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Nutrient content of Liquid Organic Fertilizer (LOF) by various bio-activator and soaking time

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Abstract. *Raden I, Fathillah SS, Fadli M, Suyadi. 2017. Nutrient content of Liquid Organic Fertilizer (LOF) by various bio-activator and soaking time. Nusantara Bioscience 9: 209-213.* Inorganic fertilizers have negative impacts on soil structure, cause water and soil pollution, and produce less healthy crop production. These conditions can be improved with organic fertilizers. The research aimed to make liquid organic fertilizer (LOF) treated with various bio-activator and soaking time and to know the nutritional content in it as well. Observed variables were pH; C/N ratio; macro and micro nutrients. Research used a completely randomized design in factorial analysis. The first factor was the various bio-activator (b), i.e. b1 = EM-4 culture; b2 = boisca; and b3 = shrimp paste. The second factor was soaking time (t), i.e. t1 = 10 days; t2 = 20 days, t3 = 30 days; and t4 = 40 days. The treatment was repeated (r) three times and tested by analysis of variance and LSD at 5% level. The results showed that culture of EM4 bio-activator had higher content of C/N ratio; organic-C; total-N; Co; B; Mn; Fe; Cu; and Zn than the other bio-activators, although it also had lower content of pH, P_2O_5; K_2O than others but those values were not significantly different compared to boisca and shrimp paste bio-activators. The other result showed that soaking time had significantly effect in determining the nutrient content of the C/N ratio; Organic-C; Total-N; P_2O_5 ; K_2O; Total-Ca; Mg; S; Co; B; Mn; Fe; Cu; and Zn, but not at pH variable. Soaking time of 40 days (t4) provided the highest value on the C/N ratio; pH; Mn; Fe; and Zn. On the other hand, soaking time of 30 days (t3) provided the highest value on the organic-C; K_2O; total-Ca; and B. Meanwhile, soaking time of 20 days (t2) provided the highest nutrient values on Cu; Co; B; Mg; and total-N. While, soaking time of 10 days (t1) gave the highest value on the nutrient content of P_2O_5 and S. The interaction between the various bio-activator and soaking time b3t3 had the highest value 575.41 ppm of B, then treatment b2t3 had the highest 0.89% of K_2O, and treatment b1t4 gave the highest nutrient content 1648.82 ppm of Fe.

Keywords: Bio-activator, liquid organic fertilizer, soaking time, nutrients

INTRODUCTION

The need for food keeps increasing along with the increasing of the population. Food production can be enhanced through the application of fertilizers. Results of research showed that the use of inorganic fertilizer could increase production, but the continuous giving of inorganic fertilizer to the soil may affect the structure of the soil that plant roots cannot be fully developed, and it may also make pollution of water and soil, as well as produce less healthy food for consumers. It even creates an understanding that the addition of inorganic fertilizers will no longer provide a significant increase in production but rather an increase in soil degradation. According to Moura Filho and Alencar (2008); Nogueira da Silva et al. (2015), another important aspect is the fact that N, P, and K chemical fertilizers produce waste that contaminates soil and water resources during the manufacturing process, and can also acidify and/or salinize soils resulting in need of cost for soil amendment. This condition is further exacerbated by the highly dependence of farmers in Indonesia to inorganic fertilizer and when the fertilizer subsidy was cut off by the government, the Indonesian farmers underwent increasingly difficulty in raising crops due to higher production costs. This condition is exacerbated by the price of agricultural products which were not significantly increased. If a solution could not be formulated, then the agricultural development in Indonesia might worsen and food security and food self-sufficiency in Indonesia will be threatened.

