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Properties and cost analysis of bio-urine liquid fertilizer (BLF) from Balinese cattle on the use of bio-activators and different fermentation times

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ABSTRAK

Penelitian ini bertujuan untuk mengevaluasi pengaruh penggunaan bioaktivator dan waktu proses fermentasi berbeda dalam proses produksi pupuk cair bio-urine (PCB) dari Sapi Bali. Ada dua jenis bioaktivator yang digunakan, yakni (1) bioaktivator hewani (BH) dan (2) bioaktivator nabati (BN). Waktu proses fermentasi adalah (1) 7 hari, (2) 14 hari dan (3) 21 hari. Penelitian dilaksanakan berdasarkan Rancangan Acak Lengkap pola faktorial. Data hasil penelitian dianalisis menggunakan ANOVA. Hasil penelitian menunjukan bahwa perbedaan jenis bioaktivator dan waktu proses fermentasi berpengaruh nyata (P<0,05) pada kadar C-Organik, N-Organik dan Rasio C/N pupuk organik cair, namun tidak berpengaruh nyata pada Nilai pH. Nilai kadar C-Organik bervariasi dengan rentang nilai 9,59-12,02%. Kadar N-Organik berada pada kisaran 1,03-1,35% dan rasio C/N 8,33-11,03. Nilai pH berada pada kisaran 8,76-8,95. Hasil akhir penelitian menunjukkan bahwa penggunaan bioaktivator nabati yang menggunakan waktu proses fermentasi 14 hari menunjukkan karakteristik terbaik dibanding perlakuan yang lain. Biaya produksi PCB yang menggunakan BN sebagai bioaktivator lebih rendah (Rp. 8.179,22,-) dibanding BH (Rp. 8.312,28,-). Pada siklus proses produksi, aplikasi BN lebih menguntungkan (Rp. 11.820,78,-) dibanding menggunakan BH. (Rp. 11.687,72,-).

Kata kunci : analisis biaya, bio-urine, pupuk cair, bio-aktivator, fermentasi

ABSTRACT

The study was aimed to evaluate the effect of bio-activator and different fermentation time in the process of producing bio-urine liquid fertilizer (BLF) from Balinese cattle. Two types of bio-activators are used, namely (1) animal bio-activator (ABA) and (2) plant bio-activator (PBA). The time of fermentation process applied is (1) 7, (2) 14 and (3) 21 days. The research was prepared based on a Completely Randomized Design (CRD) of the factorial pattern. The data of the research were analyzed using ANOVA. The result showed that the difference of bio-activator and time of fermentation process had significant effect (P<0.05) on C-organic, N-organic and C/N ratio of BLF, but no significant on pH. The C-organic content of 9.59-12.02%. N-organic of 1.03-1.35% and C/N ratio of 8.33 to 11.03. The pH values are 8.76-8.95. The final results showed that the use of bio-activator using a 14-days fermentation time showed the best characteristics compared to other. The production cost of BLF using PBA is lower IDR.8,179.22 than ABA IDR.8.312,28. The application of PBA IDR.11,820.78, was more advantageous than ABA IDR.11,687.72.

Keywords: cost analysis, bio-urine, liquid fertilizer, bio-activator, fermentation

INTRODUCTION

At present, the use of chemical fertilizers in agricultural systems is in a very worrying condition (Morari *et al*., 2011). In China, livestock waste is classified as one of the main sources of pollutants. Therefore, the government is actively conducting the recycling process (Jiang *et al.,* 2019; Jia *et al*., 2018). This is due to the enormous impact on human health (Akdeniz, 2019). The use of fertilizers from chemical compounds in plants first began when the green revolution program was launched. One of them is related to the process of nutrient cycling and the formation of soil aggregates through the process of decomposition of organic matter (Stark *et al*., 2008). Ecosystem disturbances are likely to occur due to uncontrolled use of chemical fertilizers (Kaur *et al*., 2008; Chaudhry *et al*., 2009). One of the harmful effects on uncontrolled use of chemical fertilizers is on human health (Morari *et al*., 2011). Bacterial diversity is higher in fertilizers than in agriculture without good cultivation (Ge *et al*., 2008). Microbial activity in the soil is one indicator of the soil quality. This is very important in the management of an agricultural land (Bending *et al*., 2002).

