Production of Liquid Bio-Fertilizer from Old Coconut Water and Molasses using Consortium Microbes

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Abstract. Increasing issue of returning to nature, the presence of organic fertilizer is one of the things required in agriculture sector. The presence of the liquid organic fertilizer, it is expected to have a positive impact on plants and soil. Moreover, in the manufacturing process, it was utilizing wastes. The liquid fertilizer was made by mixing waste from micro-businesses that produce a porridge (old coconut water) and side product of the sugar factory (molasses). Seven litter solutions from the liquid were mixed using a bioreactor equipped with impeller for 8 incubation days. The isolated microbes were inserted with initial number of $10^{12}$ using counting chamber method. As a phosphate source, the phosphate rock was implemented into reactor. Every 4 days, the samples were taken and analysed for knowing the concentration of NPK and C components. Three consortium microbe variables were carried out for making the fertilizer where the source of microorganisms from enrichment cultures + old coconut water + molasses (EOM); soil + old coconut water + molasses (SOM); and only old coconut water + molasses (OM). The highest (%) of N, P, K and C components was detected at 0.09; 0.04; 10.5 and 1.74, respectively achieved by the EOM after 8 day of incubation period. The bio-fertilizer was applied into the paddy test plants with a hydroponic system.

1. Introduction

The presence of waste around us that has not been treated properly yet, environmental issues and economic factors, provides a potential and at once opportunity regarding them. One way is to utilize waste from the production of porridge, in the form of old coconut water and side products from a sugar factory, in the form of molasses. Old coconut water is believed, it’s still containing enough nutrients and micro elements that can be used as a medium as well as a source of microorganisms that can be added in the process of making liquid fertilizer. The old coconut water can be found easily and abundantly in the Regency of Ponorogo, East Java Province – Indonesia, because this area is a central industry of porridge, which applies the coconut as its basic material. Referring to the data from BPS – Ponorogo, the number of coconuts that can be produced in this regency is 6.170,09 tons [1] and Indonesia produces coconut about 2.87 million tons with an area of 3.54 million hectares [2].

Likewise, molasses, it’s also still having organic elements. Molasses is an energy source that contains about 50% sugar in the form of sucrose (20-30%) and reducing sugars (10-30%). Reducing sugar is a compound that is digested easily and can be directly absorbed by the blood for the process of metabolism in order to obtain energy. The characteristics of molasses have a COD of 65,000-130,000

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mg/L and BOD5 of 30,000-96,000 mg/L and have a smell like soy sauce and a dark brown color [3]. Microorganisms contained therein also utilize both of these materials.

Furthermore, utilization of the Lapindo mud in Sidoarjo – Indonesia is as an effort to reduce the negative impact of disasters that have occurred since 2006. For generating bio-fertilizer, it requires culture source as a source of microbes. Lapindo mud is other potential components as a culture source Lapindo mud is composed of 70% water and 30% solids. Salinity of mud is very high (38-40%), so it is salty [4]. Based on the research on the chemical parameters results of Lapindo mud, it is known that the pH value ranges from 6.6 - 7, cation exchange capacity (CEC) of 3.89-35.42 (Me/100g), moisture content of 40.41-60.73 % and total organic carbon content of 54.75-55.47% [5]. Therefore, based on all of the above, this research was conducted. This study aims to make organic liquid fertilizer based on organic materials that utilize consortium microbes sourced from nature.

2. Material and Method

2.1. Microorganism sources

The consortium microbes were obtained from some natural environment sources, such as Lapindo Mud, old coconut water and molasses. The mixed cultured from Lapindo mud were enriched for three weeks by following method [6]. The sterile minimum medium was containing some nutrients such as 2 g of NH$_4$NO$_3$; 2 g of KH$_2$PO$_4$; 2 g of K$_2$HPO$_4$.3H$_2$O; 0.2 g of MgSO$_4$.7H$_2$O; 0.2 g of FeCl$_3$.6H$_2$O and 0.02 g of CaCl$_2$ within 200 mL. For isolation of the mixed cultured, the medium was supplemented using 5 g of mud and 5 g of the Jordan phosphate rock. The phosphate rock composition was described in Table 1. Meanwhile, the other microorganisms were using the old coconut water and molasses directly.

