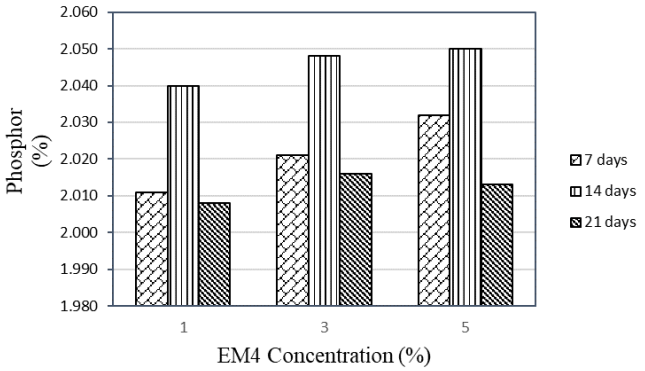

Figure 1. Effect microbial concentration and fermentation days on the phosphor content

During the 21-day fermentation period with different EM4 concentrations (1%, 3%, and 5%), a notable decline in phosphorus content was observed, with measured values of 2.008%, 2.016%, and 2.013%, respectively. This decrease in phosphorus content may be due to the dynamics of microbial growth during the stationery and death phases. As the fermentation progressed and the nutrient concentration began to diminish, the microorganisms' growth rate started to decelerate, eventually leading to a point where their growth ceased entirely. In this study the highest was at 5% EM4 and 21 days fermentation of 2.050%.

B. Nitrogen content

The data presented in Figure 3 provides valuable insights into the relationship between fermentation time, EM4 concentrations, and the resulting nitrogen content. The study examined three different concentrations of EM4 (1%, 3%, and 5%) and measured

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their effects on nitrogen content over three distinct fermentation periods (7 days, 14 days, and 21 days).

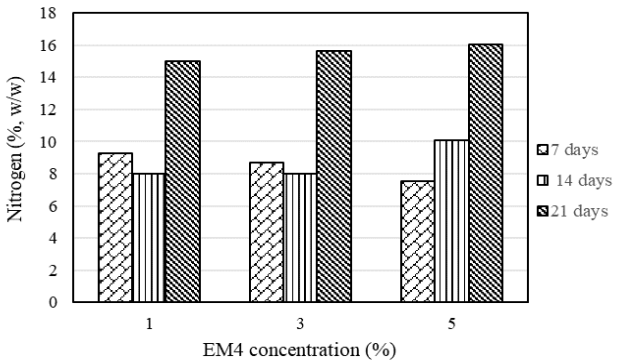

Figure 2. Effect microbial concentration and fermentation days on the nitrogen content

During the initial 7-day fermentation, it became evident that the nitrogen content decreased as the concentration of EM4 increases. Specifically, the nitrogen contents were recorded as 9.28%, 8.71%, and 7.54% for EM4 concentrations of 1%, 3%, and 5%, respectively. This observation can be attributed to the fact that the microorganisms responsible for the nitrification process, which produces nitrates, are still adjusting and adapting to their new environment. The varying concentrations of EM4 likely impact the rate at which these microorganisms establish themselves and begin their activity, leading to differences in nitrogen production.

As the fermentation duration is extended to 14 days, the relationship between EM4 concentration and nitrogen content becomes more intricate. At this stage, the nitrogen contents were measured to be 7.97%, 7.98%, and 10.06% for EM4 concentrations of 1%, 3%, and 5%, respectively. Notably, the 5% EM4 concentration exhibited a higher nitrogen content compared to the other concentrations, suggesting that the longer fermentation period might have allowed the microbe population to adapt better and optimize their nitrogen-producing capabilities. Previous research has shown that this increase in nitrogen content during composting is often linked to the proliferation of microbial populations actively involved in breaking down organic matter [7]. Nitrogen is an essential element for plants, and its availability through decomposition supports the synthesis of crucial compounds like amino acids and proteins, which are vital for plant growth and development.

The impact of fermentation duration on nitrogen production becomes even more apparent when examining the 21-day fermentation results. The nitrogen contents for EM4 concentrations of 1%, 3%, and 5% were found to be 15.0%, 15.64%, and 16.01%, respectively. These results indicate a substantial increase in nitrogen content compared to the 7-day and 14-day fermentation periods. The consistent trend of higher nitrogen content with longer fermentation aligns with existing literature, which suggests that extended fermentation allows the microorganisms involved in nitrate production to undergo an exponential phase of rapid cell division. This phase is particularly prominent in bacteria responsible for the nitrification process, leading to a higher yield of nitrogen in the final product. In this study the highest was at 5% EM4 and 21 days fermentation of 16,01 % dry basis.

C. pH of fertilizer

The findings from Figure 5 reveal that the pH levels in the liquid organic fertilizers derived from moringa leaf stalks and banana stems remained steady throughout the analysis. To ensure accuracy, a pH meter was employed to verify these measurements. Notably, there was a gradual rise in pH from the initial stages of fermentation up until the 21st day of the process. This observation suggests that the fermentation processes taking place during this time period are conducive to optimizing the activity of bacterial microorganisms.

Upon analyzing the data collected from the 7-day to 21-day fermentation experiments, considering different concentrations of EM4 (1%, 3%, and 5%), it was observed that the pH levels ranged from 7.3 to 7.7. The noticeable increase in pH values can be attributed to the conversion of organic acids that are formed during the fermentation process. This conversion occurs due to the diverse activities of microorganisms present in the

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mixture, resulting in an elevation of acidity in the materials.

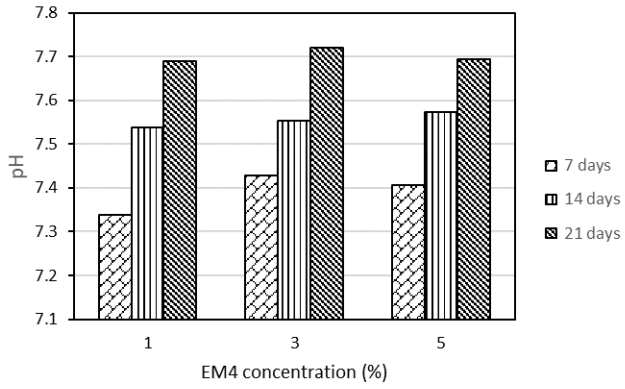

Figure 3. Effect microbial concentration and fermentation days on the pH of fertilizer

IV. Conclusion

1. The research findings shed light on the dynamic relationship between fermentation time, Effective Microorganism 4 (EM4) concentrations, and phosphorus content in liquid organic fertilizer. The study observed distinct phases of microbial growth during the fermentation process, and the phosphorus content showed a significant pattern of changes over time but reached the highest value at 14 days fermentation and with amount of EM4 of 5%.
2. Nitrogen level was influenced by fermentation time and EM4 concentrations. The findings underscore the importance of considering both factors in optimizing the nitrogen yield in the fermentation process, with potential implications for enhancing agricultural applications and the overall efficiency of fertilizer production.
3. The pH analysis results indicated that the fermentation of the liquid organic fertilizers maintains pH stability and undergoes changes in acidity levels as the process progresses. The pH values observed within the specified EM4 concentration range suggest that the fermentation fosters an environment where beneficial bacterial microorganisms can thrive and contribute to the transformation of organic compounds, ultimately enhancing the quality of the organic fertilizer.

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