Urine from cattle is classified as livestock waste. The waste is always connoted as a product that has a negative connotation. Urine waste has bad potential in the environment and humans because of its very high nitrogen content. Very high nitrogen levels have a bad impact on the environment. In developing countries like Indonesia, the waste treatment process can be utilized as a source of income (Said, 2019; Amankwaa, 2017). Balinese cattle are a type of local livestock that has the largest population in Indonesia. The total population of Balinese cattle reaches 5 million (Kementerian Pertanian Republik Indonesia, 2015). Adult Balinese cattle are able to produce urine of approximately 5 liters/day (Kementerian Pertanian Republik Indonesia, 2018). The production of urine waste produced by smallholder farms has not been fully controlled so that it has the potential as a source of pollutants in the environment. Therefore, the use of urine waste really needs to be developed to the maximum as a natural biological resource. Organic fertilizer production is an effort to improve the environment. In addition, organic fertilizer is very beneficial for increasing soil fertility (Milinković *et al*., 2019; Mao *et al*., 2018; Chen *et al*., 2017a; Chen *et al*., 2017b).

Research related to the use of urine from Balinese cattle as a raw material for making liquid fertilizer has not been fully explored. On the other hand, urine from Balinese cattle has a fairly complete nutritional composition that has the potential to be used as raw material for liquid organic fertilizer. The use of fertilizers derived from livestock manure is one of the efforts to carry out the concept of organic farming (Hu *et al*., 2011; Raden *et al*., 2017). To improve the quality of liquid organic fertilizer, of course a process is needed. One important process step in improving the quality of nutrients in liquid organic fertilizer is the fermentation process. Utilization of livestock waste as organic fertilizer is an effort to reduce waste production in livestock business (Neugebauer and Sołowiej, 2017; Pandey *et al*., 2016; Proietti *et al*., 2016). The use of microorganisms as bio-activators has been widely involved in the fermentation process. The use of commercial bio-activators has been widely applied in the fermentation process, especially in the process of liquid fertilizer production. However, the use of commercial bio-activators must certainly be considered because the price is quite expensive and does not guarantee its availability and continuity (Ahmad *et al*., 2007; Leite *et al*., 2010).

The use of natural bio-activators is very important and needs to be considered. The use of natural bio-activators has many advantages. The use of natural biactivators will reduce production costs, be safe for the environment and easy to implement. In addition, the use of natural bio-activators can guarantee availability and continuity because it is easier to produce on a small scale. Natural bio-activators can come from animals or plants. Natural bio-activators contain a number of certain microorganisms that can remodel complex compounds on the substrate into compounds that are simpler and easily absorbed by plants. Bio-activators contain a number of functional microorganisms that have a very beneficial effect on an organic farming system (Ma-der *et al*., 2002). Microorganisms play an important role in improving soil stability through de-nitrification, nitrification and nitrogen fixation processes (Hsu and Buckley, 2008; Philippot *et al*., 2011; Zhang *et al*., 2012). The price of chemical fertilizers is relatively expensive so the use of organic fertilizers is very important and needs attention. The application of local microorganisms from animals and plants as bio-activators needs to be further studied to produce environmentally friendly liquid fertilizer products. Several types of microorganisms need to be empowered and utilized. This is due to the fact that approximately 90% of the types of microorganisms are potentially harmful and pathogenic to humans (He *et al*., 2019). The performance of microorganisms in the fermentation process is influenced by the processing time. Research studies related to the quality of liquid fertilizers through the application of animal and vegetable bio-activators in the process of fermentation of liquid urine based on cattle urine have not been done. In addition, information regarding the cost analysis of the liquid fertilizer production process has not been widely publicized. Therefore, research on the combination of cost analysis and fertilizer quality is very interesting to develop further.

Objective of this study was to evaluate the effect of bio-activator use from animals (ABA) and plants (PBA) source and the time of different fermentation process in the production process of bio-urine liquid fertilizer (BLF) based on urine of Balinese cattle.