Based on these considerations, farming by processing the raw materials that exist around farmers and recycled into liquid organic fertilizer is one of the solutions to overcome the above problems. According to Adil et al. (2006), the application of organic fertilizer could improve soil fertility. Asiah (2006) added that the application of organic materials could increase yield productivity and reduce the intensity of pest and disease. Availability of raw materials and coaching farmers to be able to utilize them into organic fertilizer are very important and possible to do. The raw materials are water hyacinth (*Eichhornia crassipes*), peanut (*Arachis hypogaea*), lamtoro (*Leucaena leucocephala*) leaf, bay leaf (*Syzygium polyanthum*), coconut milk, rice bran, and molasses. According to Suhastyo (2011), the manufacture of LOF through fermentation (decomposition) are by decomposing the physical form of solids and releasing some nutrients in the form of complex compounds and simple compounds from raw materials. Therefore, this study was conducted to find

the efficient way in producing liquid organic fertilizer derived from raw materials around the farmer. This study aimed to determine the various bio-activator and best soaking time to produce liquid organic fertilizer (POC) with the variables of pH; organic-C; C/N ratio; and the content of macro and micro nutrients.

MATERIALS AND METHODS

This research was carried out from May to November 2013 in the Village of Timbau, Tenggarong Subdistrict of Kutai Kartanegara District, East Kalimantan, Indonesia. Measurement of pH; organic-C; C/N ratio; the macro and micro nutrients content of liquid organic fertilizer were conducted at Soil Science Laboratory of Tropical Forest Reforestation Study Center of Universitas Mulawarman, Samarinda, Indonesia. Water hyacinth, peanut, lamtoro and bay leaves, shrimp paste, coconut milk, rice bran, molasses, boisca, and EM-4 were used as materials. And, the tools were an analytical balance; pH meter; thermometer; and spectrophotometers; flame photometer

The procedure was done through two steps. The first step was the manufacturing of plastic bucket composters which their left and right sides of the upper part and parts of 15 cm from the bottom were perforated to make holes then the pipe was plugged into each hole and at the end of the bottom pipe, a faucet was mounted. Then the upper pipe linked to pipes that already have T connection. The pipe at the bottom was set to the L connection that linked to T connection. After all of the pipes were connected, the plastic bucket was ready to be used as a composter. The second step was to make bio-activator, namely (i) the culture of EM-4 bio-activator which was made from 5 liters of boiled water in a kettle mixed with rice bran, molasses, and shrimp paste, then stirred until they were evenly distributed. After that, the dough was cooled to room temperature, and put in the fluid of EM-4, then stirred again until evenly distributed. Then the kettle, with the dough in it, was sealed for two days (unopened), and on the third day, and the days after, it was closed loosely, then stirred every day for approximately 10 minutes, and then after one week the bacteria is filtered with gauze and put in a bottle then the bottle was closed loosely to give air to the bacteria. (ii) Boisca, this bio-activator was available in agriculture stores. It is used in making liquid organic fertilizers. Boisca was arranged to fulfill the need of this research. (iii) Shrimp paste; shrimp paste functioned as a starter and this bio-activator was dissolved in water.

Research used a completely randomized design in factorial analysis. The first factor (various bio-activators) were s1 = cultures of EM-4; s2 = boisca; and s3 = shrimp paste. The second factor (soaking time) were p1 = 10 days; p2 = 20 days, p3 = 30 days; and p4 = 40 days. Total combined treatment (t) was 3 x 4 = 12 treatments with three replications (r). Treatments were tested by analysis of variance and Least Significant Difference (LSD) at level of 5%.

After preparing composter and bio-activator, the next step was to make the fertilizer using chopped and partially blended raw materials, while liquid ingredients are given at sufficiently, and then all the ingredients were concatenated into each composter according to the number of treatments. Furthermore, bio-activator fluids, namely the culture of EM-4, boisca and shrimp paste, were poured into the composter according to each treatment, then stirred until they were mixed evenly with other LOF (Liquid Organic Fertilizer) materials. Then, each was sealed and stored according to the treatment of soaking i.e. s1, s2, s3 and s4. The parameters observed in this study were: (i) pH; it was measured after fermentation has completed in accordance with the soaking time (electrode method); (ii) C/N ratio; the data were obtained after the fermentation of each treatment has been carried out (count method); (iii) the content of macronutrients (total-N (Kjeldahl method), P_2O_5 (Spectronic method), K_2O Ca total, Mg, and S (AAS method), organic-C (Walkley and Black method), and micronutrients (total-Fe, Mn, Cu, Zn, B, and Co) which were analyzed by flame photometer.