| Parameter | Unit | Grade$^b$ |
|-----------|------|-----------|
| H$_2$O    | %    | 2.02      |
| P$_2$O$_5$| % adbk$^a$ | 30.44 |
| CaO       | % adbk$^a$ | 46.71 |
| MgO       | % adbk$^a$ | 0.29 |
| Na$_2$O   | % adbk$^a$ | 0.64 |
| K$_2$O    | % adbk$^a$ | 0.03 |
| Fe$_2$O$_3$| % adbk$^a$ | 0.25 |
| Al$_2$O$_3$| % adbk$^a$ | 0.33 |
| R$_2$O$_3$| % adbk$^a$ | 0.57 |
| SO$_3$    | % adbk$^a$ | 1.06 |

$^a$ on the basis of dry ingredients
$^b$ average

2.2. Liquid material sources

The used materials of liquid were collected from coconut water waste of the porridge manufacturer “Jenang Murni” in Ponorogo and side sugar of PT Energi Agro Nusantara (Enero) in Mojokerto – Indonesia.

2.3. Fermentation process and manuring paddy hydroponic test

The liquid medium was prepared by mixing 7 L of old coconut water; 0.01 % v/v of molasses and 0.0024 % w/v of phosphate rock. The fermentation process for 8 days was conducted using the aerobic reactor (Figure 1) inserted by consortium microorganisms as the changed variables. During the
experiment, the pH and temperature were maintained at around 7 and 30°C, respectively with aeration supply at a rate of 4 L/min. Three variables microbes used were including the enrichment cultures + old coconut water + molasses (EOM); soil + old coconut water + molasses (SOM); and only old coconut water + molasses (OM). The initial number of microbes were adjusted at $10^{10}$ cells/mL approximately with counting chamber method [7]. Every 4 days, the liquid bio-fertilizer was checked N, P, K and C-organic contents. The organic contents were analyzed at $t = 0$ days, $t = 4$ days, and $t = 8$ days, then it was tested using paddy hydroponic system for 10 weeks. The manuring test was carried out in the Islamic Boarding Institution (PP) Al-Ahsan, Jombang, East Java – Indonesia.

3. Results and Discussion
In the research, it studies the manufacture of liquid fertilizers by utilizing materials and microorganisms that are easily found originating from nature. Three consortium microbe variables were carried out for making the fertilizer where the source of microorganisms from enrichment cultures + old coconut water + molasses (EOM); soil + old coconut water + molasses (SOM); and only old coconut water + molasses (OM). During the fermentation process, bio-fertilizer was analyzed for N, P, K and C content every 4 days. After 8 days, the formed bio-fertilizer was applied to paddy plants with a hydroponic system, in which the system can be seen in the figure 2. One L of organic fertilizer was diluted within 50 L of water. There were three ways for manuring, such as after the paddy test age of 7 days, 30 days, and 60 days. The manuring to the plant test was performed for 10 weeks.
3.1. Observation N, P, K and C elements during the process.
There were some factors or parameters influenced to bio-fertilizer especially amount of N, P, K and C elements during fermentation process, such as the initial element and concentration material sources from coconut water and molasses, microbes used, duration and condition of incubation. The results obtained from the N, P, K and C element analysis can be summarised in Table 2. Based on the analysis component, it was found that the highest number on N, P, and K elements were achieved by EOM at t = 8 days with concentrations of 0.09%, 0.04 % and 10.5 %, respectively and the greatest number on C elements was obtained by OM at t = 8 days with level of 1.78 %.