MATERIALS AND METHODS

Materials

The urine from Balinese cattle were used as the main material in the study. Supporting materials were used include: cattle feces extract, brown sugar, banana root, clean water and rice wash waste.

Methods

Method of Raising Cattle

The urine were collected from Balinese cattle that the kept intensively (in cages). The structure of the cage were uses wood that equipped with a place to feed and drink. The main type of feed given was elephant grass (*Pennisetum purpureum*) that given on an ad-libitum basis. The rice bran was given as additional feed for the once/a day (morning).

Urine Collection Process

The urine collection process was done hygienically and directly to avoid the effects of contamination with feces. Urine that comes out of the body of the cattle was carried out immediately by the shelter process using a closed plastic container. The urine was processed according to the treatment plan.

Production Process of ABA Extract

A total of 1 kg of extract feces was added with 1 kg of brown sugar (ratio 1:1). The mixture was subsequently and dissolved into 500 mL of water. The solution was then mixed at 100 rpm for 10 mins. The solution was then fermented for 2 weeks in an-aerob to produce ABA extract.

Production Process of PBA Extract

The main ingredient was used the root of banana plant as much as 1 kg. The material was then milled using a grinder and then added 100 g of brown sugar and 500 mL of rice wash waste. The solution was then fermented using a plastic container for 2 weeks on an anaerobic basis to produce the PBA extract.

Urine Fermentation Process

The process of urine fermentation was done without air (an-aerobic). The initial stage of the fermentation process was mixing the ingredients according to the composition of the material in Table 1. The mixture of ingredients was then put into a closed plastic container and then stored at the room temperature. The fermentation process was carried out according to each treatment in Table 1 (7, 14 and 21 days). The final product of the fermentation process obtained results in the form of BLF which was then tested according to quality parameters.

Design of Study

The study was conducted experimentally using 2 factors. The first factor was the different types of bio-activators, while the second factor was the difference in fermentation time. Two types of bio-activators, namely (1) animal bio-activator (ABA) and (2) plant bio-activator (PBA). Three levels of fermentation time have been applied: (1) 7 days, (2) 14 days and (3) 21 days. Each treatment was repeated three times. Animal bio-activator (ABA) was the result of fermentation of cattle feces extract with other ingredients, whereas, plant bio-activator (PBA) was extract fermented root of banana plant with other material.

Parameter of Study and Data Analysis

The parameters observed in BLF were: (1) pH value, (2) C-organic content, (3) N-total content, (4) C/N ratio and (5) cost analysis of BLF. Determination of pH value, C-organic, N-total and C/N ratio of the BLF was using the test method in the fertilizer quality analysis guidelines

(Agus, 2005).

Data were analyzed statistically using two-way ANOVA. The result data showed real effect, then tested using Duncan'S Multiple Range Test (DMRT) at 5% level (Steel and Torrie, 1991).

RESULTS AND DISCUSSION

pH Value

The pH value indicates a level of acidity and alkalinity of the solution. Based on the results of statistical analysis in Figure 1, the difference of type of bio-activator and the time of fermentation process has no significant effect on pH value of BLF.

The fermentation process using ABA and PBA has almost the same performance. Based on pH test results obtained results (8.76-8.95) (Said *et al*., 2018a). This value has met the standards set by the Ministry of Agriculture of the Republic of Indonesia is pH 4-9. The results of the test on pH BLF showed value near the pH of dairy cattle urine used by Singh *et al*. (2013) in the research that is 7.8. Organic fertilizer production process will produce NH3 compounds, but in general does not have much effect on the pH value (Janczak *et al*., 2017). The components of the organic acids in the urine will undergo a reaction process during fermentation. In the hydrolysis process, urine will have an optimal pH. The range of values was in the range 8.5-10 (Zamora *et al*., 2017). The results of this test was higher than liquid fertilizer research results by Raden *et al*. (2017), i.e 5.45-5.64.