RESULTS AND DISCUSSION

Various bio-activators

The results showed that application of the various bio-activators to the LOF had a significant effect on the content of K_2O; Total-Ca; Mg; B; Total-Fe; and Cu, but gave no significant effect on pH; C/N ratio; Organic-C; Total-N; P_2O_5; S; Co; Mn; and Zn. Results of laboratory analysis showed a pH range from 5.45 to 5.64. Based on the standard quality of minimum technical requirements of liquid organic fertilizer according to the Decree of the Indonesian Minister of Agriculture (DIMA) number 70/Permentan/SR.140 /10/2011 that the resulting pH corresponding to the quality standards required was 4−9. Furthermore, Organic-C range was 0.67 up to 0.86 which was less than the category required by DIMA. Data C/N ratio indicated a value of 3.38 up to 3.96 which was very good for the development of plants. Data showed that the process of fermentation occurred in boisca bio-activator was faster than others. This was due to the type of microorganisms that existed in boisca namely *lactic acid* bacteria, *Sachromices* sp., *Actinomycetes*, and *Aspergillus* sp. These microorganisms could work faster in the decomposition of raw materials of LOF. This finding was consistent with the opinion of Hadisuwito (2007), which stated that the bacteria contained in boisca can transform organic material into simpler compounds required by plants in a short time.

The results of the analysis of total-N with the Kjeldahl method showed Total-N value of 0.20% to 0.24%, and the P_2O_5 analysis with Spectronic methods gave the result of P_2O_5 with an average value of 0.07% to 0.08%. Furthermore, K_2O analysis with AAS method resulted the average value of 0.47% to 0.59%. The average value of total-N, P_2O_5 and K_2O were below the range of values in the quality standard of minimum technical requirements of liquid organic fertilizer according to the DIMA number 70/Permentan/ SR.140/10/2011 that value range must be 3-6%. The LSD test at 5% level of K_2O indicated that treatment of bio-activator of shrimp paste had the highest

value (0.59%) and the lowest was obtained by the treatment of boisca i.e. 0.47%. According to Zaman (2007), in the fresh organic matter, nutrients of potassium (K) in the form of complex organic are not used directly by plants for growth. But after composting progress, the activity of microorganisms will transform these nutrients into a form of K_2O (K-available) which is easily absorbed by plants. Furthermore, Sutedjo (2002) stated that K is used by microorganisms in the compost material as a catalyst together with the bacteria and this activity is very influential to the increase in potassium content. Potassium is tied and kept in the cells by bacteria and fungi, if decomposition process is performed again, then potassium will become available again.

The results showed that treatment of EM4 culture had the highest values of total Ca and Mg that were 848.96 and 895.49 ppm. Apart from that, the nutrient supply has been fulfilled because the application of EM4 will accelerate the decomposition process and increase the activity of beneficial microorganisms (Higa and Wididana 1994), and also bacteria in EM4 (*Streptomyces* sp., *Pseudomonas fluorescens*, *Bacillus* spp., and *Serratia* spp.) inhibit development of both pathogens and viruses (Soesanto et al. 2014).

Sulfur is a part of the protein in the form of cysteine, methionine, and thiamine. Young plants need nutrients for growth and in the formation of seed so that the sulfur should be found in plants. In the process of raw materials decomposition in LOF production using various bio-activators, it is showed that the culture of EM4, boisca and shrimp paste did not gave any significant effect on the sulfur content, which was about 303.32 ppm to 344.54 ppm.

Based on the standards of nutrient content in LOF in the DIMA number 70/Permentan/SR.140/10/2011, the range of nutrient content must be 5−20 ppm. The nutrient content in LOF with the treatment of EM4 culture bio-activator was 5.66 ppm and it fulfilled in the minimum standard criteria. Furthermore, the treatment of shrimp paste bio-activator provided nutrient content of 289.42 ppm of B, and it was higher than the result given by boisca treatment which only reached 219.16 ppm of B, but had no significant effect compared to the result given by the treatment of culture EM4 that had 239.43 ppm of B. based on the standard of nutrient content of organic liquid fertilizer through the DIMA number 70/Permentan/SR.140/10/2011 the B nutrient contents must range from 125-2500 ppm. Based on the value of the required content of B, the three treatments have met the standard criteria for LOF.