| Variable | Time | Component (%) | Component (%) | Component (%) | Component (%) |
|----------|------|---------------|---------------|---------------|---------------|
| EOM      | 0 day| 0.26          | 0.51          | 10.5          |               |
|          | 4 days| 0.005         | 0.041         | 0.04          |               |
|          | 8 days| 0.013         | 0.014         | 0.09          |               |
|           |      | Nitrogen      |               |               |               |
| SOM      | 0 day| 0.25          | 0.37          | 9.61          |               |
|          | 4 days| 0.005         | 0.033         | 0.03          |               |
|          | 8 days| 0.013         | 0.015         | 0.05          |               |
|           |      | Nitrogen      |               |               |               |
| OM       | 0 day| 0.29          | 0.38          | 5.68          |               |
|          | 4 days| 0.058         | 0.038         | 0.03          |               |
|          | 8 days| 0.013         | 0.01          | 0.07          |               |
|           |      | Nitrogen      |               |               |               |
|           |      | C-organic     |               |               |               |
|           |      | 2.05          | 1.94          | 1.74          |               |
|           |      | C-organic     |               |               |               |
|           |      | 1.77          | 1.79          | 1.78          |               |

As can be seen from the above table, the utilization of consortium microbes from enrichment cultures + old coconut water + molasses (EOM) reported significantly more N, P, K percentages than soil + old coconut water + molasses (SOM); and only old coconut water + molasses (OM). The result indicated that consortium microorganisms from EOM especially enrichment culture from Lapindo mud can enhance N, P, K compounds well. These culture from Lapindo Mud believed have a critical role for increasing N, P, K components [8] as the nitrogen, phosphor, potassium contributors on the plants. These microbes were believed as a diazotroph bacteria in which have a good role to fix nitrogen [9] due to a nitrogenase enzyme which have capability on for nitrogen and hydrogen combination [10, 11]. Furthermore, the consortium microorganisms (EOM) might be suitable microbe combination to enhance phosphor element and increase potassium component where the condition might be caused by the hydrolysis and proteolysis reactions so that it lead to release K⁺ from the organic matter [8]

Meanwhile, the highest percentage of C element (1.78%) during process incubation period was obtained by OM. The carbon elements from coconut water and molasses were degraded into a simpler compound with more stable for 8 days incubation period. The three designated variables provide the decreased with enhancing the incubation period where the condition occurs might be caused by absence of the added microorganisms that consume C-organic within coconut water and molasses to enhance the microorganism metabolism as carbon sources [8] and at once as culture sources.
3.2. Observation of height and leaf number on paddy test during manuring

The observation of manuring on paddy test for height and leaf number during 10 weeks can be seen in the Figure 3 and Figure 4, respectively. Figure 3 shows that the paddy plant height increased with increasing manuring time. The largest growth of plant height, it can be achieved by OM. Meanwhile, Figure 4 presents that the number of leaves of rice plants increased until the fourth week then relatively constant with increasing fertilization time. The highest number of rice leaves was also experienced by OM.

![Figure 3. Observation of height plant during paddy test.](image)

![Figure 4. Observation of leaf number during paddy test.](image)

The condition of rice plants in the field with the hydroponic system before (0 week) and after fertilizing (5 and 10 weeks) with variables EOM, SOM and OM can be seen in Figures 5, 6, 7, respectively. From the pictures show that the production of liquid bio-fertilizer using natural culture sources with all the variables have a positive response in the hydroponic paddy test, which was indicated by the emergence of paddy fruit.
Figure 5. Paddy test was conducted (a); (b) and (c) at 0 week, 5 weeks and 10 weeks, respectively, using enrichment cultures + old coconut water + molasses (EOM).

Figure 6. Paddy test was conducted (a); (b) and (c) at 0 week, 5 weeks and 10 weeks, respectively, using soil + old coconut water + molasses (SOM).

Figure 7. Paddy test was conducted (a); (b) and (c) at 0 week, 5 weeks and 10 weeks, respectively, using only old coconut water + molasses (OM).
4. Conclusion
The coconut waste water supplemented by molasses and natural microbes can be used as the potential material and culture sources for generating liquid bio-fertilizer.

Acknowledgments
The authors would like to thank the Islamic Boarding Institution (PP) Al-Ahsan, Jombang, East Java – Indonesia for testing of paddy hydroponic system. Furthermore, we also acknowledge to the Institut for Research and Community Services (LPPM) of Institut Teknologi Sepuluh Nopember (ITS) on the Program (Pengabdian Kepada Masyarakat Berbasis Penelitian) for financial supporting with agreement document No: 1344/PKS/ITS/2019

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