Table 1. Material Composition for Producing Bio-Urine Liquid Fertilizer (BLF) Based on Urine of Balinese Cattle (Said *et al*., 2018a)

Material Composition	Combination of Bio-Activator-Fermentation Time					
	ABA-T_7	ABA-T_{14}	ABA-T_{21}	PBA-T_7	PBA-T_{14}	PBA-T_{21}
Urine of Balinese Cattle (UoB) (L)	2	2	2	2	2	2
Dolomite (%) (w/v) *)	1	1	1	1	1	1
Turmeric powder(%)(w/v) *)	0.5	0.5	0.5	0.5	0.5	0.5
ABA extract (%) *)	5	5	5	-	-	-
PBA extract (%) *)	-	-	-	5	5	5

ABA (animal bio-activator); PBA (plant bio-activator); T_7 (7 days); T_{14} (14 days); T_{21} (21 days); *) Components are calculated by volume of UoB.

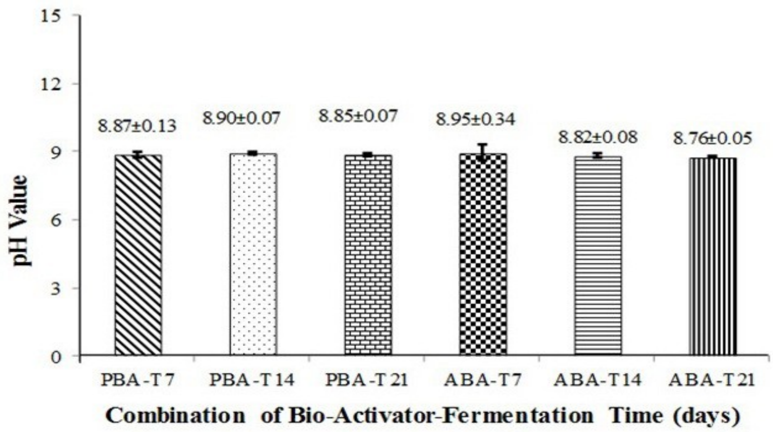

Figure 1. The pH Values of Bio-Urine Liquid Fertilizer (BLF) ; PBA = Plant Bio-Activator; ABA = Animal Bio-Activator; F7 = 7 days; F14 = 14 days; F21 = 21 days

C-Organic

One of the indicators used to determine the quality of a fertilizer is the C-organic content (Reeves, 1997). The level of C-organic on soil can be increased up to 18% by using fertilizer from livestock. Such increase may occur in the surface layer portion (Dordas *et al*., 2008). The results of the C-organic content test on BLF produced using different types of bio-activator and fermentation time process were presented in Figure 2.

The results of statistical analysis (Figure 2) showed that the different types of bio-activator and fermentation process time significantly ($P<0.05$) on the C-organic content of BLF (Said *et al*., 2018a). The test results showed that C-organic content of BLF has a value of 9.59-12.02%. The results of Raden *et al*. (2017) resulted in an organic C-content of 0.67-0.86 lower than BLF. Figure 2 shows that the C-organic level has increased from the time of fermentation process 7 days to 14 days and then decreased after experiencing the fermentation process of 21 days. During the 7-day fermentation process, the functional conditions of microorganisms in the bioactivator are still in the adaptation phase (lag phase). In the next process up to the 14-day fermentation process, microorganisms are in an exponential phase. Microorganisms have experienced a peak process of population growth and development. Based on this, of course microorganisms require the element carbon (C) as an energy source. The need for carbon elements has increased. Carbon source is obtained from organic materials found in urine. In the 21-day fermentation process, the population of microorganisms enters the stationary phase and death and carbon element requirements decrease (Said *et al*., 2018b).

In addition, the results of the study also showed that the application of bioactivator types interacted significantly ($P<0.05$) with the fermentation process time in influencing the value of C-organic (Figure 2). Different types of bioactivators will produce different types and populations of microorganisms. The need for carbon elements of each type and population of microorganisms is influenced by the time of the fermentation process. Increasing the fermentation process time will increase the activity of microorganisms, so the energy requirements of the carbon element will also increase.

C-organic content is an important factor in the use of organic fertilizer. C-organic content is one of the differentiator with chemical fertilizer. Increased levels of C-organic lead to increased production of roots and higher air biomass (Izaurralde *et al*., 2000). The availability of sufficient C-organic can improve crop productivity.