Mn is a nutrient required by plants for the formation of proteins and vitamins, especially vitamin C, maintaining the condition of the green leaves that contained the remains of plants and other organic materials. The requirement of Mn nutrient content ranged from 250-5000 ppm. Based on the requirement, the treatment of EM4 culture met the criteria namely the value of 526.26 ppm.

The LSD test at 5% level indicated that the culture of EM4 had Fe content (559.61 ppm), which was different from the Fe value of boisca (296.52 ppm) and of shrimp paste (281.07 ppm). The values of Fe in the LOF met the requirements of the DIMA number 70/Permentan/SR.140/10/2011 with the range of 90-900 ppm. EM4 culture treatment as bio-activator for decomposition of various organic materials can improve Fe content in liquid organic fertilizer.

Cuprum (Cu) contained in the liquid organic fertilizers was different from the application of EM4 culture, boisca, and shrimp paste. The value of Cu content of EM4 cultures (13.55 ppm) was higher than of boisca (8.76 ppm) and of shrimp paste (5.89 ppm). Cu was required by plants in the formation of Ascorbic acid enzymes; lactose; butirid coenzyme A; and was instrumental in the formation of green photosynthetic pigment (chlorophyll). The values of Cu in the content of LOF did not meet the requirements of the DIMA number 70/Permentan/SR.140/10/2011 that is the range of 250-5000 ppm. This was the same with Zn microelements content that had a value less than the required range of 250-5000 ppm.

Table 1. Effect of various bio-activators on pH, C/N ratio and Organic-C, macronutrients, and micronutrients in a LOF.

Variables	Units	Various bio-activators (b)			LSD 5 %
		Culture of EM4 (b_1)	Boisca (b_2)	Shrimp paste (b_3)	
pH		5.45	5.64	5.52	-
C/N ratio		3.96	3.38	3.49	-
Organic-C		0.86	0.67	0.67	-
Macronutrients					
Total-N	%	0.24	0.20	0.20	0.05
P_2O_5	%	0.07	0.07	0.08	0.01
K_2O	%	0.51 ab	0.47 a	0.59 b	0.08
Total-Ca	ppm	848.98 b	603.55 a	501.66 a	202.74
Mg	ppm	895.49 b	71.46 a	886.17 b	134.84
S	ppm	334.01	344.54	303.32	191.98
Micronutrients					
Co	ppm	5.66	4.27	3.15	2.70
B	ppm	239.43 ab	219.16 a	289.42 b	26.44
Mn	ppm	526.26	179.29	204.31	348.18
Total-Fe	ppm	559.61 b	296.52 a	281.07 a	196.86
Cu	ppm	13.55 b	8.76 ab	5.89 a	5.19
Zn	ppm	14.35	11.48	8.83	6.51

Note: Figures followed by the same letter on the same line were not significantly different at Test of LSD at 5%. level

Soaking time

The results showed that the soaking time had significant effect on all variables except pH, but the pH generated in all treatments had met the standard quality requirements of LOF stated in DIMA number 70/Permentan/SR.140/10/ 2011. Djuarni et al. (2005) stated that the degree of acidity at the beginning of composting process would decrease due to a number of microorganisms involved in the process had transformed organic material into organic acids, but, in the next process, microorganisms from other species would convert that organic acid so that the material had high degree of acidity and was close to normal.

According to Seni et al. (2013), all living things including plants composes a large number of carbon (C) and nitrogen (N) material. The results showed that there was a tendency that the longer the soaking the higher carbon and nitrogen ratio. This means that the decomposition of carbon atoms tended to be higher than the decomposition of nitrogen, but the value of this increase was not significant in the soaking time of 30 days to 40 days. In other words, the further process of decomposition of carbon contained in LOF would gradually decrease with the increase of nitrogen. This can be seen in the Organic-C data, the treatment of soaking period of 40 days had lower levels of Organic-C (0.76%) than the soaking period of 30-day (0.97%) . This was due to the carbon contained in the raw materials of LOF is mostly used by bacteria as a source of energy for its activity in the decomposition of organic materials. According to Yuwono (2006) decomposers used C (Carbon) 30 (thirty) times faster than N (nitrogen) and Sinaga (2009) stated that 2/3 of C (Carbon) in the composting process is used as a source of energy for the growth of microorganisms and the remaining 1/3 is used for bacterial cell formation.

The LSD test at 5% level indicated that the soaking time of 20 days (0.27%) had the highest total value of N than that of other treatments. There was a tendency that after 20 days soaking time, the value of Total-N decreased until it reached the value of 0.17% on 40-days soaking time. This trend also occurred in P_2O_5, soaking time 10 days gave the value of P_2O_5 higher or significantly different from the soaking time 20, 30 and 40 days. Conversely, there was a tendency that the longer the soaking K_2O levels continued to increase until the soaking time of 30 days with the highest value that was 0.95% and after 40 days decreased.

Soaking time had a significantly different effect on the content of Total-Ca, 30-days soaking time treatment provided Ca total content on LOF with 867.69 ppm, then it decreased in the soaking time of 40 days (397.38 ppm). This condition was the same with Mg nutrients, a soaking time of 10 days had a different value of Mg content from that of 20 days of soaking time. A significant increase in the Mg content occurred in 20 days of soaking time, but after 30 days and 40 days, it decreased. Nutrient content of sulfur (S) in the LOF at the beginning of fermentation with soaking time of 10 days reached the highest score namely 500.85 ppm, but on 20 days of soaking time, it drastically decreased, i.e. 28.44 ppm and then on soaking time of 30 and 40 days it seemed to increase, but the only at the value of less than 500 ppm.

The results of LSD test at 5% level showed that there was the difference in the content of Co in LOF soaked for 10 days, 20 days and 40 days. Nutritional content of Co increased at 20 days soaking time. After that, it decreased. The tendency of the content of Co was in contrast to the content of B. B content in the LOF continued to increase until at the soaking time of 30 days with a value of 473.96 ppm. After that, the decrease happened as well. The content of B in the soaking time of 10 days, 20 days and 30 days was different from one to another. Furthermore, in the soaking time of 40 days, Mn content increased and reached 1077.75 ppm and the lowest was in the soaking time of 10 days, namely 24.94 ppm. Although in a small amount, Nutrients of Co, B, and Mn are the micro-nutrients badly needed by plants and have a strategic function.

Table 2. The effect of soaking time to pH, C/N ratio and Organic-C, macronutrients, and micronutrients of LOF

Variables	Units	Soaking time (s)				LSD 5 %
		10 days (s_1)	20 days (s_2)	30 days (s_3)	40 days (s_4)	
pH		5.47	5.40	5.59	5.61	0.26
C/N ratio		2.10 a	2.57 a	4.32 b	4.55 b	1.11
Organic-C		0.55 a	0.65 a	0.97 b	0.76 ab	0.21
Macronutrients						
Total-N	%	0.18 ab	0.27 c	0.24 bc	0.17 a	0.06
P_2O_5	%	0.11 c	0.05 a	0.06 ab	0.07 b	0.01
K_2O	%	0.03 a	0.53 bc	0.95 d	0.61 c	0.09
Total-Ca	ppm	513.89 a	826.61 b	867.69 b	397.38 a	234.10
Mg	ppm	673.07 a	895.90 b	800.04 ab	817.15 ab	155.70
S	ppm	500.85 b	28.44 a	367.93 b	411.94 b	221.68
Micronutrients						
Co	ppm	4.30 b	7.45 c	5.46 bc	0.23 a	3.11
B	ppm	78.26 a	222.89 b	473.96 c	222.24 b	30.54
Mn	ppm	24.94 a	55.66 a	55.79 a	1077.75 b	402.05
Total-Fe	ppm	52.88 a	169.67 a	194.77 a	1098.97 b	227.31
Cu	ppm	6.31 a	17.28 b	9.03 a	4.98 a	5.99
Zn	ppm	3.38 a	3.47 a	16.65 b	22.71 b	7.51