N-Total

Figure 3 shows the comparison of N-total values of BLF produced using different types of bio-activators and fermentation process times. The result of statistical analysis showed that the difference of type of bio-activator and the time of fermentation process had significant effect ($P<0.05$) on the N-total of BLF. N-Total value at BLF is in the range of 1.03 to 1.35% (Said *et al*., 2018a).

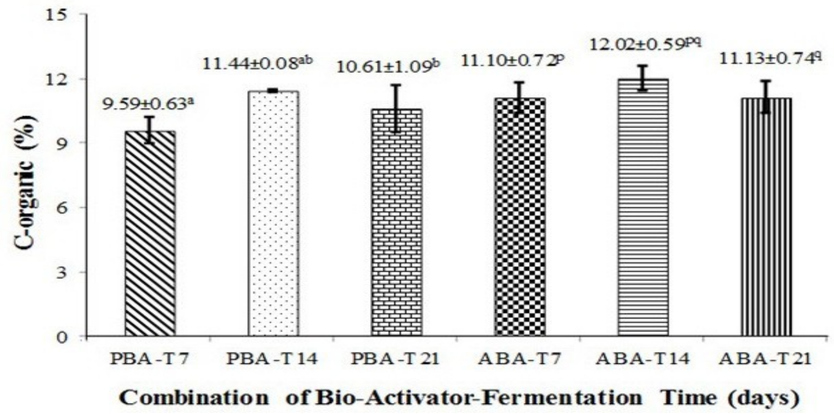

Figure 2. C-organic Values of Bio-Urine Liquid Fertilizer (BLF) ; PBA = Plant Bio-Activator; ABA = Animal Bio-Activator; F7 = 7 days; F14 = 14 days; F21 = 21 days. [a,b,p,q] Different superscripts on each type of bio-activator showed significant differences ($P<0.05$). Test the significant difference using Duncan Multiple Range Test (DMRT) at 5% level.

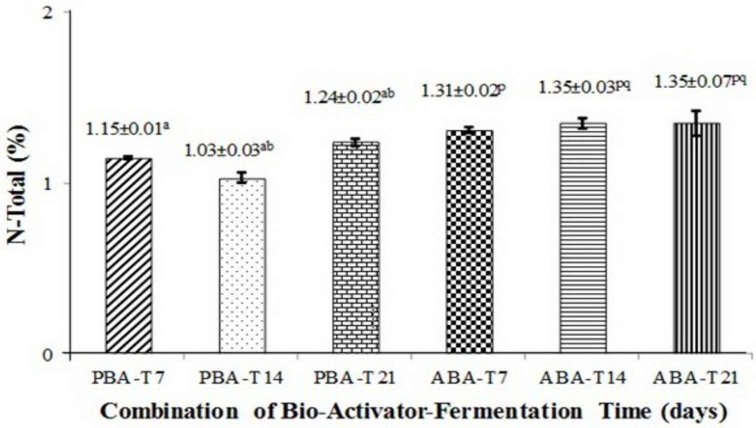

Figure 3. N-Total Values of Bio-Urine Liquid Fertilizer (BLF) ; PBA = Plant Bio-Activator; ABA = Animal Bio-Activator; F7 = 7 days; F14 = 14 days; F21 = 21 days. [a,b,p,q] Different superscripts on each type of bio-activator showed significant differences (P<0.05). Test the significant difference using Duncan Multiple Range Test (DMRT) at 5% level.

Fermentation significantly affected (P<0.05) for the N-total value of BLF. N-total levels are basically manifestations of protein content in a material. This happens because during the fermentation process, there is an increase in the activity and growth of microorganisms contained in the bioactivator in overhauling protein compounds and carbohydrates (dissolved sugars) in the urine. Microorganisms will then develop and produce enzymes that break down complex compounds (proteases). These complex compounds will then be broken down into simple compounds. An increase in fermentation time will increase the components of simple compounds such as amino acids so that the N levels increase (Said *et al*., 2018b).