Note: Figures followed by the same letter on the same line are not significantly different at LSD Test at 5%. level

Longer soaking time on raw materials for LOF caused higher Fe content. Soaking period of 40 days provided the highest Fe content value namely 227.31 ppm which was significantly different from that of other treatments. Fe nutrients tendency was similar to the nutrient content of Zn. The longer soaking raw materials of LOF caused higher Zn content with up to 22.71 ppm in soaking time of 40 days. The treatment of soaking period of 20 days provided the highest value on the nutrient content of Cu, which was 17.28 ppm. Longer soaking period on the raw material of Cu for LOF decreased as it was indicated by the treatment of soaking time of 30 and 40 days.

The interaction of various bio-activators and soaking time

Results of analysis of variance showed that there was an interaction between the various bio-activators with a soaking time of the content of boron (B), K_2O and iron (Fe). Test of LSD at 5% level indicated that the bio-activator of shrimp paste in a soaking time of 30 days (b3s3) provided the highest value of B, namely 575.41 ppm. Furthermore, bio-activator of boisca in a soaking time of 30 days gave the highest value of 0.89% of K_2O. Meanwhile, the interaction of EM4 culture bio-activator with soaking time of 40 days gave the highest value of 1648.82 ppm of Fe, as presented in Table 3.

Table 3. Interaction of various Bio-activators with soaking time to Nutrient Content of B, K_2O and Fe on liquid organic fertilizer.

Combination of treatments	B (ppm)	K_2O (%)	Fe (ppm)
b1s1	74.09 a	0.29 b	58.54 a
b1s2	219.39 bc	0.55 cd	247.97 a
b1s3	436.14 d	0.82 ef	283.12 a
b1s4	228.12 bc	0.67 de	1648.82 c
b2s1	77.49 a	0.03 a	54.69 a
b2s2	207.01 bc	0.43 bc	133.83 a
b2s3	410.34 d	0.89 f	197.76 a
b2s4	181.81 b	0.55 cd	799.77 b
b3s1	83.19 a	0.03 a	45.41 a
b3s2	242.29 c	0.60 d	127.39 a
b3s3	575.41 e	0.12 a	103.39 a
b3s4	256.78 c	0.62 d	848.31 b
LSD 5%	**52.09**	**0.16**	**393.72**

Note: Figures followed by the same letter on the same line are not significantly different at Test of LSD at 5% level

In summary, the bio-activator of EM4 culture had higher nutrient content of C/N ratio; organic C; total-N; Co; B; Mn; Fe; Cu; and Zn than others, although it had lower nutrient content of pH, P_2O_5; K_2O but they were not significantly different from that of bio-activator of boisca and shrimp paste. In addition, the soaking time had a significant effect in determining the nutrient content of the C/N ratio; Organic-C; Total-N; P_2O_5 ; K_2O; Total-Ca; Mg; S; Co; B; Mn; Fe; Cu; and Zn, but it had no significant effect on pH variable. Soaking time of 40 days (t4) provided the highest value on the C/N ratio; pH; Mn; Fe; and Zn. On the other hand, a soaking time of 30 days (t3) provided the highest value on the Organic-C; K_2O; Total-Ca; and B. Meanwhile, a soaking time of 20 days (t2) provided the highest nutrient values in Cu; Co; B; Mg; and Total-N. While, soaking time of 10 days (t1) gave the highest value on the nutrient content of P_2O_5 and S. The interaction between the various bio-activators with soaking time, i.e. b3t3, had the highest value of 575.41 ppm of B, then treatment of b2t3 had the highest value of 0.89% of K_2O, and the treatment of b1t4 had the highest nutrient content of Fe with 1648.82 ppm.

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