The type of bioactivator applied had a significant interaction (P<0.05) with the fermentation process time at the N-total level of BLF (Figure 3). Different types of bioactivators will produce different types of microorganisms. The growth and development rate of each microorganism is also influenced by the fermentation time. In ABA and PBA bioctivators, the composition of microorganisms contained therein may be different. These microorganisms can be bacteria or fungi with strains and genera. The growth of the two microorganisms is also different so that it can directly give effect to the difference in value on the N-total of the BLF composition.

The ABA application as a bio-activator significantly increases N-total levels in PCB. Comparison of N-total values (Figure 3) shows that N-total levels in ABA use are higher than PBA. ABA extract is produced from bovine feces extract which has high N levels (Draganova *et al*., 2016; Moir *et al*., 2007). The availability of N elements is one of the essential ingredients for plant growth in a grazing unit. Excess N content affects plant growth conditions. N content is a limiting factor, especially in a grazing unit (Lambert *et al*., 2004). In pastoral areas, bovine urine is one of the nitrogen sources (Roten *et al.,* 2017).

C/N Ratio

Based on the results of statistical data analysis in Figure 4 shows that the different types of bio-activator and fermentation process time significantly (P<0.05) on the C/N ratio of BLF. The C/N ratio of BLF is in the range of values from 8.33 to 11.03 (Said *et al*., 2018a).

Fermentation time affects to the C/N ratio. Increasing the fermentation process time from 7 days to 14 days increases the C/N ratio in urine, but again decreases in fermentation by 21 days. Fermentation time is related to the growth process of microorganisms in the bioactivator. During the 7 dayd fermentation period, the bacteria underwent a stage of the adjustment process (lag phase). Furthermore, at the 14 days fermentation time, the bacteria underwent a logarithmic (exponential) growth process. This can be seen from the increase in the value of the C/N ratio. At this stage, the growth of microorganisms

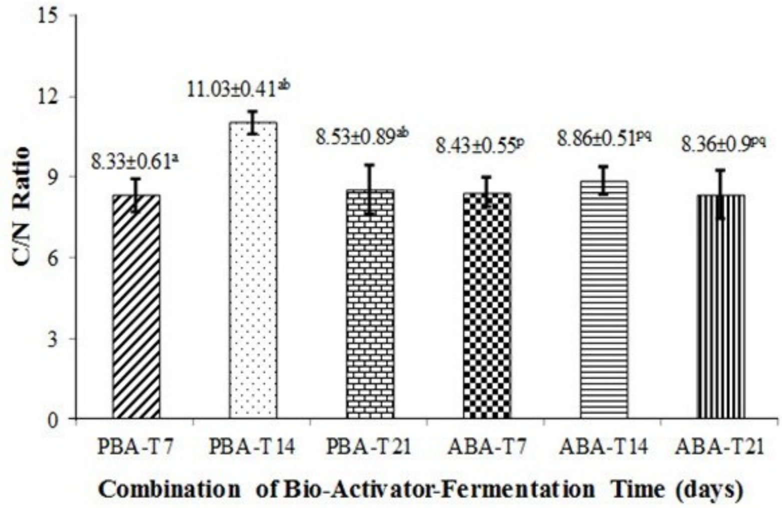

Figure 4. C/N Ratio Values of Bio-urine Liquid Fertilizer (BLF) ; PBA = Plant Bio-Activator; ABA = Animal Bio-activator; F7 = 7 days; F14 = 14 days; F21 = 21 days. [a,b,p,q] Different superscripts on each type of bio-activator showed significant differences (P<0.05). Test the significant difference using Duncan Multiple Range Test (DMRT) at 5% level.

experiences very rapid and maximum growth. Furthermore, at the time of fermentation of 21 days, bacterial growth is in a stationary condition until it is gradually leading to death. This can be caused by the reduction in food reserves for the life of microorganisms so that the impact on the declining C/N ratio of BLF (Said *et al*., 2018b).

The results of other studies showed a signifikan interaction (P <0.05) between the types of bioactivators used with the fermentation process time on the C/N ratio of the BLF. Based on Figure 4 shows that the interaction of each type of bioactivator has increased C/N ratio at 14 days fermentation time. The fermentation time shows the population of microorganisms that work on bioactivators experiences a peak. It also directly affects the increase in microorganism activity in overhauling and degrading protein substrate components in the urine. Along with this, the need for carbon (C) element has also increased so that it affects the value of the C/N ratio of the BLF.

The concentration of nitrogen in the soil is reduced by the high C/N ratio of the fertilizer (Lugo-Perez and Lloyd, 2009). Dead plants and microorganisms will leave behind a number of sediments and carbon (Ishiwatari and Uzaki, 1987). The rate of decline in the fermentation process can be due to the high C/N Ratio (Prahl *et al*., 1994).

Cost Analysis of BLF Production

Production cost is one important component of the overall cost of a product. Lower production costs are synonymous with increased profitability of existing manufacturing units (Khan, 2016). In the development of BLF production business required an appropriate analysis. Material cost requirements and production profit analysis were presented in Table 2 and Table 3.

Based on Table 2, the need for equipment to produce BLF using ABA and PBA is relatively the same. Equipment costs represent fixed costs calculated against depreciation costs of equipment. The total fixed cost for each production cycle of both BLF product types is the same i.e IDR. 5,005.62 (US$ 0.35) The long cycle of the production process of BLF is 1 week. The life time of equipment ranges from 1-4 years. A list of components of raw materials and comparative analysis of the profit of BLF production was presented in Table 3. The price of ABA is more expensive (IRD.136,66/100 mL) than PBA (IDR.3.60/100 mL). This price difference is due to the difference in the price of basic material components in the bio-activator making. The allocation of fixed cost components can be used to estimate costs in capacity building. Therefore, this needs to be considered (Haka *et al*., 2002). Energy and its sources are significant factors that affect costs in the manufacturing

Table 2. Depreciation Value/Fixed Cost of Production Process Equipment from BLF

Equipment	Price (IDR)	Life Time (LT)	Long Cycle of Production (LCP)	Depreciation Value of Equipment (1 week) / Fixed Cost (Fc) (IDR) (Price/LT)
Chopper	32,000	4 years (208 weeks)	1 week	153.42
Container	10,000	1 year (52 weeks)	1 week	191.79
Filter	15,000	1 year (52 weeks)	1 week	287.69
Bucket	15,000	1 year (52 weeks)	1 week	287.69
Measuring cup	73,000	1 year (52 weeks)	1 week	1,400.07
Scales	500,000	4 years (208 weeks)	1 week	2,397.27
Basin	15,000	1 year (52 weeks)	1 week	287.69
Total	660,000 (US$ 47.14)			5,005.62 (US$ 0.35)

Table 3. Raw Material Component and Production Cost Analysis from BLF using ABA and PBA

Raw Materials	Use of ABA as bio-activator (IDR)	Use of PBA as bio-activator (IDR)
Urine of Bovine (UoB) (2 L)	3,000.00	3,000.00
Dolomite (20 g)	20.00	20.00
Turmeric powder (10 g)	150.00	150.00
Bio-activator (100 mL)	3.60	136.66
Variabel cost (Vc)	3,173.60	3,306.66
Profit Analysis of Product		
Depreciation /Fixed cost (Fc)	5,005.62	5,005.62
Variable cost (Vc)	3,173.60	3,306.66
Total cost (Tc) = (Fc) + (Vc)	8,179.22	8,312.28
Price (P)/liter	10,000.00	10,000.00
Quantity (Q)	2 liter	2 liter
Total revenue (Tr) = (P) x (Q)	20,000.00	20,000.00
Profit (Pr) = (Tr) – (Tc)	11,820.78/ (US$ 0.84)	11,687.72/ (US$ 0.83

industry (Fadare, 2003). The energy input varies from operating one unit to another. Different patterns of energy consumption affect the cost of producing organic fertilizer (Fadare *et al*., 2010)

CONCLUSION

In the application, the use of plant bio-activator (PBA) combined with 14 days fermentation time demonstrated the best properties of bio-urine liquid fertilizer (BLF) compared to other treatment combinations. In production process, BLF production cost using PBA as bio-activator is more efficient than using animal bio-activator (ABA).

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